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Explanatory Note.

Illustrated articles are marked with an asterisk (*). Book notices are marked with a dagger (†). Cross references to a particular initial word may refer to any cognate work beginning in the same way. Thus, a reference from "Oil" to "Lubricant" would apply equally to "Lubricating," "Lubrication" or "Lubricator." The cross references condense the matter and assist the reader, but are not to be regarded as conclusive. So, if there were a reference from "Boiler" to "Furnace" and if the searcher failed to find the required article under the latter entry, he should not regard it as useless to turn back and look through all the "Boiler" entries, or others that the topic may suggest, as he would have done had there been no cross reference. Not all articles relating to a given topic necessarily appear under the same entries. Users of the index should bear in mind further that frequently more regard is paid to the actual contents of an article than to the precise title under which it appeared.

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ELECTRICITY.

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An Extensive Power System in the South

The Development of the Southern Power Company in the Carolinas
Four Hundred Miles of Lines Operated at 44,000 to 100,000 Volts

BY CECIL P. POOLE

The Development Stage

Until within the last two or three years the hydroelectrical developments in the South were mostly local in scope, furnishing power to a few cotton mills in the immediate neighborhood of the power plant, or at the end of a comparatively short transmission line. This was due in part to the attitude of the mill men who, although the reliability, convenience and economy of the electric drive had been demonstrated in several instances, still looked upon it with distrust, and in part to the mistaken idea that power could be produced with a local steam plant cheaper than purchased from a hydroelectric company. But their feelings in this respect have recently undergone a change, a fact which capitalists were not slow to note, and the indications at present are that the next ten years will produce networks of systems extending over hundreds of square miles, and rivaling in amount of power transmitted any of the great Northern or Western systems.

It may be asked here where is the market for so much power, to which the reply is that in cotton mills alone nearly 13,000,000 spindles, using approximately 400,000 horsepower, are in operation in the South today. Less than one-third of this is furnished by water power, while something like 2,000,000 horsepower is still undeveloped in the very heart of the cotton field.

One of the pioneer companies to organize for this work was the Catawba Power Company. The first plant was built on India Hook Shoals on the Catawba river, 18 miles from Charlotte, N. C. This plant commenced operation in March, 1904, and the quick sale of the entire output (10,000 horsepower) led Dr. W. Gill Wylie, president of the company, to consider the advisability of developing other plants in different parts of the country. The result was the formation of the Southern Power Company, with a capital of $10,000,000, to acquire and develop a sufficient number of water powers to furnish power to a section of the country 130 miles in length and 100 miles in breadth in the heart of what is known as the Piedmont region, the richest and most fertile section of the Carolinas. This section is dotted with cotton mills throughout its length and breadth and 150,000 horsepower is used, generated mostly by steam.

Eight undeveloped water powers on the Catawba river, besides that at the Catawba station, were taken over and one on the Broad river, the water rights covering a distance of 110 miles on the Catawba river, giving an aggregate head of 500 feet, and an average capacity of about 150,000 horsepower. At the outset it was clear that the most practical plan of development involved beginning at Great Falls, and three generating plants hydraulically "in series" were planned. These are designated the Great Falls, Rocky Creek and Fishing Creek stations. The original plan was slightly modified, however, by distribution conditions, which made it advisable to establish a generating station farther up toward the center of the area covered by the system before putting in the Fishing Creek station. Consequently, as soon as the Rocky Creek plant was about completed, work was begun on a 10,000-horsepower generating station at the Ninety Nine Islands (see Fig. 11).

FIG. 1. VIEW OF GREAT FALLS STATION AND DAM FROM THE TAIL STREAM

Problems Involved

The engineering problems involved were somewhat different from those found in any other system of comparable size. It was not definitely known how much power could be marketed in any one town or district, which left unsettled the capacity of the lines and amount of territory to be covered. This complicated the question of voltage regulation, as did also the fact that power would first be taken off at two or three points toward one end of the system, and finally at ten and probably a great many more points over the whole area covered. It was also necessary to make provision in the scheme for line regulation in order that the most economical method of passing water from the upper stations to those lower down in dry seasons could be practiced. The generators and step-up transformers were purchased under specifications covering a 15 per cent. rise in voltage and will operate under full load continuously under these conditions. Taps were also put on transformers in case this increase of voltage was not sufficient.

it would help matters materially to be able to throw a large amount of power on the system at one point in order to give other stations on the system sufficient time to cut in before the load would become too large to be carried. The three projected stations in the neighborhood of Great Falls would together be capable of carrying a load of 90,000 horsepower, so it was decided that this point be made the principal one of the system.

In order to carry out this idea and to make the system pliable, it was further decided that the equipment of these three stations should be subdivided into four units, consisting of two generators and three transformers, at each station; that the high-tension leads from each bank of the insulation; that choke coils and series transformers should withstand a shop breakdown test of 120,000 volts for one minute, and that the complete high-tension equipment should withstand a breakdown test of 100,000 volts to ground after installation.

Great Falls, on the Catawba river, 50 miles below Charlotte, N. C., and 24 miles from Camden, S. C., was selected for the first development. Surveying was begun in June, 1905, and the water was turned on early in March, 1907. This station is now working in parallel with the Catawba station, the auxiliary steam plant having been shut down a year ago, and a sister station has been built at Rocky Creek, 1¾ miles from the Great Falls station, and

FIG. 2. VIEW IN THE GREAT FALLS GENERATOR ROOM

It was estimated that at least one hundred substations would be necessary to dispose of 150,000 horsepower and in the neighborhood of 800 miles of transmission line, no point of which would be more than 60 miles from the nearest power house. The large number of small substations and the comparatively short transmitting distance made it feasible to adopt 44,000 volts for the potential at receiving stations.

From the foregoing it is evident that the design of the switching arrangements necessary to facilitate the location of a fault in a line or substation, and for synchronizing after the fault had been repaired or the line cut out, was a serious problem. Much study was given this subject and the conclusion was reached that transformers should pass through one switch and connect with a switching station common to all three stations; that the busbars in the switching station should be divided into as many sections as there would be outgoing lines and arranged so that in case of necessity one or more units in any one station could feed into one or more lines; that provision for synchronizing should be made at first only on the switch between the transformers and the low-tension busbars, and that provision for synchronizing at the old Catawba station should be made on the low-tension side of transformers.

It was also deemed advisable to use as few switches as possible and to have a large factor of safety in all, with regard to both the current-carrying capacity and put into operation. These three stations are supplying current to 385 miles of transmission—or more accurately, high-tension distribution—lines, other stations are being laid out, and the construction of 240 miles of 100,000-volt transmission line is in progress. The potential of the existing lines is 50,000 volts at the Great Falls end and 44,000 volts at the substations.

Great Falls and Rocky Creek

These two stations are mates, the buildings and equipment being practically the same in both. The only important difference is in the exciter equipment, which will be described in detail farther on in this article. Fig. 2 is an imperfect view of the interior of the Great Falls generat-

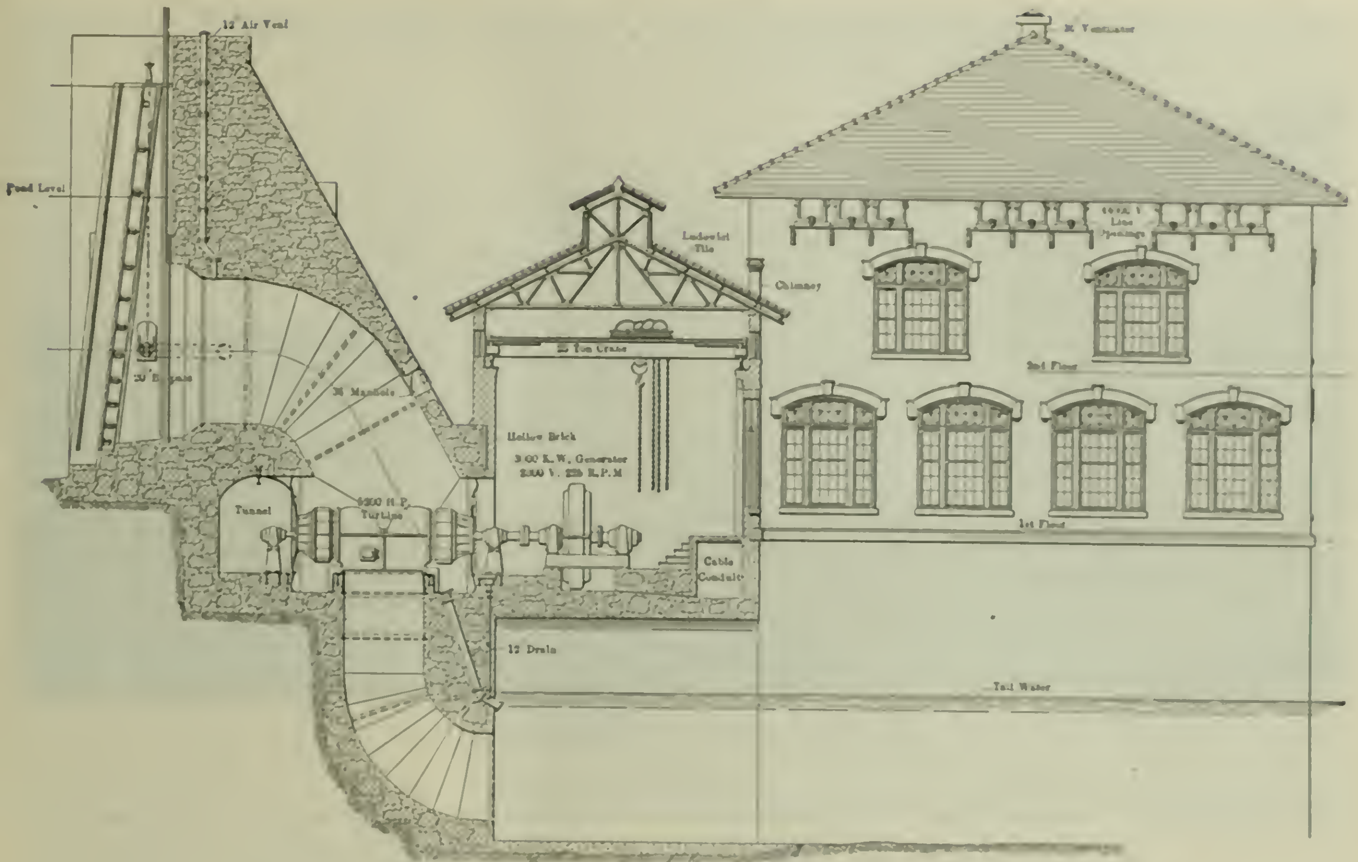


FIG. 3. SECTIONAL ELEVATION OF ROCKY CREEK GENERATING HOUSE, INTAKE AND HEAD GATES

ing room, which is 250 feet long by 37 feet wide and is 30 feet pitch. The transformer and switch house is 85 feet long by 71 feet wide, and is three stories high. The basement, which is on a level with the cable conduit and contains the cables and pipe work, is 8 feet pitch The next story, which is on a level with the switchboard gallery and contains transformers and low-tension switching apparatus, is 22.8 feet pitch, and the third story, in which at present are the high-tension switches, busbars, choke coils and lightning arresters, is 22 feet pitch Both buildings are of fireproof construction throughout, red pressed brick outside and light gray inside. The roof is built of large tile made of reinforced concrete with a waterproofing burned into it. The vertical cross-section, Fig. 3, and the plan view, Fig. 4, show the construction of the buildings, intake flumes and tail flumes, and the general arrangement of the generating equipment. Fig. 5 shows the dam at Rocky Creek during construction; the cross section of the unfinished portion on the right is clearly shown

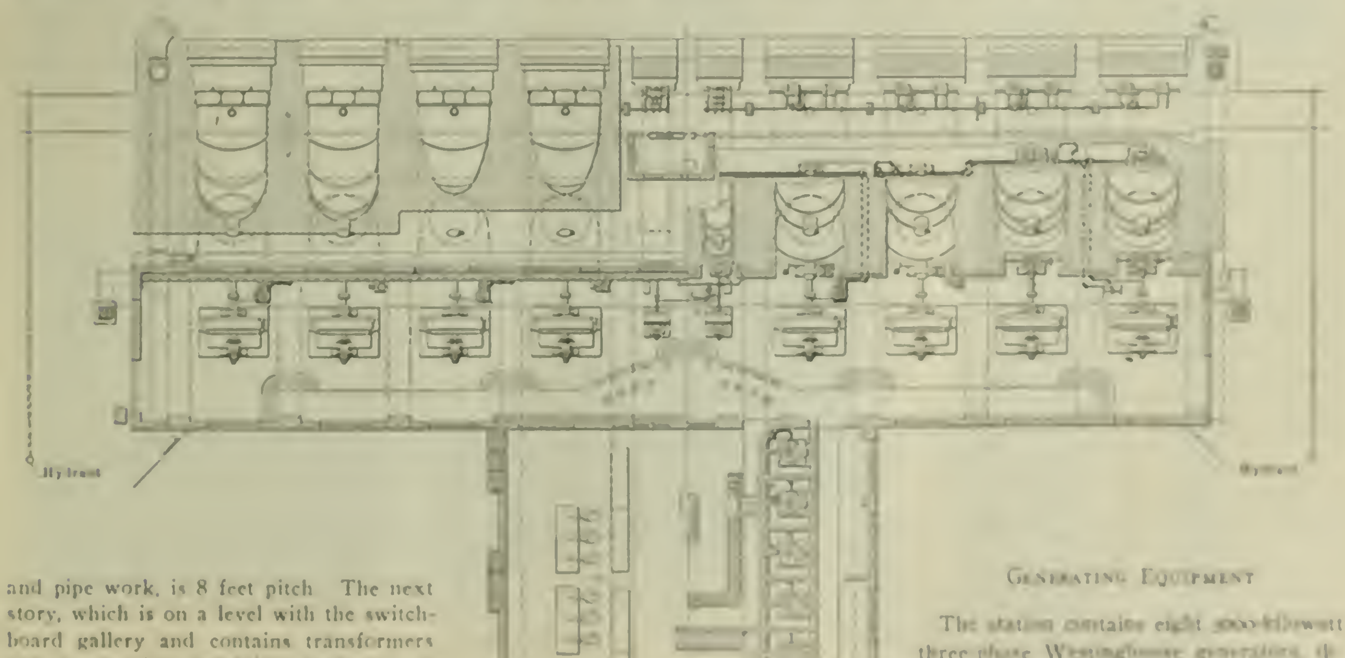


FIG. 4. PLAN OF GREAT FALLS STATION

Generating Equipment

The station contains eight 3000-kilowatt three-phase Westinghouse generators, direct-connected to six horizontal-shaft turbines of the Escher-Wyss pattern, built by the Allis-Chalmers Company, and two Hercules turbines of 5300 horsepower capacity each, built by the Holyoke Ma-

FIG. 5. THE ROCKY CREEK DAM DURING CONSTRUCTION

chine Company, with two 400-kilowatt, 250-volt exciters, each capable of carrying the total exciter load. The main generators were designed for an efficiency of 96 per cent. and to operate at full load at any voltage between 2200 and 2530, with 80 per cent. power factor, with a rise in temperature not to exceed 35 degrees Centigrade at any part. Tests have shown that the machines more than meet the specifications. They are driven at 225 revolutions per minute and deliver current at 60 cycles. Each two generators are connected in parallel through power-operated switches to a bank of three 2000-kilowatt step-up transformers connected in delta. This arrangement gives four complete 6000-kilowatt units capable

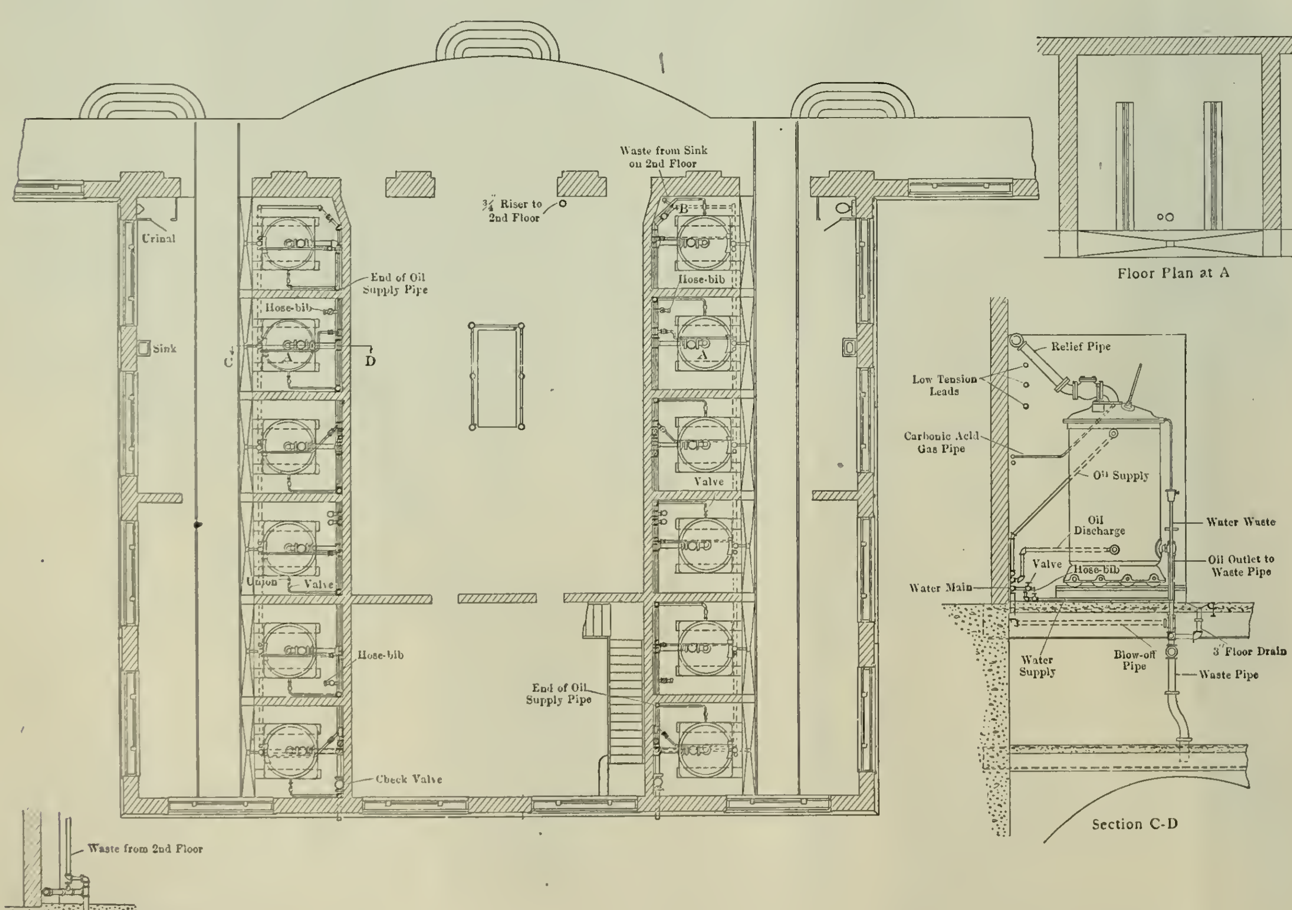


FIG. 6. PLAN OF TRANSFORMER ROOM AND ELEVATION OF TRANSFORMER-PIPE CONNECTIONS

of being run independently or in parallel, as may be found necessary.

The generators are controlled from pedestals standing in front of instrument posts, arranged in an arc of a circle to enable the operator to see all instruments without moving from one point. The advantage of the instrument posts and control pedestals in comparison with panel boards is that the operator can look over the pedestals and under the instruments at any machine which he is putting in service. On each of the eight instrument posts are mounted a 3000-volt voltmeter, a 1500-ampere ammeter, a 4500-kilowatt indicating wattmeter and a 400-ampere ammeter in the field circuit of the generator. On posts Nos. 1, 3, 6 and 8 are also mounted busbar voltmeters. To avoid confusion these are in a different type of case from the generator voltmeters. On posts Nos. 2 and 7 frequency meters are mounted and on posts Nos. 4 and 5 synchroscopes are mounted.

On the control pedestals are mounted the controllers for operating the oil switches, the hand wheels for operating the field rheostats, and the field switches; jacks used in calibrating instruments are also mounted on these pedestals.

Transformers, Switches, etc.

All transformers are oil-insulated and water cooled; they are located in separate fireproof compartments, as shown in Fig. 6, and mounted on trucks to facilitate handling. The tanks are made of heavy boiler plate which will stand 150 pounds pressure per square inch, and the tops are provided with check valves opening into a 6-inch pipe which leads to the tail water, to provide for any explosion which might take place due to the ignition of oil gas. The transformers are controlled from a standard blue Vermont marble board set in an archway between the control pedestals in the generating room and the low-tension switch room. For each bank of transformers the board carries an ammeter, a power-factor meter and an integrating watt-hour meter. In this archway are

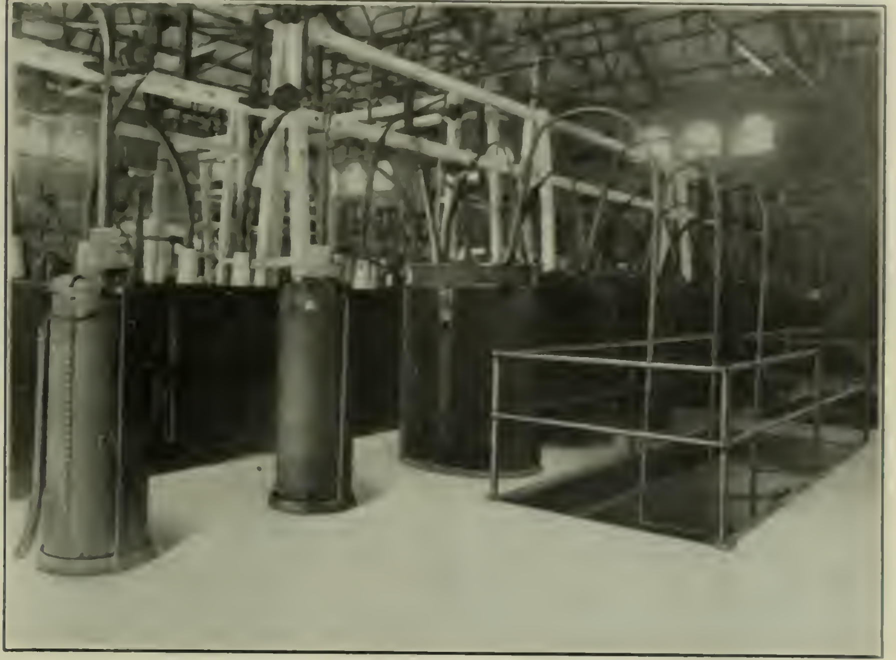


FIG. 8. VIEW IN HIGH-TENSION SWITCH ROOM

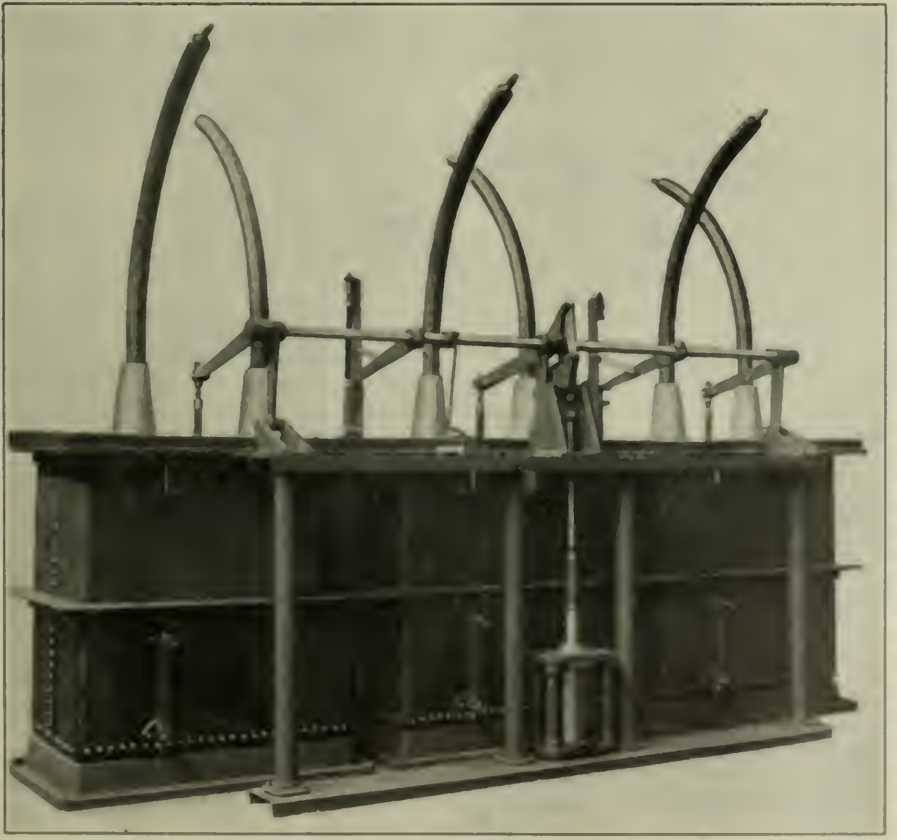


FIG. 7. SOLENOID-OPERATED OIL SWITCH

also set the panels for controlling the switches in the high-tension switch room. Ammeters only are used on the outgoing feeders.

The low tension switches and busbars are mounted in a concrete structure forming three sides of a rectangle in a separate room. The oil switches and circuit-breakers are each capable of breaking the entire output of the plant on short circuit; they are of the solenoid type, shown by Fig. 7, and operated with current from the exciter busbars.

The switchboard is located on a gallery raised above the power-house floor, but on a level with the transformer room and low-tension switch room. In the space below are the field rheostats, exciter busbars and control wires. This gallery is narrowed and extends in either direction to form a conduit for the cables between the generators and the transformers. These cables are laid on concrete shelves provided for the purpose, and are brought through floors and walls in vitrified conduit.

All the 44,000-volt apparatus is in an entirely separate room, occupying the third story of the transformer house. The high-tension switches are capable of breaking the entire output of the station on short circuit. The three poles of these switches are mounted in individual boiler-plate tanks sufficiently strong to resist any explosion that might be caused by opening the circuit during short-circuits on the high-tension line. The line and transformer switches are controlled from the panel board in an archway between the generator room and the low-tension switch room. All high-tension conductors in the buildings are made of insulated copper pipe.

Fig. 8 is a view in the high-tension switch room, and Fig. 9 is a schematic diagram of the main wiring and switching arrangements in the Great Falls and Rocky Creek stations, and this will be used also in the Ninety Nine Islands station when it is built. This illustrates clearly the banking of the transformers and generators into four equivalent units or "batteries."

The equipment at Rocky Creek is exactly the same as that at Great Falls, except as to the arrangement of the exciters. At Great Falls the two exciters are driven by individual water wheels. At Rocky Creek the two exciters and a 600-horsepower induction motor are set in line with the shaft of a single water wheel, and clutches are provided by means of which either the water wheel or the motor can be used to drive the exciters. Fig. 10 is a diagrammatic plan of the arrangement.

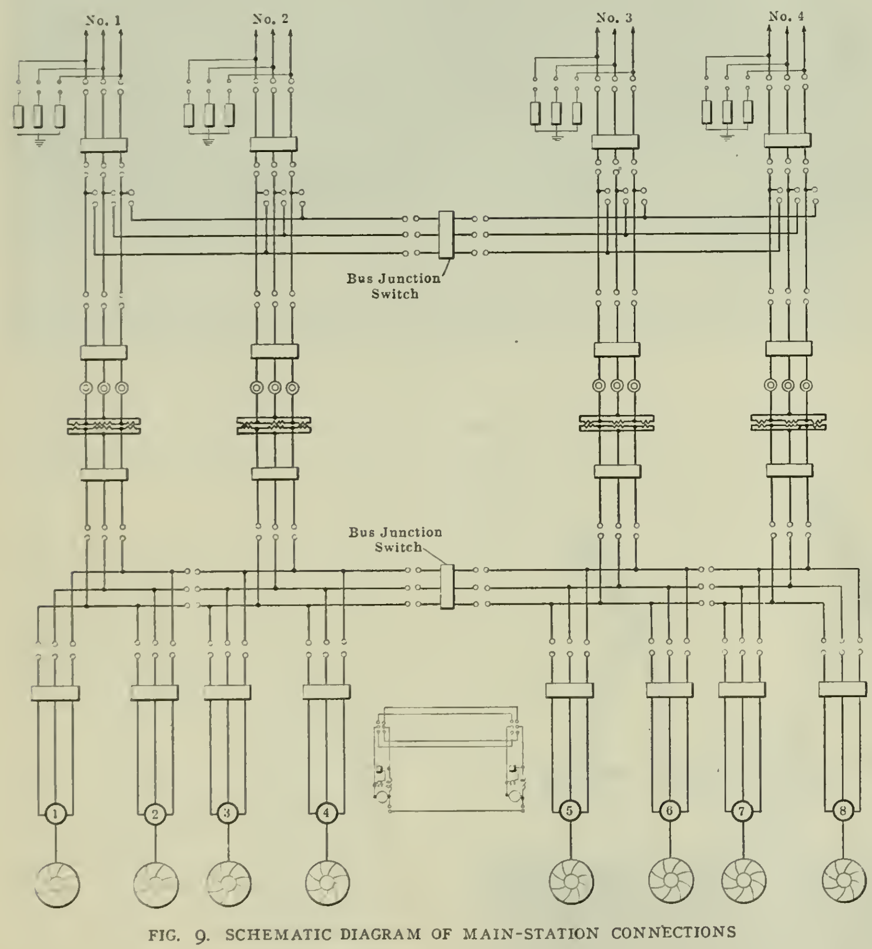


FIG. 9. SCHEMATIC DIAGRAM OF MAIN-STATION CONNECTIONS

The Catawba Station

The original station at Catawba contains four 750-kilowatt and four 900-kilowatt General Electric generators driven by Holyoke turbines and delivering three-phase currents at 13,000 volts to step-up transformers on the main 50,000-volt system. This station also supplies a separate system extending to Rock Hill, Pineville and other nearby towns, working at 10,000 volts at the receiving substations. This system takes current directly from the generator busbars. The Catawba power house serves also as a switching station for the 50,000-volt lines radiating northward from it, and is provided with facilities for connecting the short line to Rock Hill and other towns to the main system through step-down transformers. That is, the station contains three 2000-kilowatt delta-connected transformers with switches whereby they can be used to step up current from the generators and deliver to the main system, or to step down from the main system to the short line.

Transmission Lines and Connections

Fig. 11 is a map of the system, including lines under construction and those which it has been definitely decided to build. The double lines between the Great Falls district and the town of Concord, passing through the Catawba station, give some indication of the growth of the system, but even more significant than these are the double 100,000-volt lines now being built from Great Falls northward to Greensboro and westward to Greensville, S. C. These are transmission lines in the strict sense, while the 44,000-50,000-volt lines are really primary distribution feeders with respect to the general system. This is more clearly shown by Fig. 12, which is a diagram of the connections at all of the important stations and substations and also gives the distribution of power amongst the principal secondary stations.

At the generator end of each 100,000-volt line a 12,000-kilowatt group of two-to-one transformers connect these lines with the 50,000-volt busbars; at Salisbury, the two sets of lines will be tied together through a 9000-kilowatt group and at Spartanburg through a 6000-kilowatt group of two-to-one transformers. From Fig. 11 it is evident that each of the important points receives current from two or more directions; consequently, the supply cannot be cut off by trouble on any one feeder.

The main trunk line from Great Falls to Catawba station is 33 miles in length. It is carried on steel towers and consists of two three-phase circuits. Fig. 13 is a view of this line. Three sizes of tower are used, standing 35, 43 and 50 feet, respectively, from the lowest wire to the ground, as the nature of the country demands; 500-foot spans are used in general. The conductors are each built up of six strands of No. 6 copper, with a hemp center, equivalent to No. 000 Brown & Sharpe gage. Tests of this conductor gave a breaking strength of about 62,000 pounds per square inch for the individual strands, and about 58,000 pounds per square inch for the complete cable. The elastic limit was taken at 40,000 pounds, two-thirds of which gives 3330 pounds per conductor as the maximum working strain. To be on the safe side this was taken at 3000 pounds and the corresponding sag adopted, assuming a maximum change in temperature of 125 degrees Fahrenheit. After the lines were strung and before current was turned on they were subjected to a severe sleet storm and no breaks occurred.

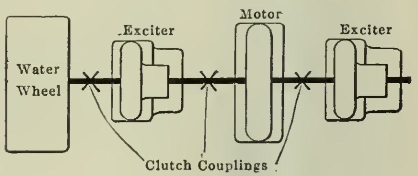


FIG. 10. ARRANGEMENT OF ROCKY CREEK EXCITERS

The trunk lines are sectionalized at points of transposition in order that in case of trouble on one line one section of the other may still be used and the remaining parts of both lines paralleled. The ordinary line towers are built of galvanized-steel angles with rod braces, and will withstand a total pull of 8000 pounds at the top. The sectionalizing and transposition towers are similar to the ones

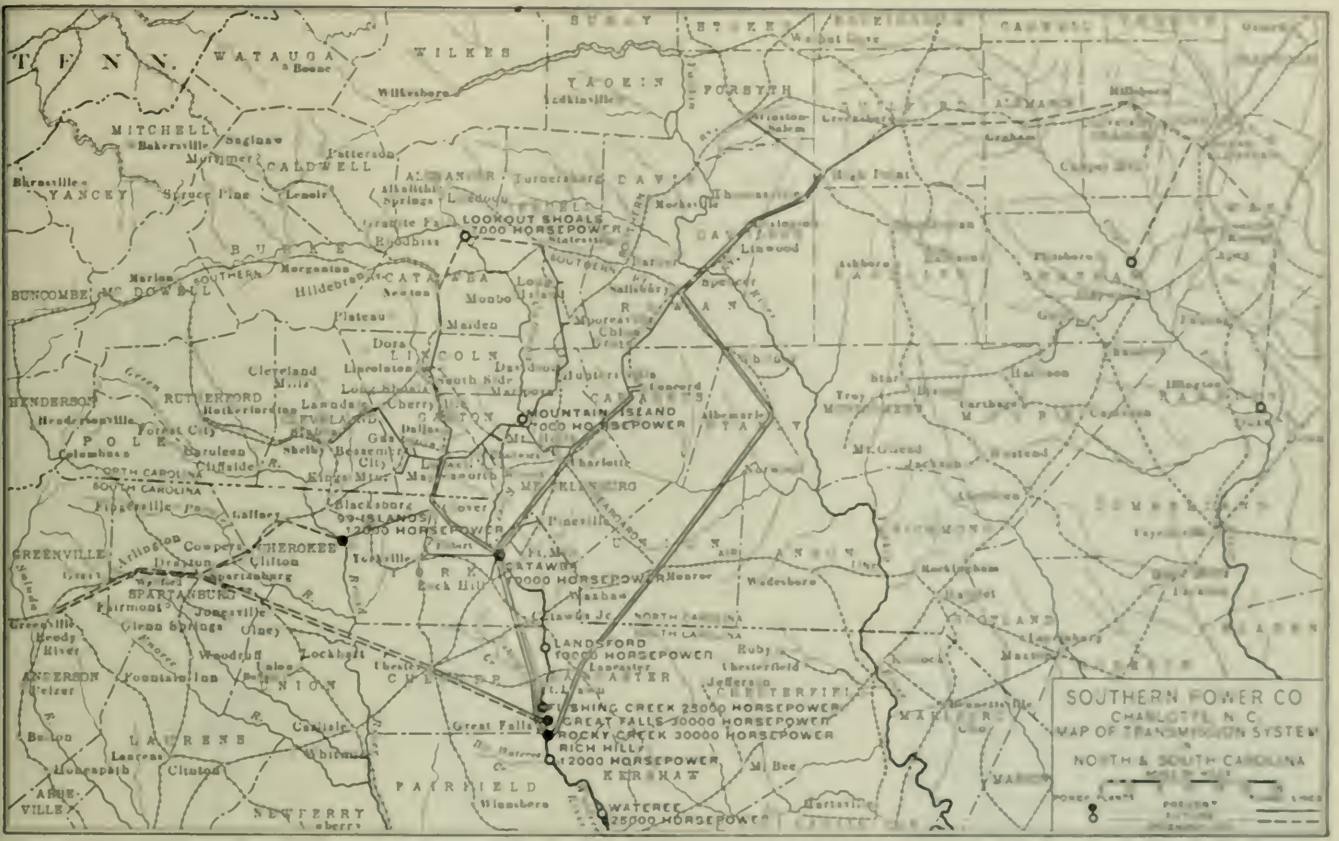


FIG. 11. MAP OF THE SOUTHERN POWER COMPANY'S TRANSMISSION SYSTEM

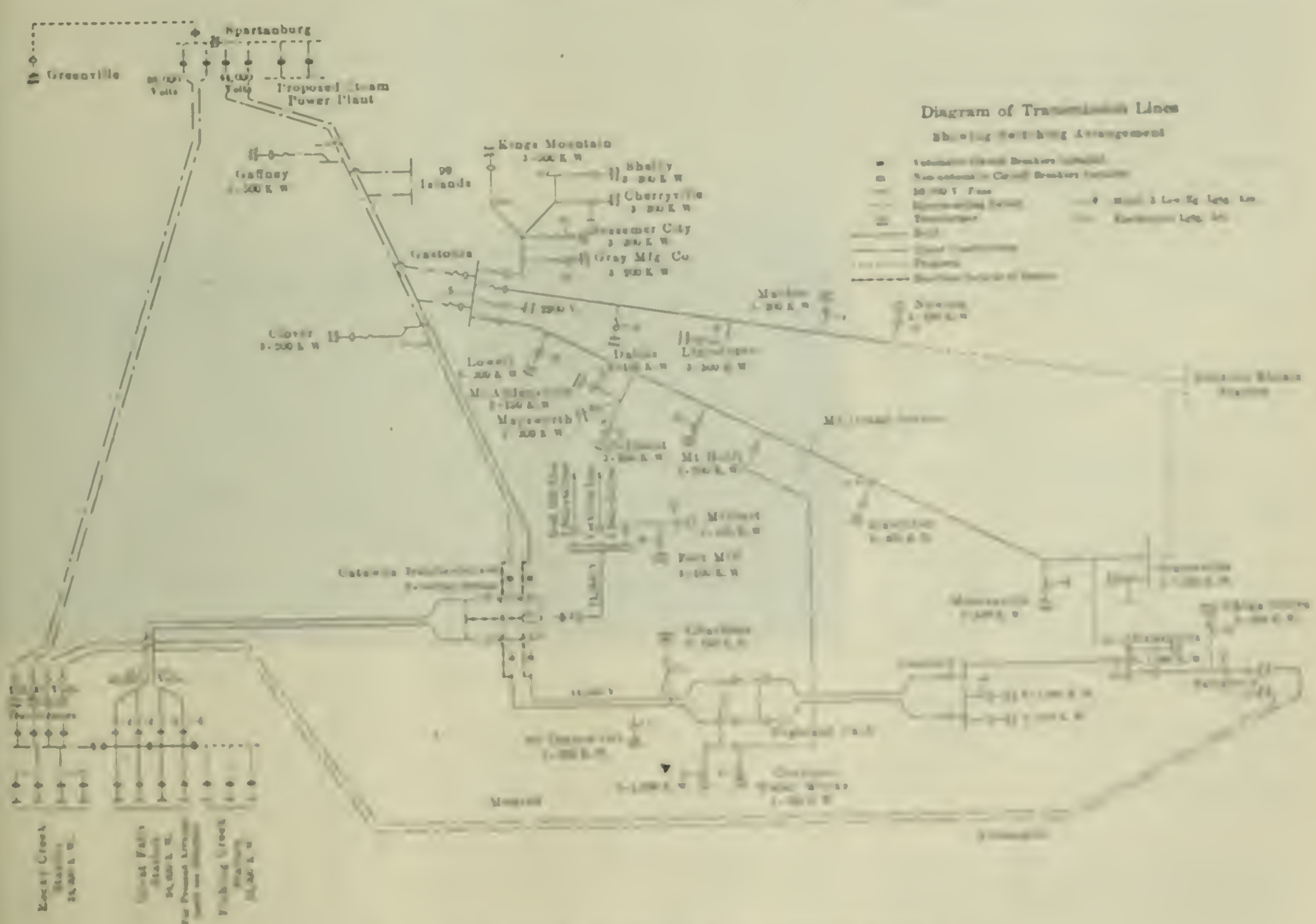


FIG. 12. DIAGRAM OF TRANSMISSION AND FEEDER CIRCUITS

used at angles greater than 30 degrees or for terminal or tap-off towers, except for the arrangement to which lines are connected. They were tested to 6000 pounds per conductor. The line between Catawba station and Gastonia, a distance of 25 miles, is carried on the same type of tower, though it consists of only one circuit of No. 00 Brown & Sharpe stranded copper at present.

The remaining 44,000-volt lines now completed or under construction are carried on 35-foot wood poles, 8 inches in diameter at the top, and spaced 150 feet apart. The cross-arms are 4¾ inches by 5¾ inches by 7 feet hard pine treated with hot carbolineum. The pins are iron and a special iron cap was designed to accommodate the top pin and to support a galvanized pipe, which in turn supports a grounded wire. An iron pin was also designed which has proved very satisfactory, not only with regard to convenience and strength, but also with regard to cost. The shank is cast and the pin head may either be cast or forged, according to strength required. These pins with cast heads were used on terminal towers and three of them proved amply strong. The bolt can be made any length and makes a very convenient method of fastening an insulator to a wall or wood beam. The heads are cemented in the insulators either at the factory or before insulators are taken out of the shipping crates.

On account of using towers that would not withstand the strain of a broken wire, a tie-clamp had to be designed that would allow the wire to slip through in case of emergency. The clamp is made of cold-pressed steel, galvanized, and will allow the conductor to slip at about 350 pounds pull. In other words, the strain will be distributed amongst ten towers, leaving an ample margin for wind pressure. This clamp costs less than an ordinary tie-wire.

The line insulators were specially designed to meet the views of the company's engineers and were mostly made by the R. Thomas and Sons Company. Those on the 44,000-50,000-volt lines are of the construction shown by Fig. 14. They will arc over at approximately 88,000 volts under a precipitation test of ¼ inch of water per minute at a pressure of 50 pounds per square inch from a sprinkler nozzle played on the insulator at an angle of 30 degrees above the horizontal. They were all subjected to a dry test of 120,000 volts for ten minutes. The insulators used on the 88,000-100,000-volt lines are of the suspension double-petticoated type 14 inches in diameter.

Substation Equipment

The substation transformers were all purchased under one specification in order that they could be changed from one point to another in case of a burnout, or in case the output became too large for the size of the transformer. They are capable of carrying full load continuously at 5 per cent. above and 10 per cent. below the rated voltage, taps being provided for these voltages on the high-tension side.

In the small transformer substations the cost of automatic high-tension switches such as are used at the generating stations would be excessive and a comparatively cheap oil switch, with the poles mounted separately in brick cells, and equipped with expulsion fuses (of type similar to what is known as the "T. D." fuse made by the General Electric Company) is used. Before the adoption of these fuses they were tested on short-circuit on lines of large capacity and proved very satisfactory. It is hoped that these fuses will prove more satisfactory than the automatic switch in that the series transformers necessary for the circuit-breaker, which has been such a source of trouble in lightning storms, are now not necessary.

Lightning Protection

An equal number of General Electric multiple-unit and Westinghouse low-equivalent lightning arresters, together with horn arresters, have been used in the main and substations, and an electrolytic lightning arrester is now being installed for comparison with the arresters of the older type. In addition to the lightning arresters, grounded wires are strung over all transmission lines. On the twin steel line towers two grounded wires are used, and on the pole line one 9/32 galvanized S. M. strand. Each pole is grounded by attaching to the side thereof a galvanized plate 12 inches

FIG. 13. TRUNK LINES BETWEEN GREAT FALLS AND CATAWBA

square of No. 20 metal. This plate is connected with the overhead wire by means of a No. 8 iron wire. The effectiveness of this grounded wire has been questioned, but the company's experience on the old lines has shown that it is well worth the money spent on it.

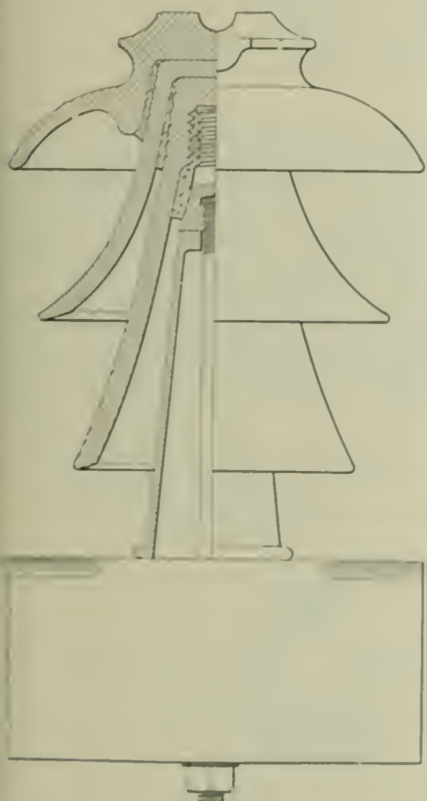


FIG. 14 INSULATOR USED ON 50,000-VOLT LINES

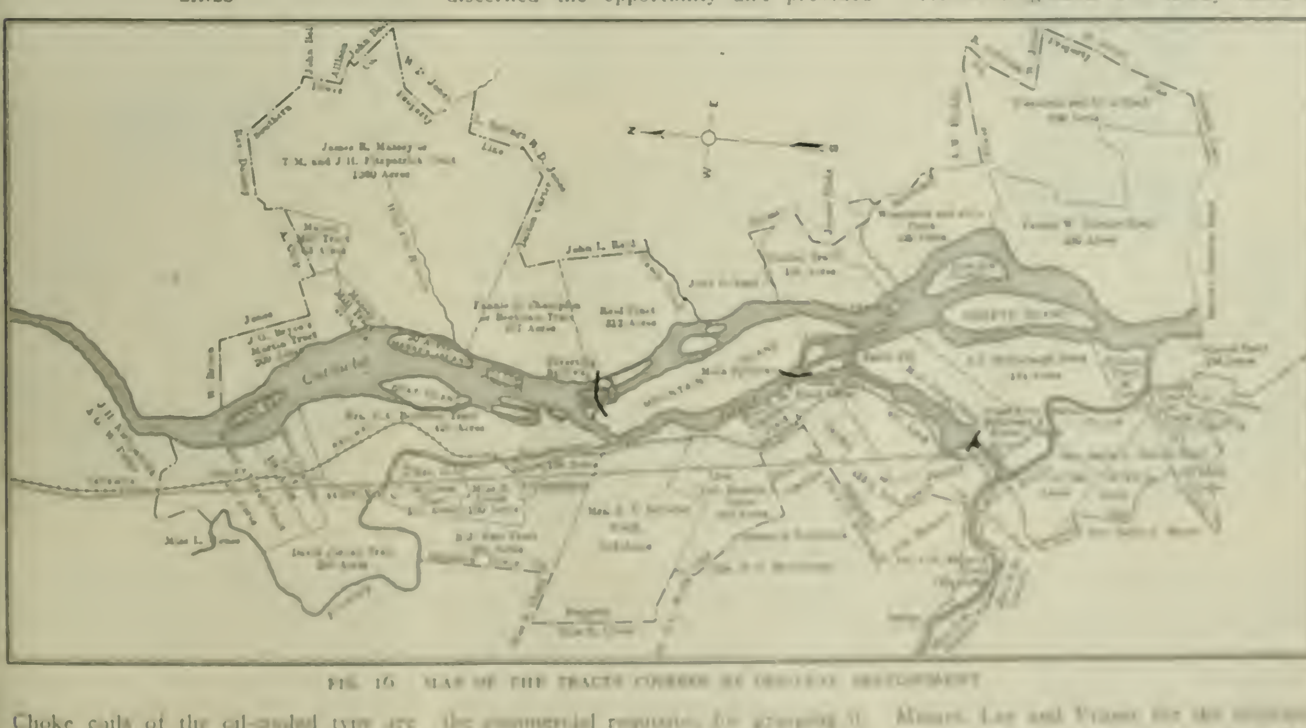


FIG. 16 MAP OF THE TRACTS COVERED BY [illegible] DEVELOPMENT

Choke coils of the oil-cooled type are used at the generating stations. The impendance drop in these is about 1 per cent. of the line voltage and the resistance loss about 1800 watts when the transformer bank is carrying normal full load current. Smaller choke coils of air-cooled type are used in substations.

In General

As the load on the system is constantly increasing and changing in distribution characteristics, any specific statement concerning it would be out of date by the time this article actually appears in print. It is of interest to note, however, that on November 1, more than one hundred cotton mills were operated by current from the system; all of the street lighting in Charlotte, Salisbury, Concord, Statesville, Lincolnton and some twenty smaller towns was being done by it, and countless small factories and industrial plants depend on it for their motive power. In the cities and towns where general lighting and power service is supplied, the current is stepped down to 2300 volts for distribution by the local primary network. In most of these places the Southern Power Company merely sells power "in bulk," so to speak, to local companies who formerly operated central-station plants; the prime movers in most of these plants have been discarded, and the station equipment restricted to transformers and series-circuit regulators, reducing the problem of attendance to a state of beautiful simplicity. In many of the towns, however, the power company maintains its own substations and deals directly with the consumers.

The success and rapid progress of the company was primarily due to two men—Dr. W. Gill Wylie, the president, whose foresight, energy, and financial ability discerned the opportunity and provided the commercial resources for carrying it and W. S. Lee, Jr., chief engineer, whose sound engineering judgment and executive ability are responsible for the working out of the details and the technical application of Dr. Wylie's industrial scheme. During the past four years Mr. Lee has had an invaluable assistant in J. W. Fraser, who has practically the entire responsibility for the mechanical and electrical portions of the work. Since Mr. Fraser's advent, in the spring of 1904, Mr. Lee has confined his attention to the

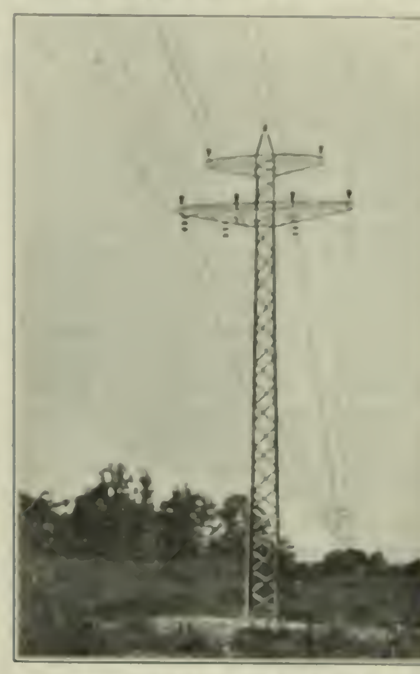


FIG. 15 TOWER USED FOR LINES IN CITIES

practical construction work—the executive side of the engineering department. During this period the load carried has increased from 300 horsepower to 50,000 horsepower for ten hours.

Acknowledgments are hereby made to Messrs. Lee and Fraser for the information presented in this article and to Mr. Fraser for his cheerful cooperation in the preparation of it, as well as for several drawings and photographs made especially to illustrate the description here.

The Use and Abuse of Globe Valves

Plain Descriptions of the Principal Features of the Different Types, with Practical Suggestions for the Guidance of Engineers

BY W. H. WAKEMAN

The ordinary globe valve is a mechanical monstrosity, illogical and crude when viewed as a machine, but owing to its convenience of operation and low cost of repairs it has gained well deserved popularity among engineers and steam users. A few suggestions concerning its proper use, and in disapproval of the abuse to which it is often subjected, ought to prove profitable to all concerned.

Fig. 1 illustrates the first thing that I do to one of these valves when it is to be used in my plant. A stout bench, well braced from the ceiling to hold it down firmly, is shown at *A*, on which there is a pipe vise *B*. A short piece of pipe of a size suited to the valve is clamped in this vise, and the valve is screwed on it. A large monkey wrench is fitted to the bonnet, and a quick, strong pull on the handle loosens the screw and removes the bonnet without further trouble under ordinary conditions. The reason for using a large wrench for this job is because a small one is much more liable to spring and round off the corners without loosening the bonnet.

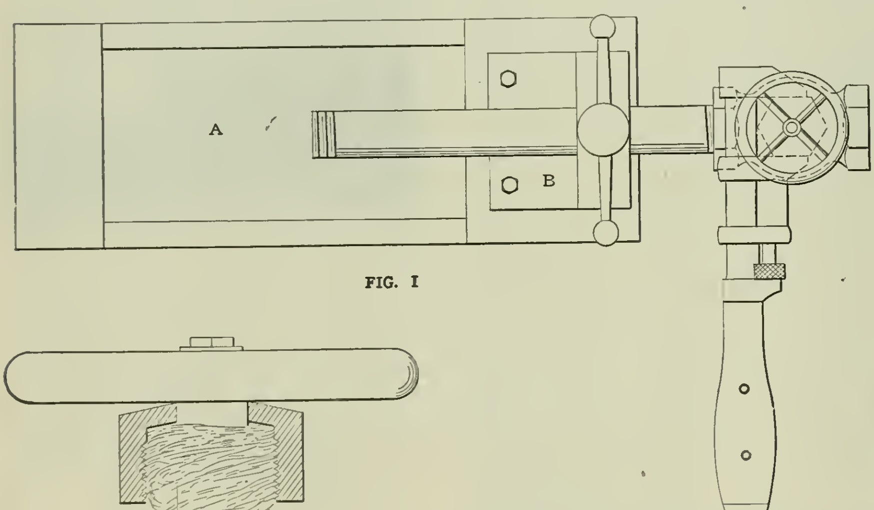


FIG. I

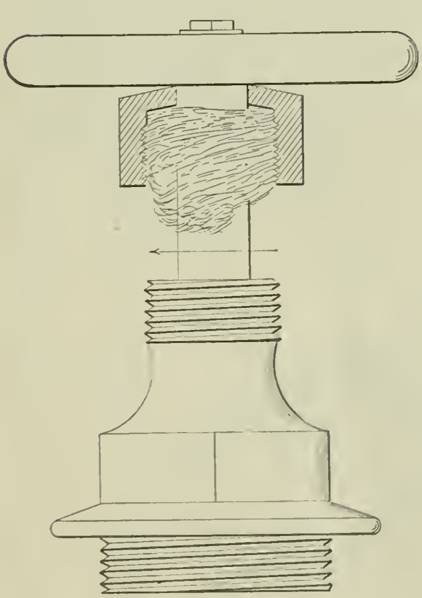


FIG. 2

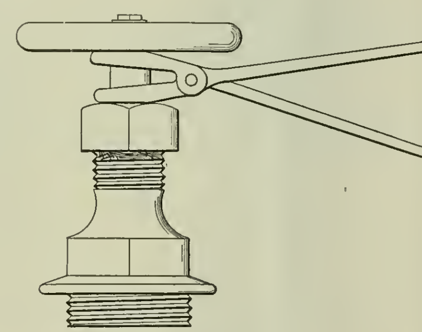


FIG. 3

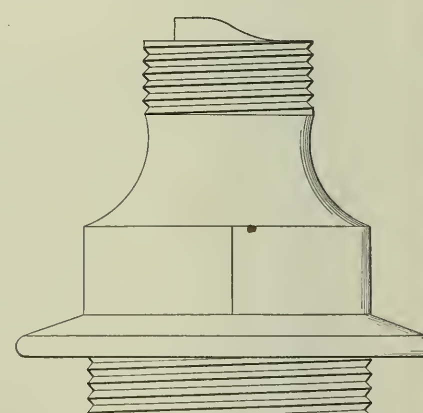


FIG. 4

The reason for removing the bonnet at this time is owing to the assumption that it was screwed on very tightly when first assembled; therefore, if not loosened before it is subjected to the action of steam, it will be almost impossible to take it off when it must be repaired in order to stop a leak at this point. If it is replaced and brought to its proper seat by reasonable pressure on the wrench handle, it will be steam- and water-tight, and later it can be removed without serious injury. The use of lead or anything else on these threads is not recommended, for whatever is applied will prove detrimental when the bonnet is again removed after long service. When considering this point it is well to remember that the joint is not made in the threads (like a pipe joint), but where the two flat surfaces come together and are held in close contact by the threads.

The next move is to unscrew the packing nut, remove whatever packing may be there, and fill the nut as nearly full as possible with asbestos wicking, either oiled or coated with graphite, according to the conditions under which the valve is to be used. It is surprising to note the indifferent way in which engineers sometimes pack these valves. A short piece of packing is put in and the nut is screwed down as far as it will go, which means that nearly all of the threads on the bonnet are covered. If this prevents the escape of steam it is considered sufficient. When it does begin to leak, a wrench is applied and a hard pull brings it around perhaps one-quarter of a turn, but it will go no farther, and steam still blows out; consequently, pressure is removed from the pipe line, the nut is taken off, more packing is added (without removing the old material) and the nut is screwed on. The result is the same as before, but the process is repeated indefinitely, as the unsatisfactory results obtained do not suggest an improved method.

A better plan is to press the packing tightly into the nut with a packing hook, or other suitable tool, and wind it around the stem until it appears as shown in Fig. 2. The end of this packing is left so as to show the direction in which it should be wound, because the nut is turned as indicated by the arrow, in consequence of which action the packing will be smoothly prêssed into plâce, whereas if it were wound in the opposite direction, turning the nut would unwind the packing and prevent smooth action. It ought to be wound around the stem in the opposite direction from that in which the nut is turned when screwing it on the bonnet.

FIG. 5

Having thus filled the nut, it is pressed down until a pair of packing pliers can be inserted between the nut and the wheel, as illustrated in Fig. 3. These pliers are designed to open when pressure is applied to the handles (instead of closing in the usual way); consequently, the nut is forced down until it begins to screw on the bonnet, when a wrench is applied to it. Usually it can be turned until the packing is compressed into about one-half of the nut, then it ought to be unscrewed and another ring or two of packing put in.

This calls attention to the form adopted for the top of the bonnet on which the packing rests. Originally it was a plain, flat surface, and this is better than any other kind for the following reason: When the packing nut (or waste nut, as it is technically called) is unscrewed as described, the packing remains in it; therefore, more can easily be added until the desired amount is secured. If anything prevents free movement of the packing, it is pulled out of the nut and it must be replaced, but it is then loose and requires force to make it compact, as when it was first put in.

Fig. 4 illustrates a device that appeared on a certain kind of globe valve a few years ago, but it is not used much at present. The tapering side of it is presented to the packing when the nut is screwed on, but any movement in the opposite direction is opposed by the square edge which effectually pulls out the packing. About the first thing that I did with a valve of this kind was to take a flat file with a safe edge and file off these objectionable projections, leaving the top flat and smooth.

Another Device for Holding Packing

Fig. 5 represents another device for holding packing, consisting of a depression in the top of the bonnet next to the valve stem. This is of hexagon form, and when packing is forced into it by screwing down the nut, it cannot turn easily. To overcome what is an objectionable feature from my point of view, I put one ring into this depression and make it independent of the remainder of the packing used; therefore, after it has been forced downward into place, the top of the bonnet is smooth and practically flat. Valves of this kind that I have recently purchased contain a ring of fibrous packing nicely fitted to and forced into this cavity, thus leaving the top perfectly free from obstruction. This is an excellent idea, because it gives the engineer a chance to

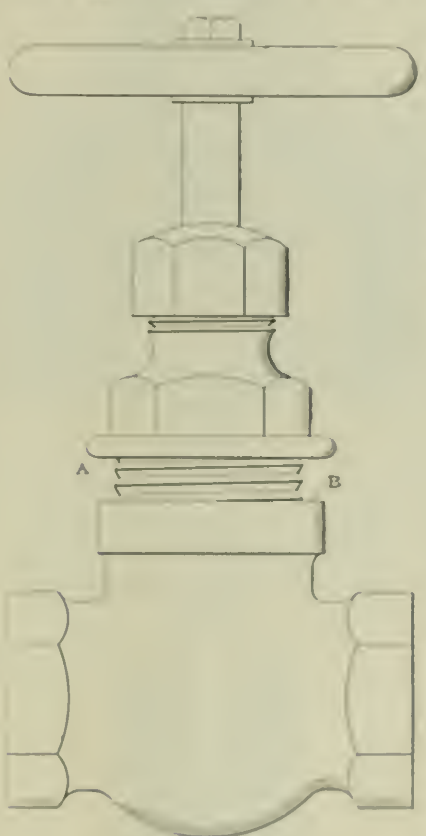


FIG. 6

choose which he will use. If this ring is not taken out he has a plain top on the bonnet, but if removed it leaves the hexagon cavity to prevent the packing from turning.

The object of the features shown in Figs. 4 and 5 is to prevent the nut from unscrewing when the valve is opened, but this very seldom happens in my plant, and there is no good reason why it should in others. If the packing is lubricated and the nut screwed down as it ought to be, no other precautions need be taken to hold the packing from turning. This refers to ordinary globe valves. There should always be enough in the stuffing box or nut to allow for screwing it down another revolution or turn, if it leaks after being in use for several weeks.

When the bonnet of a valve that has been used more or less is removed for any purpose, the surfaces at *A* and *B*, Fig. 6, ought to be thoroughly cleaned, then they will come together, metal to metal, when the bonnet is replaced. If there is a slight leak at this point when full pressure is on the valve, the only safe plan is to remove all pressure, take off the bonnet, clean the surfaces as described, and screw the bonnet on again, using force enough to secure perfect contact at all points. It is dangerous to force it down farther with full pressure on, as the leak may be due to a defect which careless usage will develop into a rupture, allowing steam or hot water to escape. Many accidents have resulted from poor management along this line.

Fig. 7 is a valve that is not always satisfactory, at least in my experience; therefore, it is never used in an important place. It is all brass, with a beveled seat and a disk that adjusts itself to the seat. This disk can easily be taken from the stem and, by fitting a wooden handle onto it, there is what may be termed "a fighting chance" for regrinding it and thus repairing a leak; but as there is no provision made for grinding the disk, the operation

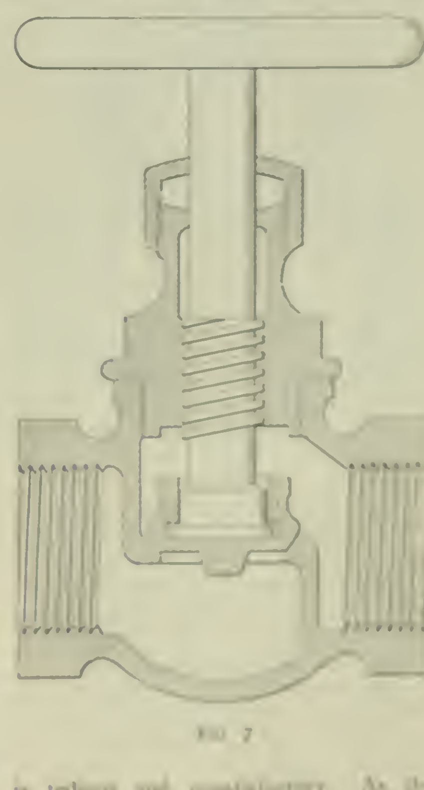


FIG. 7

is tedious and unsatisfactory. As the manufacturers of these valves are not willing to put their names or trademarks on them, it is assumed that they are not guaranteed.

The disk shown in Fig. 8 is loose on the stem in ordinary use, but provision is made for fastening it when it leaks enough to make regrinding necessary. The guide near the lower end of this stem is held in the position shown by a screw, but when a screwdriver is inserted in the slot and it is given a turn backward, the lug on the lower side of this guide drops into the slot in the disk, where it is fastened by tightening the screw. Of course, it was necessary to remove the bonnet before the screw could be loosened, and by bringing it to the position illustrated the stem and disk can be freely turned for the purpose of regrinding the worn surfaces. As the body of this valve is fitted with an external thread and the bonnet is threaded internally, these threads are not subjected to the direct action of steam, because the joint is made by the surfaces *A* and *B* joining perfectly when the bonnet is screwed into place.

Fig. 9 is another all-metal valve which can be reground at pleasure. The bonnet is removed in the ordinary way, and the disk is then taken off from the stem. A temporary holder is inserted in the disk, then by means of a carpenter's brace the disk can be turned until the regrinding process is complete.

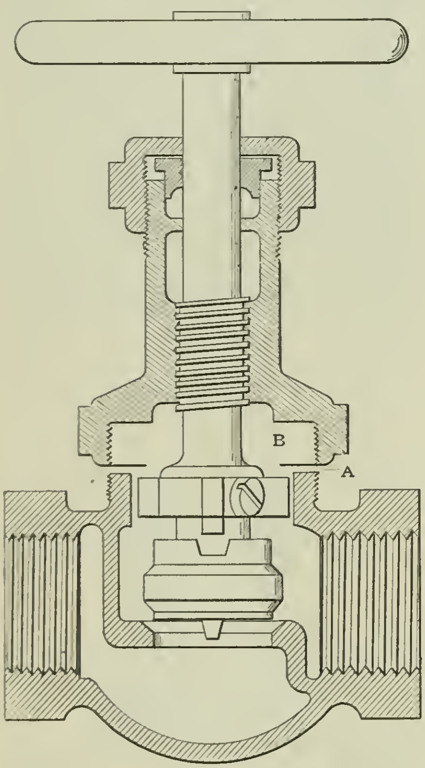


FIG. 8

Special attention is called to the guide forming part of the disk, as it insures true surfaces when efforts are made to eliminate leaks.

Some Peculiar Features

Fig. 10 has peculiar features which are worthy of attention. The bonnet is secured to the body by an internally threaded ring *A*, which resembles a union connection. By unscrewing this ring the trimmings, or, in other words, the entire upper part of the valve can be removed, leaving the body only in place. The disk is now loose on the stem, but by inserting a small wire nail in the hole shown in the former and passing it through a corresponding hole in the latter, as shown in the illustration, the disk is caused to turn with the stem; consequently, the bonnet can be replaced temporarily without screwing the ring down tight, thus forming a guide for the stem, which is turned by the wheel until a perfect joint is secured. It is better to give this wheel not more than one-half revolution and then reverse the motion than always to turn it in one direction, as the grinding material seems to do better work under these conditions. Care must be taken to remove the wire nail and thoroughly clean the internal parts before the trimmings are permanently replaced. When the seat of this valve is badly worn, it can be taken out and a new one inserted.

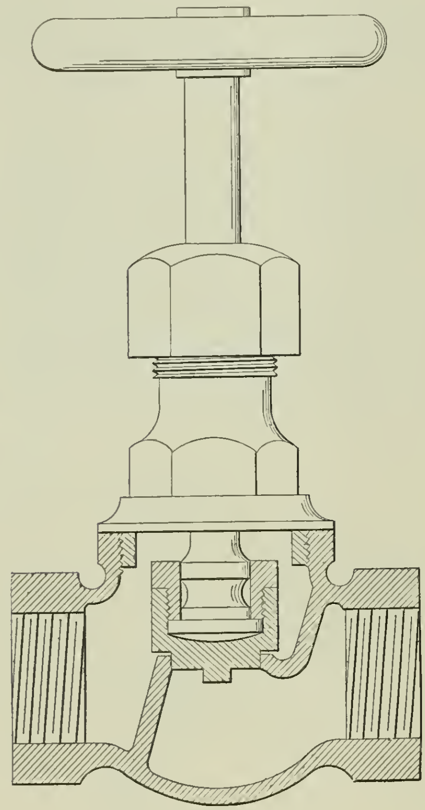


FIG. 9

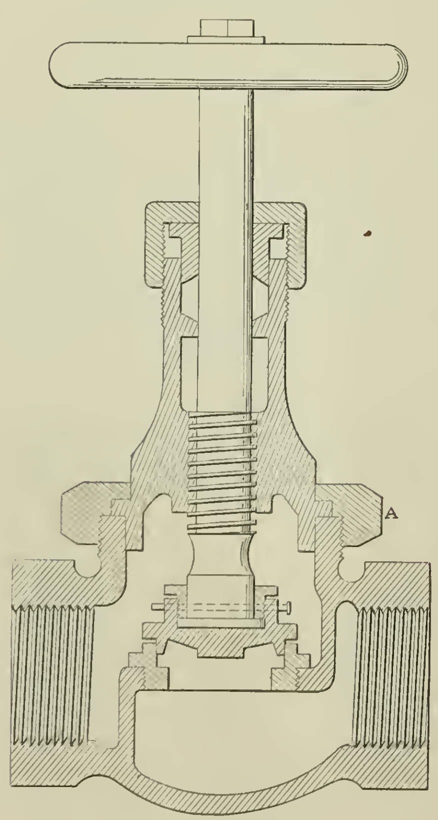


FIG. 10

As this valve is quite different from those previously shown, an external view of it is presented in Fig. 11.

Fig. 12 is fitted with a removable disk holder which cannot come off the stem while in use, but when it is worn out the bonnet is taken off in the usual way, and the stem screwed down as far as it will go, bringing the disk holder clear of the bonnet, thus allowing it to be removed without the use of tools of any kind. A new holder containing a hard-rubber disk is substituted, the stem drawn up and the trimmings put back on the body. Another kind of valve is designed to embody the same principle, but the disk is packed with asbestos which is forced into place under great pressure. Because asbestos is not affected by heat, acids, or oils, these disks should prove durable.

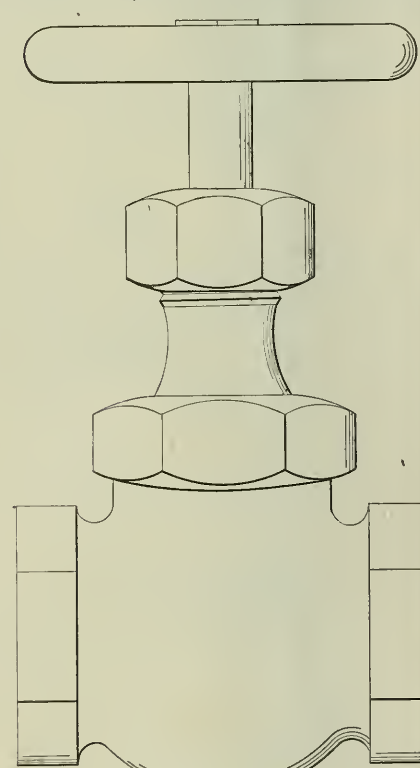


FIG. 11

Fig. 13 is an all-brass valve, except the disk, which is made of copper. The holder is retained on the stem by a slender nut and the disk is kept in the holder by another nut. When this valve is closed, only the round edge of this disk is in contact with the seat; therefore, it forms a tight joint with comparatively light pressure of the stem. This disk will prove durable when used on lines that carry high-pressure superheated steam. It is possible for this nut to become loosened and finally be turned off by the action of steam passing it swiftly, especially when water is mixed with the steam, which is a condition frequently found in practice during the first few seconds after the valve is opened, and it may exist at other times. To prevent this, put two prick-punch marks in the thread after the nut is screwed firmly into place. These will hold the nut while in service, but will not prevent it from being turned off with a

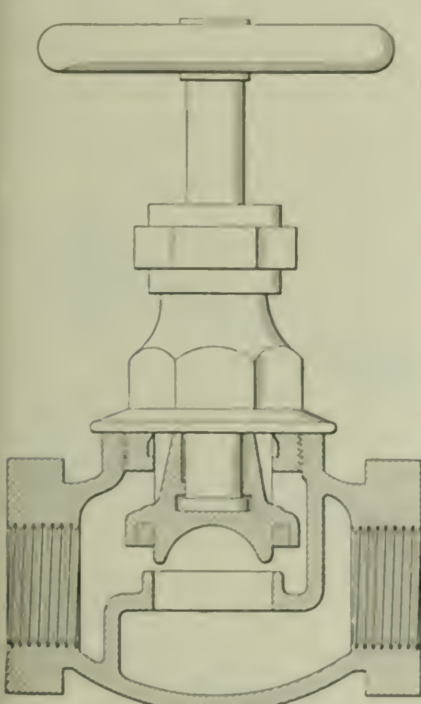


FIG. 12

wrench when a new disk is to be put on.

Fig. 14 shows a brass globe valve fitted with a hard-rubber disk that can be removed at pleasure, as it is held in place by a nut. If the disk does not come out easily with the nut off, hold it in the flame of a gas jet for about one minute. The heat will soften the composition and may be pried out with a small chisel, or a packing hook.

Under common conditions this disk will make a tight joint with no trouble, and will last for a long time. When worn out it can be removed at small expense and with slight trouble. If it lasts only a few days on a steam-pipe line, the pressure is probably too high for that particular kind of disk. Order one that was made to withstand high pressure, and if that fails get one made of babbitt metal. If that does not prove satisfactory, secure a brass disk and grind it to a perfect fit on the seat, as if it were designed for regrinding.

While these valves are used extensively, there are many engineers who do not understand their design and operation.

Shape of Disk Important

Another point to be considered is the shape of the disk, for although the ex-

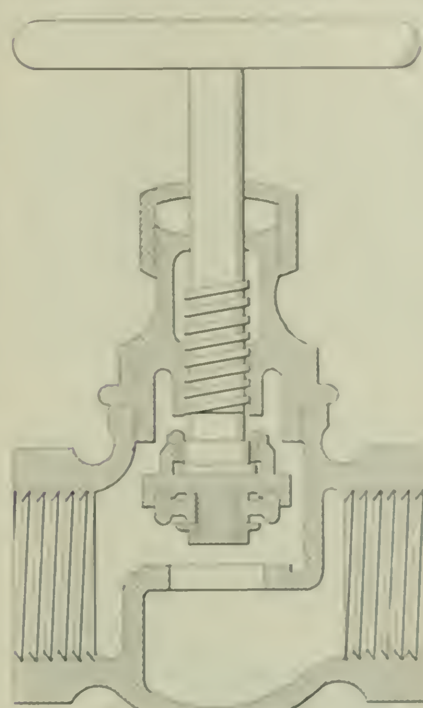


FIG. 13

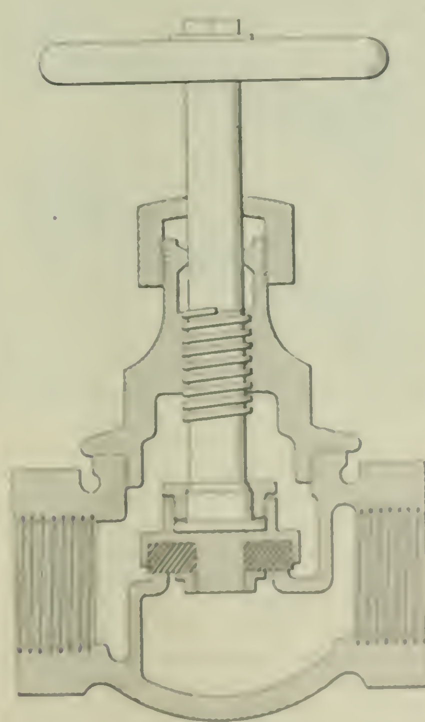


FIG. 14

ternal form is round, it does not necessarily follow that it is the same internally. Fig. 15 illustrates a very common design, the object of which is as follows: The nut projects into the disk and corresponds to it, hence one cannot be turned without moving the other. This is a good feature, because the disk becomes fastened to its seat by the action of steam and holds the nut and prevents it from turning off while in use. When the disk is worn out, and a wrench is applied to the nut, the disk must turn also, so no further trouble is found in removing the old disk, provided the wrench can be made to hold on the nut.

As a general rule the corners are spoiled by the operation. The wrench slips off, and both nut and disk stay where they were until a Stillson wrench is applied; as the teeth sink into the metal, it cannot slip, but the nut is disfigured or perhaps spoiled by the operation. On this account it is better to file out the flat spots and leave the internal surface a true circle. Thus there is a much better chance of unscrewing the nut without injury, and there is really but little danger of losing it in service if it is fastened according to the

FIG. 15

suggestions made in connection with Fig. 13. The advantage of having these disks made as shown in Fig. 15 is that the engineer may use them in this condition or not according to the results of his experience and observation in the matter, but if they were made round internally it would be impracticable to add the flat spots afterward.

Fig. 16 is a globe-valve stem with disk holder and fixtures complete. It has nine full threads which are sufficient to hold any pressure that other parts can withstand, but when the valve to which this stem belongs is closed, only a part of them will be meshed into the threads in the bonnet, while the remainder are not in a position to hold anything. A valve that I have just examined has ten threads, but only four are in service when the valve is closed, and in others there may not be more than two. Assuming that it is connected so that pressure acts on the under side of the disk when closed, the maximum stress is on the threads at this time; therefore, one-half of them ought to be where they can assist in holding the disk to its seat.

A globe valve was located with its stem in a horizontal position. After being used for several years the disk holder was quite loose on the stem, and although the seat and disk were in good order, the valve leaked continually. When lost motion at this point was reduced to a very small amount (leaving only enough for correct operation of the valve), by filing the back of the holder until the nut which screws

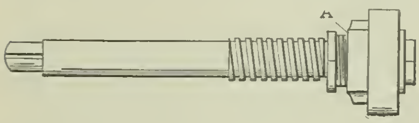


FIG. 16

into it at this point could be turned in almost far enough to grip the stem (see *A*, Fig. 16), the valve was tight when closed. The philosophy of this action is as follows: Lost motion allowed the top of the disk to strike the seat first, and further action of the screw was not sufficient to make it bear evenly; consequently it leaked. When this unnecessary lost motion was taken up, the disk rested against the seat squarely and made a tight joint.

The manufacturers of many of the globe valves now in the market claim that when they are opened wide it is possible to pack them at pleasure. This is undoubtedly correct when applied to the valves actually guaranteed, but it is not wise to apply it to all valves found in a steam plant without knowing their design. To test a valve for this feature, open it wide, apply the packing pliers illustrated in Fig. 3 and cautiously unscrew the packing nut. If steam escapes it shows that this valve cannot be packed under pressure, but the nut can be forced down into its proper place by the pliers, and the application of a wrench will soon stop the leak of steam. Let the matter rest until pressure can be removed from the line, then pack the valve in a workmanlike manner.

The Oppressiveness of Erudition

"The trouble with me is that I know too darn much," drawled the puzzle editor as the chief passed his desk.

"How so?"

"Didn't you ever notice that the less a man knows about a thing the quicker he can give you an answer about it? For instance, here is a fellow who wants to know what is the difference between the gage pressure and the absolute pressure. I was on the point of telling him 15 pounds. If your gage pressure is 75 pounds, the absolute pressure is $75 + 15 = 90$ pounds. That is good enough for most cases, and more exact than men ordinarily read gages or than gages usually are, but I happened to think that that fellow may use Kent's table, where the gage pressures are all given with an 0.3 after them and the gage pressure corresponding with 90 absolute is 75.3. So I start in to tell him to add 14.7 to the gage pressure to get the absolute, and then it struck me that this is only right if the pressure of the atmosphere is 14.7 pounds, and if it happens to be so it is an accident. I can tell him to add the pressure of the atmosphere to his gage pressure, but how is he going to get the pressure of the atmosphere? If he takes it by the barometer, it will be right for that place and time, but may not be right for another place or another time or for the case that he is working on. And then he gets it in inches of mercury and he has to use it in pounds per square inch. No two authorities agree as to the weight of a cubic inch of mercury and it is dollars to doughnuts that he wouldn't have pure mercury in his barometer, and the weight per cubic inch varies with the temperature, which he would not know, and then again a cubic inch of pure mercury at the same temperature weighs less at the equator than it does at the poles on account of the centrifugal force, so that the latitude comes in. Gee, I could write a book about it. If I only knew half as much my work would be twice as easy."

Steam Boiler Water Gages

By H. A. Jahnke

The writer has noticed quite often that the water gage and try cocks on a boiler do not receive the attention they should get. A great many firemen, and some engineers who do their own firing, blow the dirty water out of the water column and gage glass perhaps once or twice a week, which is bad practice.

The water column and gage glass should be blown out three or four times a day, or as often as is necessary to keep the water-column and gage-glass connections free from mud and scale. If there are valves in the water-column connections the steam valve should be closed and the valve in the water connection and drain valves on the bottom of the water column opened for a short time, in order to blow out of the lower connection all obstruction which may have lodged there. Then the valve in the lower connection should be closed and the valve in the top connection opened for awhile, after which the drain valve should be closed and the valves in both connections opened wide.

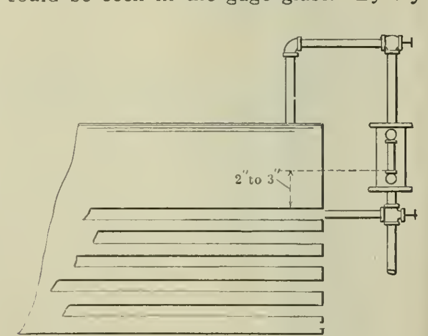
Water columns and gage glasses are often connected up in such a way that as soon as there is no water shown in the gage glass the top row of tubes in a horizontal return-tubular boiler are dry. The proper way to arrange the water column and gage glass is to locate the gage glass fairly high, then as long as water shows in the glass there will be at least 2 to 3 inches over the top row of tubes, as shown in the accompanying sketch.

It is a good plan, when an engineer takes charge of a new plant, for him to find out at the first opportunity how the water column and gage glass are set, in order to determine at what point it is safe to carry the water and to fix the low and high points. He should also find out what condition the water-column connections are in and know if they are clear of obstructions.

Some Causes of Gage Glasses Breaking

Gage glasses often break because the water-gage valves are not in line with each other and when the packing nuts are screwed up tight they bind the glass, causing it to break. The hole in the packing nut may be too small for the diameter of the glass and prevent the glass from expanding. When it gets hot, the hole should be enlarged a little with a file. Air striking the glass in cold weather when a door or window is opened will cause unequal expansion of the glass, which will break it. Where the cold air cannot be prevented I have found that the "Gilbert" gage-glass ring is a good thing to use for the packing nuts of the gage glass.

If the packing rings of a gage glass are in use for a long time they get too hard and there is no cushion to prevent the strain on the glass and it will break. This trouble can be avoided by renewing the packing rings frequently. In steam plants which are in operation only during the daytime it is good practice to close the gage-glass valves at night after shutting down, as the glass is liable to break during the night, and if there is no watchman in the plant there will be trouble in the morning. Some years ago, when I entered the boiler room one morning the room was full of steam. Looking for the cause, I found that one of the gage glasses had broken during the night, and that it must have happened in the early part of the night because most of the steam had been blown out of the boiler and no water could be seen in the gage glass. By try-



SHOWING PROPER HIGHT OF GAGE GLASS

ing the drain cock at the water gage it was found there was water up to this point and there still was water over the top row of tubes. Cold water had to be run into the boiler in order to bring water into the glass again. All the pipe covering in the boiler room on the steam pipes was dripping wet. Had the gage-glass valves been closed the night before all this trouble would have been avoided.

Classification and Uses of Wrenches

A Treatise on the Proper Names, Uses and Abuses of Wrenches in Everyday Practice; Notes on the Screwdriver and a Few General Kinks

BY HUBERT E. COLLINS

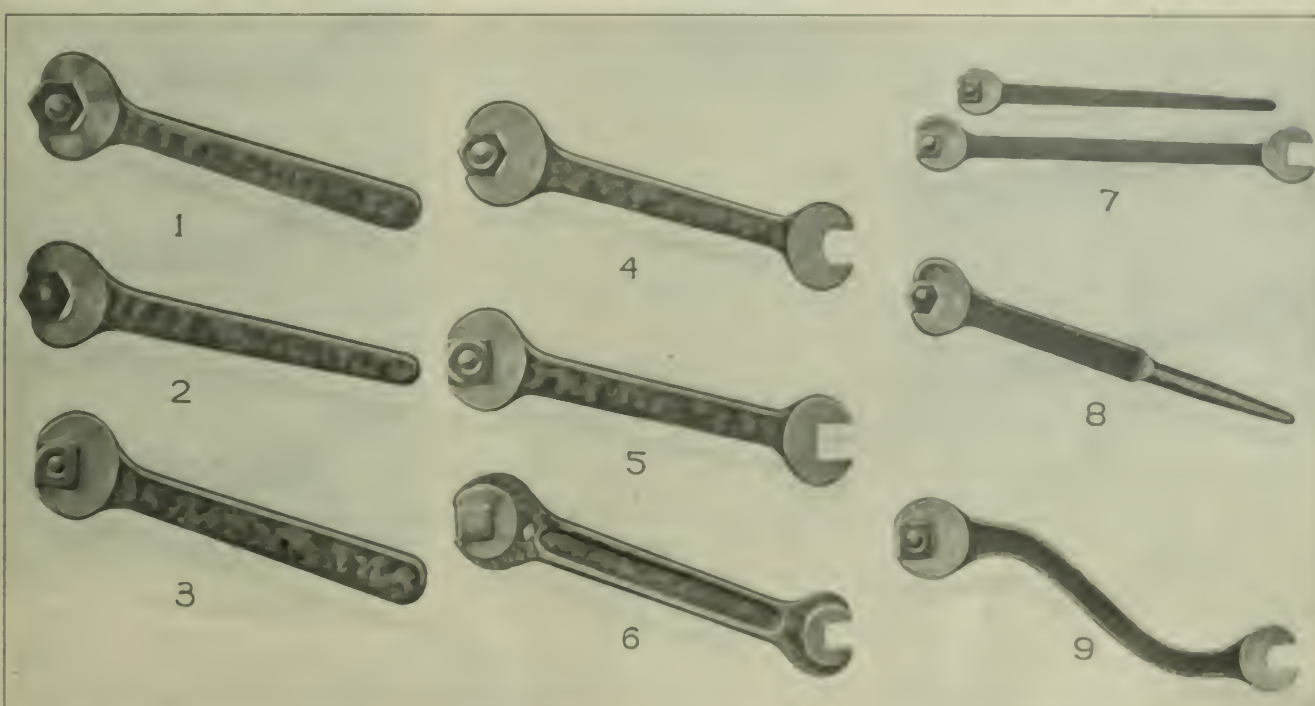
Good machinists understand the proper use of wrenches of every kind and description, and it is only natural that they should, as it is a part of their training. Among engineers with no mechanical training, over 50 per cent. do not know how to properly handle wrenches, and the percentage among steamfitters, firemen, oilers, dynamo attendants and the help generally is nearer 100 than 50. Not only are they ignorant of the proper uses of wrenches, but very few can call them by their proper names. These statements are made after a period of 17 years' observation, and it is believed that they cannot be successfully contradicted.

It is of great importance in the saving of time around a plant to have the men all trained in the use of wrenches, although to many it may seem a trivial matter. In many plants it will be found that there are no wrenches to fit certain nuts or bolt heads. Upon investigation it will be found that when the engine, dynamo, pump, or whatever piece of machinery it is, was installed, a wrench was supplied for the place now requiring its use, but it is either lost or more frequently, through ignorance, it is spoiled so that it cannot be used. For these reasons, it is believed that a talk on this subject should be of value in the engine room, and more especially if proper consideration is given to it. When the reader considers the various types of wrenches here illustrated and the proper uses here explained, it is believed that if he has not the wrench wanted, he can find some way to use what he has or get an idea of how to make the proper wrench for his service.

Classification

Many times in calling for a wrench, the one asked for is not brought, because the man sent for it does not know the names of wrenches and cannot associate in his mind a wrench to fit the name given it, or *vice versa*. This is due to a lack of familiarity with the different types of wrenches and their names. For the purpose of classifying and properly naming, the accompanying illustrations of wrenches are given. Figs. 1 to 9 inclusive, are types of wrenches commonly called solid, open-ended wrenches. They are drop-forged and case-hardened, and are in general use. Fig. 10 is a cut of a special solid, open-ended wrench, as is also the one shown in Fig. 11. Figs. 12 and 13 are types of standard make box wrenches. Figs. 14, 15 and 16 are types of socket wrenches, and Fig. 17 is two views of a socket wrench made for heavy work. Fig. 18 is a box wrench for heavy work. Figs. 19, 20 and 21 are types of spanner wrenches, Fig. 19 being a pin spanner, Fig. 20 a hook spanner, and Fig. 21 a face spanner.

Figs. 22, 23, 24, 25, 26 and 27 are types of strap wrenches, Fig. 28 is the common monkey wrench and Figs. 29, 30 and 31 are types of pipe or Stillson wrenches. Figs. 32 and 33 are types of alligator pipe wrenches, and Fig. 34 is a pair of pipe tongs. Figs. 35 and 36 are two views of a chain pipe wrench or chain wrench, and Fig. 37 is a type of key wrench.

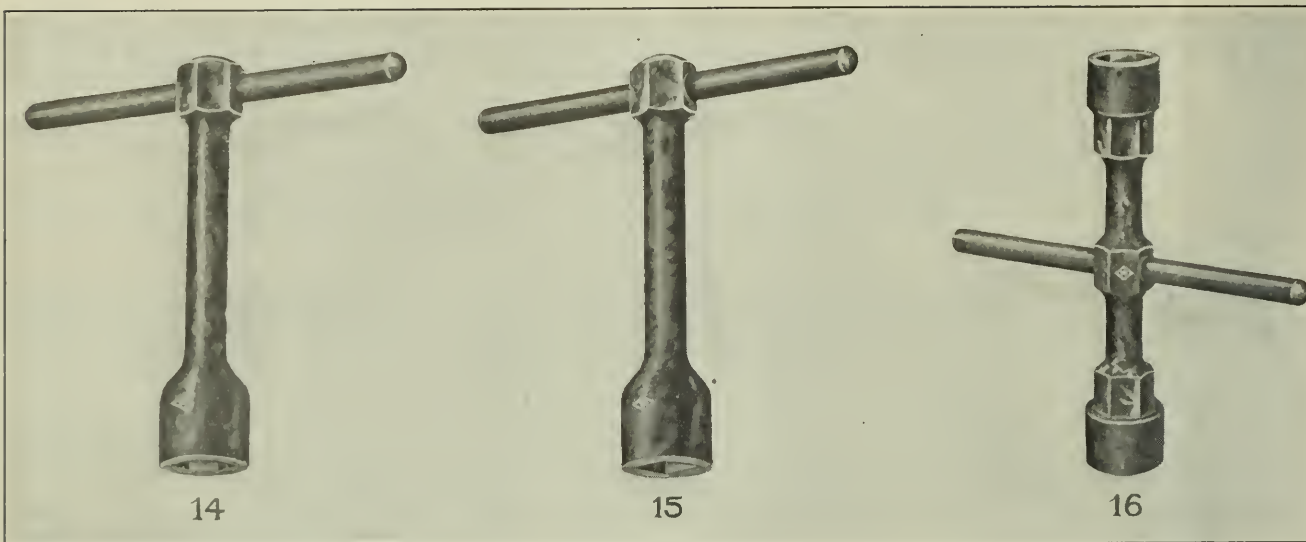


SOLID OPEN-ENDED WRENCHES

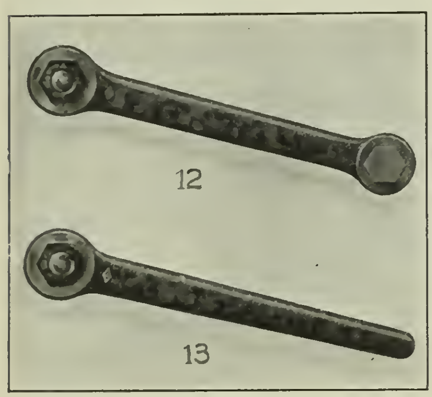
The open-end and box wrenches here illustrated are either straight or angle wrenches. Fig. 7 shows two types of straight wrenches, and Figs. 1, 2, 3, 4, 5, 6, 8, 9, 12 and 13 are angle wrenches. These open-end, box and socket wrenches are also single or double headed as shown.

The Various Uses of Wrenches

All types of angle wrenches are for use where a straight or monkey wrench will not reach, the tool held on a nut or bolt



TYPES OF SOCKET WRENCH



BOX WRENCHES OF STANDARD MAKE

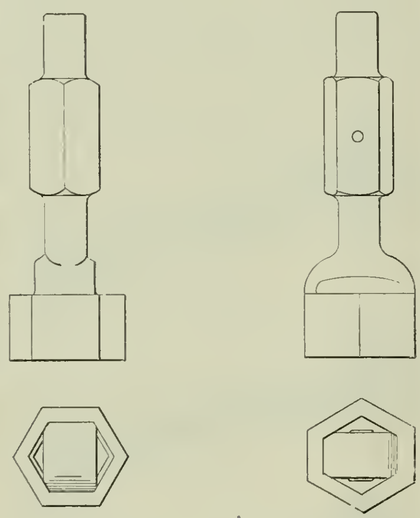
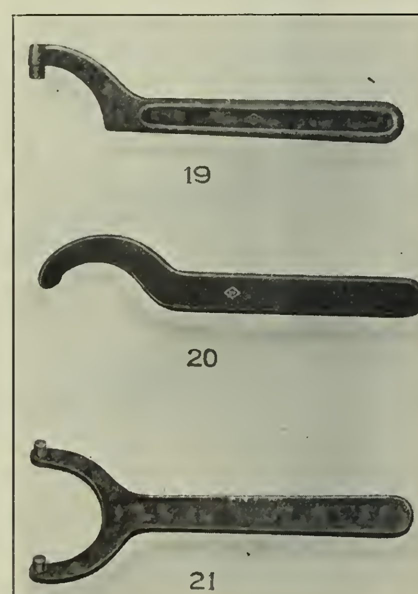


FIG. 17. SOCKET WRENCHES FOR HEAVY WORK



PIN, HOOK AND FACE SPANNERS

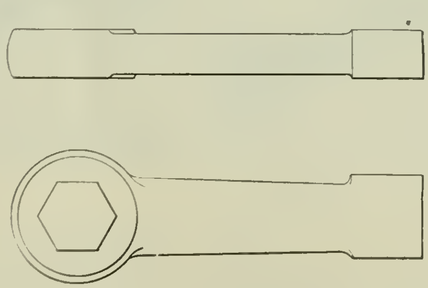
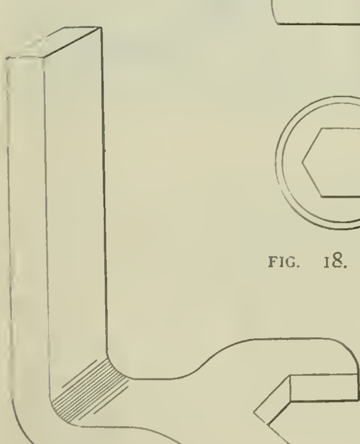
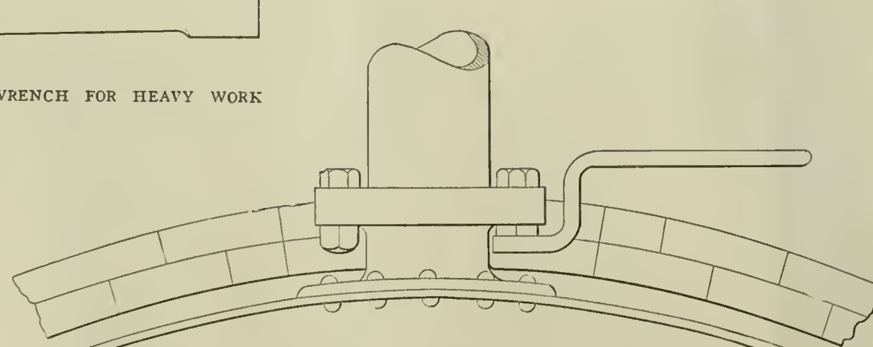


FIG. 18. BOX WRENCH FOR HEAVY WORK





FIGS. 10 AND 11. SOLID OPEN-ENDED WRENCHES OF SPECIAL DESIGN

head after starting to set up on or slack the nut. This type of wrench is needed in every plant in places such as the nuts of a cylinder head, flange bolts, engine frames, etc. The angle is the amount the wrench head is offset from the center line of the wrench handle, as shown in Fig. 38, where A is the head of an angle wrench and B the head of a straight wrench. The line CD is the common center line of the two wrench handles. It will be seen that the line EF through the head of A is offset 30 degrees from CD. Many degrees of angle for this offset have been used by manufacturers, but the angles are mostly 15, 30 and 60 degrees for hexagon nuts, and 45 degrees for square nuts.

As angle wrenches are to be used in tight places or close corners, the object is to turn the nut or bolt head just far enough so that the next flats can be caught by the wrench. A hexagon nut must be turned 60 degrees in order that a wrench may catch the next flats, while the wrench remains or is brought back to the first position to start again in the operation of setting up or slacking off. A square nut needs to turn 90 degrees to present a new set of flats to the jaws of a wrench. If there is room enough to turn a hexagon nut 60 degrees or a square nut 90 degrees, a straight open-ended or monkey wrench may serve the purpose as well as an angle wrench, but where closer quarters do not allow of this much play of the wrench, the latter must be offset just enough for it to take hold twice on the same side of the nut in one turning. Then the required pitch or angle of the wrench will be one-fourth of the amount required to turn the other around. For a hexagon nut this would be one-fourth of 60 or 15 degrees, and for a square nut one-fourth of 90 or an offset of 22½ degrees.

Referring to Fig. 38, it will be seen that with the wrench starting at A and moved to B, the nut will be turned 30 degrees, and by turning the wrench over and bringing it back to A, it will engage the nut, and when moved over to B for the second time, the nut will have been turned 60 degrees. By again turning the wrench and bringing it to A, the operation may be repeated and so continued until the work is finished. The same thing applies to the turning of a square nut with a wrench offset 22½ degrees. For this reason, when buying angle

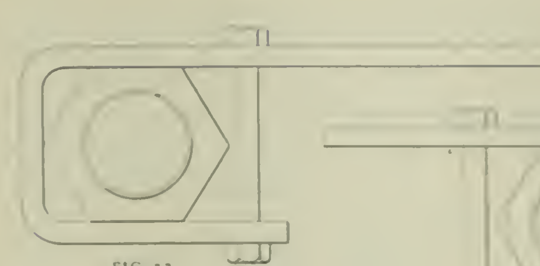


FIG. 22

FIG. 24

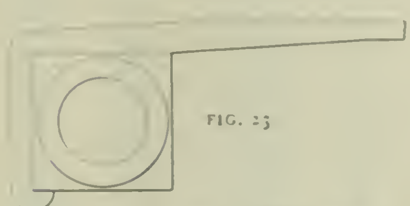


FIG. 23

FIG. 26

FIG. 25

FIG. 27

STRAP WRENCHES

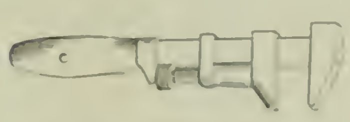


FIG. 28 MONKEY WRENCH

FIG. 37 TYPE OF KEY WRENCH

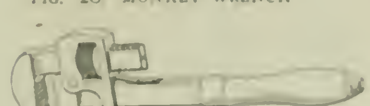


FIG. 30

FIG. 29

FIG. 38. WRENCH OFFSET 30 DEGREES

FIG. 31

PIPE OR STILLSON WRENCHES

FIG. 32

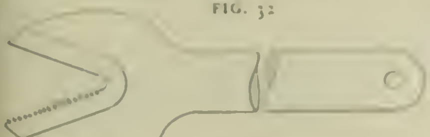
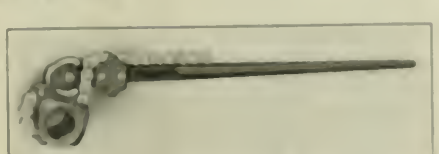
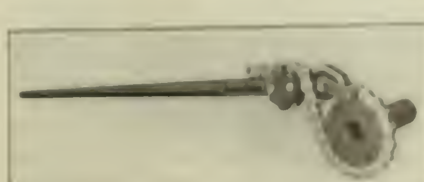


FIG. 33

ALLIGATOR PIPE WRENCHES





FIGS. 35 AND 36. APPLICATIONS OF SIDE WRENCH TO DIFFICULT JOB

FIG. 34. PIPE TONGS

wrenches made to order, do not allow them to be offset more than these amounts.

Box wrenches, shown in Figs. 12, 13 and 18, whether angle or straight, have

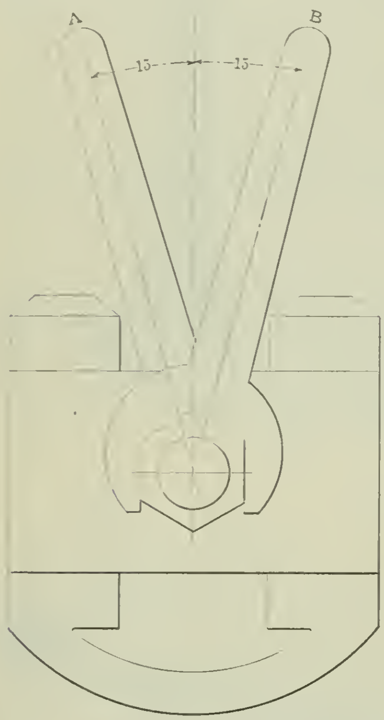


FIG. 39. WRENCH WITH 15-DEGREE OFFSET

many advantages over the open-ended wrench whenever it is possible to use them. The head, fitting all sides of the nut, brings less strain on it, and fitting closer allows it to hold the nut with but little possibility of slipping.

Open-ended wrenches with long leverage, such as those in Figs. 7, 8 and 9, are used on iron work, pipe flanges and other construction work. A good style of wrench for pipe flanges is that shown in Fig. 8. The handle of this wrench can first be used as a drift to bring the bolt holes in line. The wrench shown in Fig. 9 is called an S-wrench because of its shape.

Socket wrenches, such as are shown in Figs. 14, 15 and 16, are used mostly where the bolt heads or nuts are in a recess, as in the case of piston-follower bolts or the screw heads on a universal chuck for a lathe. When socket wrenches are made as in Fig. 17, they are used on the larger sizes of bolt heads or nuts.

Spanner wrenches, like those in Figs. 19 and 20, are used largely on stuffing-box nuts for pumps and small engines. The face spanner, Fig. 21, is a special wrench. One use for it is shown in Fig. 40, where an eccentric, which needs turning around the shaft, is situated between the bearing and flywheel of an engine so close that no other method of grasping it will do. This is only one illustration of its use.

The various types of strap wrenches here shown are to be made for specific purposes, and Figs. 22 to 27, inclusive, offer many suggestions as to type of wrench and places for their use. In Fig. 28 we recognize the familiar monkey wrench, whose uses are many and varied. Owing to the fact that it is easily adjustable to any size of bolt head or nut within its range, it is used more than any other wrench, except for pipe work and in close places. Fig. 37 shows a type of key wrench which also has a wide use. One jaw is slotted to slip over the handle and hold a key *A*. By slacking on the key, the jaws can be adjusted to any size and the key set up so as to hold the jaw rigid.

TABLE 1. SIZES FOR TAPER-HANDLED ENGINEERS' WRENCHES.

For U. S. Standard Nut; Size Bolt.	Opening, Milled.	Extreme Length.	Thickness, Head.
1/4	1/2	3 3/4	1/4
5/16	19/32	4 3/4	9/32
3/8	11/16	5 5/8	5/16
7/16	25/32	6 1/2	11/32
1/2	7/8	7 1/2	13/32
9/16	31/32	8 3/8	7/16
5/8	1 1/16	9 1/4	1/2
3/4	1 1/4	11 1/8	9/16
7/8	1 7/16	13	21/32
1	1 5/8	14 3/4	3/4
1 1/8	1 13/16	16 1/2	27/32
1 1/4	2	18 1/2	29/32
1 3/8	2 3/16	20	1
1 1/2	2 3/8	22	1 1/16
1 5/8	2 9/16	24	1 1/8
1 3/4	2 3/4	25 1/2	1 7/32
1 7/8	2 15/16	25 1/2	1 7/32
2	3 1/8	29 1/2	1 3/8
2 1/4	3 1/2	33	1 17/32
2 1/2	3 7/8	37	1 5/8
2 3/4	4 1/4	37	1 5/8
3	4 5/8	44	1 7/8
3 1/2	5 3/8	44	1 7/8
4	6 1/8	59	2 5/8
4 1/2	6 7/8	59	2 5/8

TABLE 2. SIZES OF DOUBLE-HEADED ENGINEERS' WRENCHES. (FIG. 7.)

For U. S. Standard Nuts; Size Bolts.	Openings, Milled.	Extreme Length.	Thickness, Heads.
1/8 & 3/16	5/16 & 13/32	3 1/4	13/64 & 7/32
1/8 & 1/4	5/16 & 1/2	4	13/64 & 1/4
3/16 & 1/4	13/32 & 1/2	4	7/32 & 1/4
3/16 & 5/16	13/32 & 19/32	4 7/8	7/32 & 9/32
1/4 & 5/16	1/2 & 19/32	4 7/8	1/4 & 9/32
1/4 & 3/8	1/2 & 11/16	5 7/8	1/4 & 5/16
5/16 & 3/8	19/32 & 11/16	5 7/8	9/32 & 5/16
5/16 & 7/16	19/32 & 25/32	6 7/8	9/32 & 11/32
3/8 & 7/16	11/16 & 25/32	6 7/8	5/16 & 11/32
3/8 & 1/2	11/16 & 7/8	7 3/4	5/16 & 13/32
7/16 & 1/2	25/32 & 7/8	7 3/4	11/32 & 13/32
7/16 & 9/16	25/32 & 31/32	8 3/4	11/32 & 7/16
1/2 & 9/16	7/8 & 31/32	8 3/4	13/32 & 7/16
1/2 & 5/8	7/8 & 1 1/16	9 3/4	13/32 & 1/2
9/16 & 5/8	31/32 & 1 1/16	9 3/4	7/16 & 1/2
9/16 & 3/4	31/32 & 1 1/4	11 1/2	7/16 & 9/16
5/8 & 3/4	1 1/16 & 1 1/4	11 1/2	1/2 & 9/16
5/8 & 7/8	1 1/16 & 1 7/16	13 1/2	1/2 & 21/32
3/4 & 7/8	1 1/4 & 1 7/16	13 1/2	9/16 & 21/32
3/4 & 1	1 1/4 & 1 5/8	15 1/2	9/16 & 3/4
7/8 & 1	1 7/16 & 1 5/8	15 1/2	21/32 & 3/4
7/8 & 1 1/8	1 7/16 & 1 13/16	17	21/32 & 27/32
1 & 1 1/8	1 5/8 & 1 13/16	17	3/4 & 27/32
1 & 1 1/4	1 5/8 & 2	19	3/4 & 29/32
1 1/8 & 1 1/4	1 13/16 & 2	19	27/32 & 29/32
1 1/8 & 1 3/8	1 13/16 & 2 3/16	21	27/32 & 1
1 1/4 & 1 3/8	2 & 2 3/16	21	29/32 & 1
1 1/4 & 1 1/2	2 & 2 3/8	23	29/32 & 1 1/16
1 3/8 & 1 1/2	2 3/16 & 2 3/8	23	1 & 1 1/16
1 3/8 & 1 5/8	2 3/16 & 2 9/16	25	1 & 1 1/8
1 1/2 & 1 5/8	2 3/8 & 2 9/16	25	1 1/16 & 1 1/8
1 1/2 & 1 3/4	2 3/8 & 2 3/4	27	1 1/16 & 1 7/32
1 5/8 & 1 3/4	2 9/16 & 2 3/4	27	1 1/8 & 1 7/32
1 5/8 & 1 7/8	2 9/16 & 2 15/16	27	1 1/8 & 1 7/32
1 5/8 & 2	2 9/16 & 3 1/8	30 1/2	1 1/8 & 1 3/8
1 3/4 & 2	2 3/4 & 3 1/8	30 1/2	1 7/32 & 1 3/8
1 7/8 & 2	2 15/16 & 3 1/8	30 1/2	1 7/32 & 1 3/8
1 3/4 & 2 1/4	2 3/4 & 3 1/2	34	1 7/32 & 1 17/32
1 7/8 & 2 1/4	2 15/16 & 3 1/2	34	1 7/32 & 1 17/32
2 & 2 1/4	3 1/8 & 3 1/2	34	1 3/8 & 1 17/32
2 & 2 1/2	3 1/8 & 3 7/8	39	1 3/8 & 1 5/8
2 1/4 & 2 1/2	3 1/2 & 3 7/8	39	1 17/32 & 1 5/8
2 1/4 & 2 3/4	3 1/2 & 4 1/4	39	1 17/32 & 1 5/8
2 1/2 & 2 3/4	3 7/8 & 4 1/4	39	1 5/8 & 1 5/8
2 1/2 & 3	3 7/8 & 4 5/8	46	1 5/8 & 1 7/8
2 3/4 & 3	4 1/4 & 4 5/8	46	1 5/8 & 1 7/8
2 3/4 & 3 1/2	4 1/4 & 5 3/8	46	1 5/8 & 1 7/8
3 & 3 1/2	4 5/8 & 5 3/8	46	1 7/8 & 1 7/8

Figs. 29, 30 and 31 are Stillson or pipe wrenches to be used on pipe and pipe fittings and in some instances on studs. The alligator wrenches in Figs. 32 and 33 are for use on pipe and fittings also, but not for as heavy work as stillsons. The pipe tongs, shown in Fig. 34, are for use on pipe, and more especially on work where there is not much space to operate in. For illustration, in making up pipe coils with manifold headers, the space is so small between the pipes while they are being screwed into place, that a Stillson wrench cannot be used, as the head is too thick. In such an event, the pipe tongs must be called into service. Figs. 35 and 36 show two views of a chain wrench illustrating its application to a difficult job. This style of wrench can be had in small sizes to do the work of a stillson wrench, and with success, but they are used mostly on large pipes and fittings.

Proportions of Wrenches

Manufactured wrenches, whether finished or unfinished in reputable factories, are so proportioned that they will stand all strain brought to bear on them, or that should be put upon the stud or bolt they are used on. The manufacturers have adopted a standard table of proportions in most cases, and where sizes vary from these here given, the variations are in proportion. For example, in the tables given, a wrench is proportioned with a certain thickness of head for a given length of handle or lever. Where tables show a thinner head, the length of handle is shorter. The size of opening in the jaws for the nut or bolt head is the same in all makes of wrenches for nuts and cap-bolt heads. The wrenches for standard finished nuts are larger in the openings than for cap bolts.

For comparison of sizes refer to Tables 1, 2 and 3. Table 1 gives the sizes for engineers' wrenches, single head, as illus-

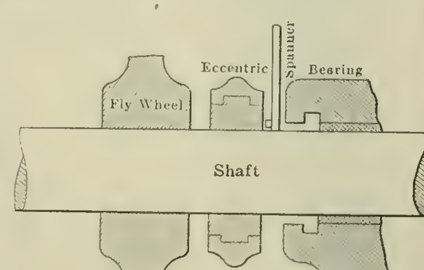


FIG. 40. FACE SPANNER TURNING ECCENTRIC ON SHAFT

trated in Fig. 2; Table 2 the sizes for engineers' wrenches, double head, as illustrated in Fig. 7, and Table 3 the sizes for cap-bolt wrenches, single head, the appearance of which is the same as Fig. 2. Table 4 gives the principal dimensions of socket wrenches, such as are shown in Fig. 16, and is also of use when recesses for bolt heads are to be provided for in castings.

Where wrenches are not easily obtainable and a blacksmith can be found to make some, these tables are of value for the proper proportioning of a wrench for strength and for a fit to standard sized nuts and bolts. For additional information regarding other dimensions of wrenches, refer to Table 5, in which it will be noted that the heads are thinner and the levers shorter than in Tables 1 and 2, but are of the same proportion.

Size of Wrench with Reference to Size of Nut

When the size of a solid wrench is spoken of, the reference is made to the wrench which will fit a nut or head for the given size of bolt. For example, if a ¼ inch engineer's wrench is called for to use on a finished nut, it means a wrench for that size of nut, or on referring to Table 1 to an ¼ inch bolt, it will be noted that the opening in the head for that size is ½ inch between the jaws. If an ¼ inch cap-bolt wrench is called for, the opening will be 7/16 inch, as shown in Table 3. This point is brought out for the reason that many times a helper is sent for a certain size of wrench, and is found measuring all the wrenches for one with the opening the size called for, instead of one to accommodate the nut size.

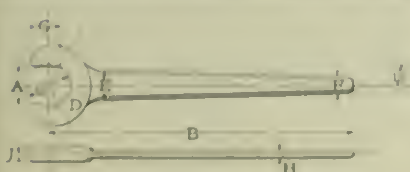
For the purpose of becoming familiar with the sizes of nuts for a given tap size, and for use in finding the sizes of drills to be used in drilling for a given size of tap, also to show the strain a bolt of given size will stand, Table 6 is compiled. The sizes for unfinished nuts are not given, but it is well to know that an unfinished nut is 1/16 inch thicker and wider from side to side than a finished nut. A finished nut is 1/16 inch thinner than the bolt sizes.

TABLE 3. CAP-BOLT WRENCHES, SINGLE HEAD

For Hexagon Head Cap-screws; Diameter Screws.	Openings, Milled.	Extreme Length	Thickness, Head.
¼	[illegible]	2¼	¼
[illegible]	[illegible]	2[illegible]	[illegible]
[illegible]	[illegible]	3[illegible]	[illegible]
[illegible]	[illegible]	4[illegible]	[illegible]
[illegible]	[illegible]	5	[illegible]
[illegible]	[illegible]	5[illegible]	[illegible]
[illegible]	[illegible]	6[illegible]	[illegible]
[illegible]	[illegible]	7[illegible]	[illegible]
[illegible]	[illegible]	8	[illegible]
[illegible]	1	9[illegible]	[illegible]
[illegible]	1[illegible]	11	[illegible]
1	1[illegible]	12[illegible]	[illegible]
1[illegible]	1[illegible]	14	[illegible]
1[illegible]	1[illegible]	15[illegible]	1[illegible]
1[illegible]	1[illegible]	17	1[illegible]

TABLE 4. DOUBLE-HEADED SOCKET WRENCHES, HEXAGON HEADS (FIG. 16)

Hexagon Openings: For U. S. Standard Nuts; Size Bolts.	Hexagon Openings: For Cap Screws; Diameter Screws.	Hexagon Openings: Short Diameter Broached Openings.	Extreme Length	Diameter of Head	Diam. of Shank	Hexagon Parts of Shank Same Size as U. S. Nut, for Size Bolt	Size of Pin Handle: Diameter	Size of Pin Handle: Length
[illegible]	[illegible]	[illegible]	4½ / 6½	[illegible] & [illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	6½	[illegible] & [illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	7½	1[illegible] & 1[illegible]	[illegible]	[illegible]	[illegible]	7
[illegible]	[illegible]	[illegible]	9½	1[illegible] & 1[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	11	1[illegible] & 2[illegible]	1	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	13½	2[illegible] & 2[illegible]	1[illegible]	1[illegible]	[illegible]	11[illegible]



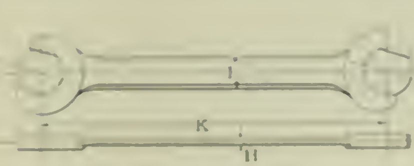


TABLE 5. APPROVED PROPORTIONS OF WRENCHES

Bolt	A	B	C	D	E	F	G	H	I	J	K
¼	[illegible]	3[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4
[illegible]	[illegible]	4[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	4[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	5[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6[illegible]
[illegible]	[illegible]	6	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	6[illegible]	1[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1[illegible]	7[illegible]	1[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1[illegible]	8[illegible]	1[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	10
[illegible]	1[illegible]	10	1[illegible]	[illegible]	1[illegible]	[illegible]	[illegible]	[illegible]	1[illegible]	[illegible]	11[illegible]
1	1[illegible]	11[illegible]	1[illegible]	[illegible]	1[illegible]	[illegible]	1[illegible]	[illegible]	1[illegible]	[illegible]	1[illegible]
1[illegible]	1[illegible]	12[illegible]	2[illegible]	[illegible]	1[illegible]	[illegible]	1[illegible]	[illegible]	1[illegible]	[illegible]	1[illegible]
1[illegible]	2	14	2[illegible]	[illegible]	1[illegible]	[illegible]	1[illegible]	[illegible]	1[illegible]	[illegible]	16
1[illegible]	2[illegible]	15[illegible]	2[illegible]	1	1[illegible]	[illegible]	1[illegible]	[illegible]	1[illegible]	[illegible]	17[illegible]
1[illegible]	2[illegible]	16[illegible]	2[illegible]	1[illegible]	1[illegible]	1	1[illegible]	[illegible]	1[illegible]	[illegible]	1[illegible]
1[illegible]	2[illegible]	18	2[illegible]	1[illegible]	1[illegible]	1[illegible]	1[illegible]	[illegible]	2[illegible]	1[illegible]	[illegible]
1[illegible]	[illegible]	19[illegible]	3[illegible]	1[illegible]	2[illegible]	1[illegible]	1[illegible]	[illegible]	[illegible]	1[illegible]	[illegible]
1[illegible]	2[illegible]	20[illegible]	[illegible]	1[illegible]	[illegible]	1[illegible]	1[illegible]	[illegible]	2[illegible]	1[illegible]	[illegible]
2	3[illegible]	22	3[illegible]	1[illegible]	[illegible]	1[illegible]	2	[illegible]	2[illegible]	1[illegible]	[illegible]

Proper and Improper Uses of Wrenches

Monkey wrenches of all makes have the general appearance shown in Fig. 18, and it must be said that there is no wrench in existence more misused than this type. They are designed for use by hand on the nuts that they will take, and will stand all work put on them with the hands only, giving good service if they are always applied in the proper manner. Invariably on calling for a monkey wrench, one is brought out looking very much like Fig. 21, with the jaws at an angle with each other when closed, instead of being parallel, as they should be. This condition is caused by abuse in the use of the wrench, principally through ignorance.

When the monkey wrench is applied as shown in Fig. 20, there will be no difficulty about it doing its work. When the nut is to be turned in the direction shown by the arrow, the wrench must always be applied as shown. Not only must the wrench be applied in the right direction, but it must come down full on the nut as far as it will go, the reason being that the force which tends to break the wrench or bend the jaws into the shape of Fig. 41 is along the line *A*, Fig. 42, and with the wrench clear down the leverage is reduced to a minimum.

In Fig. 43 it will be seen that the line *A* is increased by not letting the wrench down on the nut, although the jaws are closed up tight on the nut. Fig. 44 shows line *A* not greatly increased, but through the loose adjustment of the jaws the corners of the nut get a greater purchase on the wrench and tend to push the jaws apart more forcibly. In Fig. 45 the two forces which tend to ruin the wrench have the best opportunity on account of the poor adjustment of the width between the jaws and the wrench resting high up on the nut.

These are common faults in the use of monkey wrenches, but the abuse most common is illustrated in Fig. 46, which shows the wrench upside down. As soon as the force is applied in the direction of the arrow, the outside jaw takes hold of the nut at *B* and line *A* is increased at once. This is positively a case where there is only one way that is right, and any other is wrong. Not only can wrenches be saved by applying them as in Fig. 42, but many skinned knuckles and mashed fingers might have been prevented, and of more importance, considerable time saved. When a monkey wrench cannot be applied to its work properly, some other type of wrench should be used.

Another infallible rule for the right use of a monkey wrench, is to never use a piece of pipe over the handle to increase the leverage. Nor is it right to strike on one of these wrenches with a hammer. Most of the ruined handles on monkey wrenches come from these two sources.

All types of wrenches should be used with care and precision, and should always be placed squarely on the nut and made to fit it snugly. With socket wrenches it is often impossible to use them unless they are held squarely and snugly to the work. Pipefitters often handle Stillson wrenches in a manner destined to ruin the pipe. In screwing up or slacking off on a pipe, always catch the wrench as close up to the thread as possible. Many cases of split pipe have been attributed to the wrench being held at the middle of its length, allowing the pipe to twist under the heavy strain and split the seam.

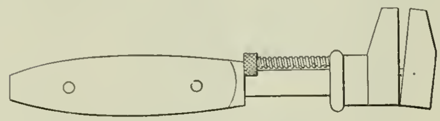


FIG. 41 JAWS AT AN ANGLE

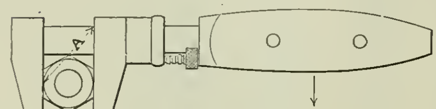


FIG. 42

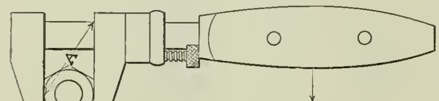


FIG. 43

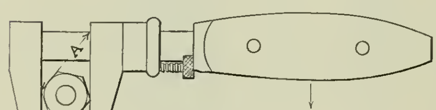


FIG. 44

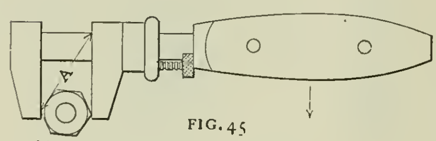


FIG. 45

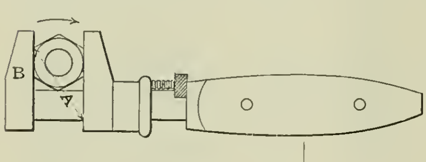


FIG. 46

METHODS OF APPLYING MONKEY WRENCH

Another source of trouble with Stillson wrenches originates from constantly taking hold of the pipe in the same place. When many hard pulls are necessary to set up, the result is a pipe cut through in places. The proper thing to do in taking holds is to move the wrench along the length a little and back again, so that the teeth of the wrench will not grip twice in the same place. A Stillson wrench should also be set down on its work, so that the jaws will take hold with the work well up in them. There is one thing which limits this, however, and that is the amount of pull which the hold must stand. The stronger the pull, the farther up on the work the jaws must be in order for the teeth to take hold. For this reason also, when making a hard pull, it is not advisable to use a very large wrench on small pipe, as the larger teeth may cut through the pipe or crush it.

A Stillson wrench is not so liable to crush pipe as a pipe tongs, and for this reason the former is the best to use. It is best to use a chain wrench on the larger sizes of pipe, discarding the Stillson for sizes over 3 inches. Never use a Stillson on a bolt head, nut, stud or finished work, as there is always a way in which these may be handled with standard or special wrenches.

Kinks

Oftentimes it is necessary to loosen up nuts on bolts which have rusted on. If time is allowed to do so, it will help much to pour kerosene oil over the nut and

TABLE 6. BOLT DIMENSIONS AND THE SIZE OF DRILLS TO CORRESPOND.

Size of Bolt or Tap, Inches.	Number Threads to Inch.	Size Drill for Tap, Inches.	Diameter at Bottom of Thread of Bolt, Inches.	Area in Sq. In. at Bottom of Thread of Bolt.	Stress on Bolt Upon Basis of						Diameter of Opposite Sides of Nut, Finished, Inches.	Diameter of Opposite Corners of Nut, Inches.
					3,000 Lb. Per Sq.In.	4,000 Lb. Per Sq.In.	5,000 Lb. Per Sq.In.	7,000 Lb. Per Sq.In.	10,000 Lb. Per Sq.In.	Possible Breaking Load.		
1/4	18.20	11/64	....	....	....	....	....	....	....	....	7/16	37/64
5/16	16.18	7/32	....	....	....	....	....	....	....	....	17/32	11/16
3/8	14.16	17/64	....	....	....	....	....	....	....	....	5/8	51/64
7/16	14	11/32	....	....	....	....	....	....	....	....	23/32	9/16
1/2	13	3/8	0.38	0.12	350	460	580	810	1,160	5,800	13/16	1
9/16	12	7/16	0.44	0.15	450	600	750	1,050	1,500	7,500	29/32	1 1/8
5/8	11	31/64	0.49	0.19	560	750	930	1,310	1,870	9,000	1	1 7/32
3/4	10	39/64	0.60	0.28	850	1,130	1,410	1,980	2,830	14,000	1 3/16	1 7/16
7/8	9	23/32	0.71	0.39	1,180	1,570	1,970	2,760	3,940	19,000	1 3/8	1 21/32
1	8	53/64	0.81	0.52	1,550	2,070	2,600	3,630	5,180	25,000	1 9/16	1 7/8
1 1/8	7	61/64	0.91	0.65	1,950	2,600	3,250	4,560	6,510	30,000	1 3/4	2 3/32
1 1/4	7	1 5/64	1.04	0.84	2,520	3,360	4,200	5,900	8,410	39,000	1 15/16	2 5/16
1 3/8	6	1 11/64	1.12	1.00	3,000	4,000	5,000	7,000	10,000	46,000	2 1/8	2 17/32
1 1/2	6	1 19/64	1.25	1.23	3,680	4,910	6,140	8,600	12,280	56,000	2 5/16	2 3/4
1 5/8	5 1/2	1 23/64	1.35	1.44	4,300	5,740	7,180	10,000	14,360	65,000	2 1/2	2 31/32
1 3/4	5	1 1/2	1.45	1.65	4,950	6,600	8,250	11,560	16,510	74,000	2 11/16	3 3/16
1 7/8	5	1 5/8	1.57	1.95	5,840	7,800	9,800	13,640	19,500	85,000	2 7/8	3 13/32
2	4 1/2	1 23/32	1.66	2.18	6,540	8,720	10,900	15,260	21,800	95,000	3 1/16	3 5/8
2 1/4	4 1/2	....	1.92	2.88	8,650	11,530	14,400	20,180	28,800	125,000	3 7/16	4 1/16
2 1/2	4	....	2.12	3.55	10,640	14,200	17,730	24,830	35,500	150,000	3 13/16	4 1/2
2 3/4	4	......	2.37	4.43	13,290	17,720	22,150	31,000	44,300	186,000	4 3/16	4 29/32
3	3 1/2	....	2.57	5.20	15,580	20,770	26,000	36,360	52,000	213,000	4 9/16	5 3/8
3 1/2	3 1/4	....	3.04	7.25	21,760	29,000	36,260	50,760	72,500	290,000	5 5/16	6 7/64
4	3	....	3.50	9.62	28,860	38,500	48,100	67,350	96,200	385,000	6 1/16	7 3/32

allow it to loosen up the rust. If the kerosene will not loosen up the rust enough, then take a hammer and strike the nut sharply on all sides. To do this properly, hold another hammer squarely against the nut on the opposite side. This will loosen up badly rusted nuts, but if it does not do the work, then more kerosene will be needed.

FIG. 47. TIN COVERED TAP TO ENLARGE NUT

When Necessary, Split the Nut

Sometimes a loosened nut will start off and again stick before entirely off. This is caused by the thread of the nut or bolt stripping, and if continued, will ruin one or the other. More often it is the bolt or stud which suffers, and the only way to save them is to split the nut apart. To do this, take a flat chisel and cut into one side, opening the nut up from top to bottom through the center of one flat. Hold a heavy hammer or piece of iron against the nut on the side opposite while doing the cutting.

On pipe flanges it is often cheaper to split all the nuts that are rusted in than to work to get them off with a wrench, providing plenty of spare nuts are available. If this is done, the bolts should be given a bath in kerosene before being used again.

When Nut and Bolt Do not Fit

In some cases nuts will not go on bolts or studs because the nut is tapped a little small or the thread on the bolt is too large. More often it is the latter, and the thread on the bolt should be made smaller to fit the nut, so as to keep the nuts of uniform size. When time, circumstances or material will not allow of the thread being turned down on the bolt, and a tap of the right size is to be had, the nut may be tapped larger as follows:

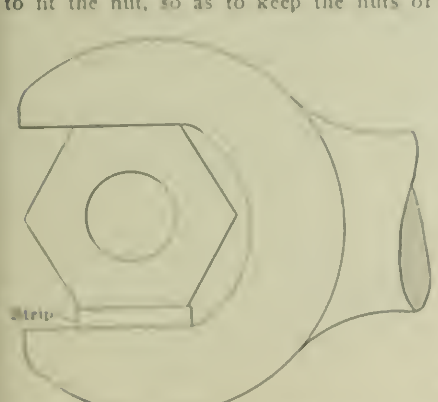


FIG. 48. WRENCH TOO LARGE FOR NUT

Cut into a strip of tin of the right width and length and bend it into the shape shown at *A*, Fig. 47, and just wide enough to cover one set of threads on the tap and long enough to reach over the ends of the threads, as shown. Enter the tap into the nut with this tin over the threads, and the threads in the nut will be enlarged. Some difficulty may be experienced in starting the tap through the nut, but after starting it, it will follow through all right. Use the first tap of a set for this, or as it is called, the taper tap.

Fitting Wrench to Bolt Head

When a wrench does not fit a nut or bolt head (the wrench being too large) and no other is to be had, it is permissible to use a strip of iron, steel or any other metal substance handy to fill up the space between the jaws, as illustrated in Fig. 48. For convenience of handling, the strip can be longer than shown.

Turning a Stud

A great many do not know how to readily remove a stud from its place, when necessary, with the tools at hand. Fig. 49 illustrates how two nuts may be locked together on a stud to withdraw it. If the length of the thread will permit, run two full nuts down on the stud, with the two flat sides of the nuts coming together. Take the two wrenches, as shown in the plan, and pull them together. Note the angle at which the top and bottom wrenches are held in this figure, for if the respective wrenches were held at the same angle and changed, No. 2 to the bottom and No. 1 to the top, the pull together in the direction of the arrows would have the effect of loosening the nuts. The rule of operation is, that while facing the nuts, take wrench No. 2 in the right hand and place it on the top nut and wrench No. 1 in the left hand and place it on the bottom nut at the angles shown or anywhere under the line *A B* down to *C D*. To lock the nuts, pull the wrenches together, and to loosen them, change the top wrench to the bottom, and *vice versa*, and pull them together. There are several other ways of using the wrenches to attain these ends, and in some instances other ways must be found, but this manner of doing it allows the operator to get the strongest pull either while tightening up or slacking off.

To get the greatest purchase on the nuts, place the wrenches at an acute angle from each other, say along the lines *F* and *G*, respectively, while still standing in the same position. After the nuts are locked, if it is intended to take the stud out, take one wrench and use it on the bottom nut to back out a right-hand thread, and if the stud is to be driven in, use the one wrench on the top nut.

Where a great many studs are to be driven home to stay, a stud driver, such as is shown in Fig. 50, can be used. It can be made from a special nut drilled and tapped half-way through its length, and is run down on the thread until the stud bottoms in the nut. When the stud is driven as far as it will go, remove the stud driver by giving it a quick, strong twist with the wrench, in the opposite direction to that followed while driving the stud.

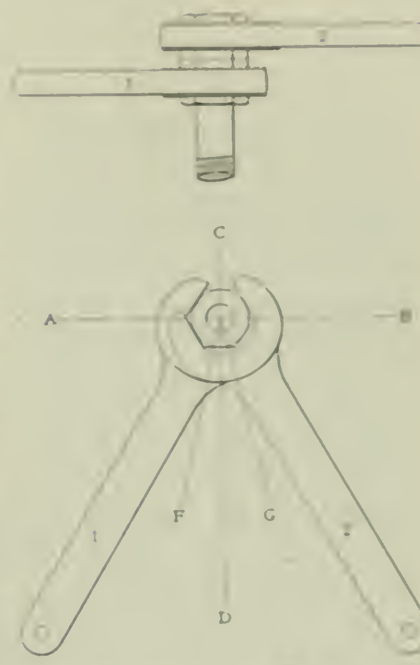


FIG. 49. LOCKNUT METHOD OF TURNING STUD

FIG. 50. STUD DRIVER

Increasing the Leverage of a Wrench

It is often desirable to increase the leverage of an ordinary engineer's wrench, and the practice of permissible under certain conditions. Never use a hammer on the handle, as it ruins it. If a sharp blow is required, use some form of a soft hammer, or use a block of hard wood for a ram. It is still better to make a handle of pipe sufficiently long to give the desired leverage. Flatten one end of

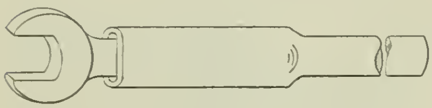


FIG. 51. INCREASING THE LEVERAGE

the pipe to fit over the wrench handle, running the flat back far enough to allow the handle to be run in up to the head, as shown in Fig. 51. It must be remembered that there is a limit to the size of bolt or stud on which it is advisable to use a longer leverage on the handle of the wrench than the makers have allowed for. Bolts up to and including ⅞ inch in diameter can be twisted off with an ordinary wrench and a muscular operator, so that pipe handles are not to be tolerated on any size smaller than that.

Pulling up Joints

All joints should be pulled up square and even all around from start to finish, especially where a metal joint is used. Dirt being left on joint surfaces often causes leaks, because the two cannot be brought evenly together, and just as often the leak is caused by the uneven strain on the bolts. Take, for example, the cylinder head shown in Fig. 52, which has a shoulder all around the inside of the flange. It will be seen that by pulling on one nut first, the head could be tipped out of true, and only one edge of the shoul-

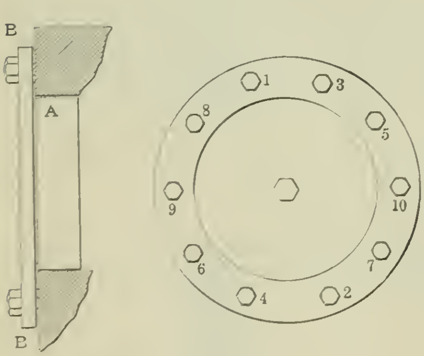


FIG. 52. TIGHTENING UP A CYLINDER HEAD

der joint would touch. When first starting to set up on the nuts, a good method to follow is to set up on No. 1 nut lightly until the surfaces of the joint meet, then take up the same on No. 2 nut opposite to No. 1, then Nos. 3 and 4 in succession, after which the nuts can be taken up the same amount in the order given. Then go over them all again in the same order until the joint is tight. The space *B* will be equal all around if the pulling up has been properly done. This rule applies equally well on all joints, taking any nut for No. 1 and making No. 2 come opposite. Some bolt circles are divided as in Fig. 53, where one nut will be on the center line *A B* and opposite to it the nuts will straddle, perhaps not just as shown in the illustration, but similar. In this event, take up on the nuts in rotation, as indicated by the figures.

Screwdrivers

A screwdriver with a wedge-shaped head which fits the slot of the screw, as at *A*, Fig. 54, is a type which never should be used, and yet is universally sold by manufacturers and used in that form. It is plain that this form of screwdriver never fits the slot in the screw head and takes as much force to hold the driver in place as it does to drive the screw. Another fault is that it puts a strain on the screw head where the power which tends to break it apart is greatest. When the head of the screwdriver is ground so that it takes hold of the screw head in the bottom of the slot, as at *B*, Fig. 54, the strain on the screw head is at a minimum, and the power of the operator is all spent in driving the screw alone. All screwdriver heads should be made as shown at *B*, Fig. 54.

In some cases it is impossible to use ordinary screwdrivers, owing to the cramped space, and the driving force must be applied at right angles to the driving line. Fig. 55, *A* and *B*, show views of two screwdrivers which are useful in such cases. It can be seen that with *A* the screw head can be moved one-fourth of a turn and be picked up with *B* and turned another quarter, when *A* can be used again and so alternately until the work is done.

Things in General

On very large nuts or bolt heads it is necessary to use more than a straight pull. A sharp blow with a hammer often starts an obstinate hold, where a straight pull would not. It is not advisable only in extreme cases to use the hammer on the wrench, but a hardwood block will do as well. In extreme cases a steady pull aided with blows of a ram will do the work. Very extreme cases call for the use of a block and fall on the end of a large wrench and a ram in addition. An aid to the wrench on large sizes of nut, when it is desired to have the nuts extra tight, is to heat the bolts before they are put in place. To do this properly, heat the bolts midway of their length to a dull red, and then place them in position and set up on the nut quickly. The contraction of the bolt will make the nut hold more tightly than a wrench can set it, if the job is done quickly and in a proper manner.

The use of a hammer and chisel on nuts and bolts in place of a wrench is not to be condoned in general practice, for it puts the nuts forever beyond the possibility of using a wrench on them. There are times and places where a wrench cannot be had, and a hammer and chisel must be used. When this is necessary, use a calking chisel or drift so as to spare the nut as much as possible. Then have a suitable wrench made. The illustrations will offer suggestions to fit any case.

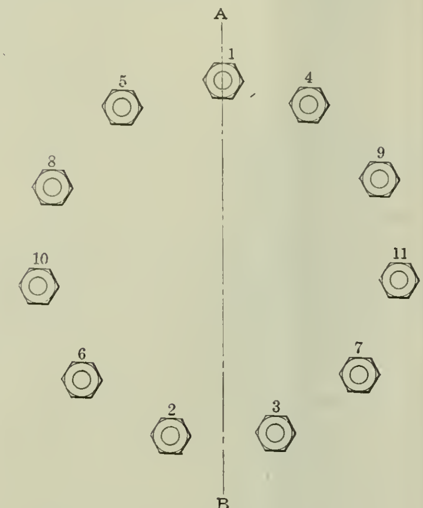


FIG. 53. TIGHTEN NUTS IN ROTATION

Several years ago in one of our Western Indian agencies there was employed an old man called Uncle Bill by the rest of the Government employees. He was a good mechanic of the old school and was often called on to loan his monkey wrench to others. He would do so once, and the borrower could have it again if he showed that he could follow Bill's instructions as to its proper use. If not, and they failed to apply the wrench rightly to its work, they need never ask again for the loan of it. He was right, for he had no wrenches

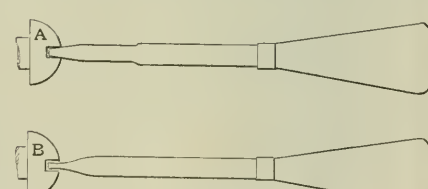


FIG. 54

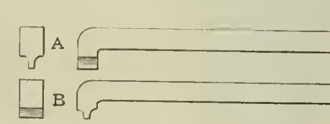


FIG. 55

FORMS OF SCREWDRIVER

to spare, and this article may serve to enlighten the reader as to the reasons why.

Niagara river develops 8,500,000 continuous horsepower. If two pounds of coal were burned per horsepower per hour, the hourly amount necessary to equal the work of Niagara river would be 8500 tons. Continuous work for a year would require over 74,000,000 tons of coal.

An Early American Engineer—Robert Erskine

Sketch of the Life and Activities of One of the Men Who, in Colonial Times, Did Much to Advance Engineering in Many Departments

BY EDWARD P. BUFFET

Among the men of note in our colonial days were few who could be called "engineers" in any sense of the word. Robert Erskine deserves that appellation in many senses. He made his mark as a civil, an hydraulic, a mining and a military engineer, a mathematician, a metallurgist and a first-class works manager. There is a strong hint that he was also something of a steam engineer.

The same old Scottish city—Dunfermline—which furnished our most successful industrial leader of the nineteenth century supplied one who is entitled to almost an equal rank for the eighteenth. As a Scottish ironmaster on American soil, Robert Erskine might be called the Carnegie of the colonies. He differed from Carnegie in being more of an engineer and less of a financier.

His active career was divided between the old and new countries. In the former he established his reputation as inventor of pumps, machine designer and consulting engineer, while in the latter he closed his career as an industrial executive, intrusted with interests of great responsibility.

In the library of the New Jersey Historical Society have been on file for nearly half a century the venerable documentary records of his work—portfolios of family and other letters relating to his early life; numerous manuscripts describing his inventions and their exploitation, with sketches and wash drawings, a dissertation on the tides, account books of the American works, and a volume in which his own epistles concerning their administration are laboriously copied out. There are also many pages written in cryptic characters which may be either shorthand or cipher. The mass of material, if edited with discriminating selection, would form an interesting volume. It is curious that among his sketches, although a century and a half have told upon the tint of the ink lines, the pencil marks remain perennially fresh. Very few of these documents have yet been published, though a few extracts were given by Rev. Dr. Tuttle, a famous local historian by whom the papers were secured for the society.

Robert Erskine was born September 7, 1735, his father being the Rev. Ralph Erskine, minister at Dunfermline, a man of sufficient note to find a place in encyclopedias down to the present day. Ralph's title to fame was acquired by founding, with his brother, Ebenezer, a free branch of the Scottish kirk and in being the author of several books, including a volume of "Gospel Sonnets." A copy of the latter was long ago exhumed by the writer of this memoir in a nook of an old house on Long Island. It was a ninth edition, Glasgow imprint of 1760, and contained, apart from the body of the book, a poem of uncertain authorship, entitled, "Smoking Spiritualized." The verses inculcate a number of edifying lessons that may be drawn from the pipe, its contents and its use.

Robert Erskine's father died in 1752, when the lad was 17. The youth evidently received a collegiate education, or its equivalent, for we find him in London in the sixties, well grounded in scientific knowledge and casting about after opportunities to make it useful. The following letter from his mother indicates that he had his eye on a place in the faculty of Glasgow University:

Dear Robbie—I received yours the [illegible] day. I write to you this day eight days with a shipmasters receipt for a box to you with some linnings which you have got by this time. I shall be very glad that I am in a mistake about your being obliged to be present as a candidat for ye vacancy at Glasgow it was the opinion of your Brother and many others that you should be present but if it is needless it may be they may cause you yet for to be sure the professerie is not pleased with that Buchannan but is like as ye *D* of Argyl is hear he will oblige them to take him fit or unfit if he serves his turn I think you have got a sufficiant swack of his Grace as I hope you will expect no favours from him it would be a great mercy if you could think of doing something hear for I am afrayd you will get some offers to go to Jemeky Gebrallter or some of the colonies abroad which would be very disagreeable to me.

GRAVES OF ERSKINE (ON THE RIGHT) AND [illegible]

It appears that a professorship of mathematics, or some such branch, was suggested to him as a natural opportunity, but although he possessed the theoretical mastery of a university specialist, he had also the instincts of a practical engineer. His ultimate triumphs must have been reached through struggle and vicissitude, and there is ample evidence of the financial embarrassments to which he was at one time subjected.

Among the inventions that Erskine developed as practical machines, was a "centrifugal engine," or rather pump, very simple in principle. If, as he shows, we have a pipe not too long for suction and shaped as an inverted L, the lower end being immersed in water, and if after having started a stream flowing, we continue to revolve the pipe with sufficient speed about its vertical axis, the centrifugal force of the water in the arm will produce a continuous flow. The top part may, if desired, be made in hollow disk form, with

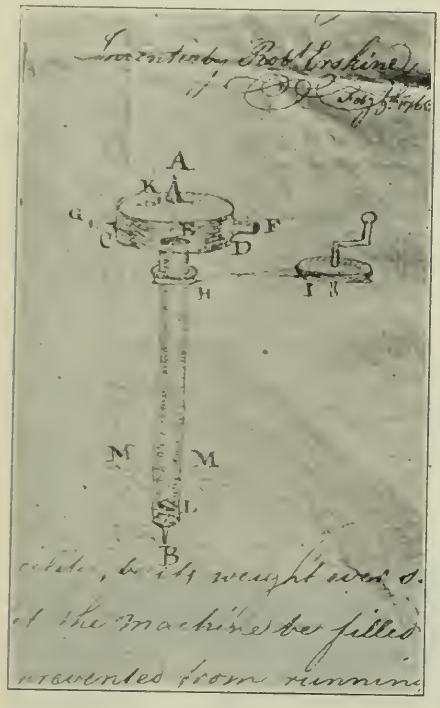


FIG. 1. PRINCIPLE OF THE "CENTRIFUGAL ENGINE" PUMP

several orifices, but their total cross-section should be less than that of the inlet pipe. The mechanical development of this conception was easy. Obviously the device possessed advantages as a pump through minimizing the number of moving parts and reducing frictional losses. The Erskine papers contain several sketches of this pump whether in its most elementary form or put into more marketable shape. Fig. 1 is a drawing that appears on a sheet bearing date February 9, 1763, the time of the writing or of the invention.

This centrifugal pump was offered as a competitor of the chain pump for bailing out ships, which led to a pumping of the ink bottle by their respective protagonists. Disputes over the features of a machine were waged in print 140 years ago quite after the modern fashion, but since specialized engineering papers like POWER did not then exist, the general press served as a forum for the discussion.

A correspondent of the *Gazetteer*, signing himself "W. B.," had atacked the centrifugal pump in favor of the chain pump, for we find among the Erskine manuscripts drafts of a letter to the printer of that newspaper in rejoinder, taking to task "W. B." for having "endeavored to impose on the *ignorant*." One such document is signed with Erskine's name, and another somewhat differently worded, with the disinterested *nom de plume* "Mechanicus." It does not appear which he employed in the letter as finally sent off.

He opened his defense with a remark that the invention had been suggested by a problem which one of the *Gazetteer's* own correspondents had proposed, viz., "contrive a method to make the siphon run out of the shorter end by means of an air pump." Erskine stated that one of the machines might be seen at Mr. Coles', near St. Thomas' Coffeehouse, on the Strand, and proceeded to describe it. With such a pump six men could raise 2 tons of water a minute at least 20 feet. The delivery increased faster than in proportion to the power applied. The radius of the ejecting tubes of the present engine, designed for a 60-gun ship, was 4 feet. He went on to compare the velocities of motion of the centrifugal and chain pumps under practical conditions of operation and to demonstrate that "W. B." had assumed for the operation of the chain pump feats of sustained human activity quite unreasonable to expect. Further, he pointed out that his own machine possessed advantages in its simplicity, high mechanical efficiency and freedom from liability to injury by anything less than a cannon ball.

Fumbling further among the old documents we come across a copy of a certificate by a committee to a comparative test of these two types of pump on board H. M. S., "Princess Mary," at Woolwich, 1766. The chain pump was in exceedingly good order. Ten stout men were allowed to each. Erskine's raised, in ten minutes, 14¾ tons of water, and the chain pump 11½ tons.

The Mr. Coles, to whom reference has been made was the builder of Erskine's pumps. The documents contain proof of extensive dealings between them, some of which were not altogether harmonious. One of the papers is an award of arbitration in a dispute with the result that Mr. Coles was not to make any of certain machines for 12 years. Another of Erskine's memoranda is a permit to certain men to build a machine for their own use in consideration of making one for him within a definite time.

Another of Mr. Erskine's inventions was a "continuous stream pump," which was an ordinary double-acting one in principle, though having an external contour that suggests the pulsometer. (Does Erskine pose as originator of the duplex pump?) Fig. 2 is a sketch of it, while Fig. 3, is an illustrated circular or data sheet relating to a form of it as constructed for domestic uses.

The drawing, Fig. 2, appears in a letter by Erskine to Mr. Watthews, or Matthews, watchmaker, on Fleet street, February 11, 1766, which concludes by describing methods of raising water where there is a fall. He writes:

> If the situation of the place is such that the hight from the surface water to the back level is *greater* than from the back level to the bottom from whence the water is raised, if this is the case there is a method of raising the water from the bottom to the back level [bv] the force of the surface water (if the back level is but a few feet lower than the middle of the pit) without any machinery at all and the same quantity of water that runs down from the surface can be made to flow up from the bottom, it will only require the attendance of a boy to turn the cocks and I suppose will last some centuries. It is called Hero's fountain. I have seen it described with four cocks and some valves, but could improve it to want only two cocks and by a little study and some few experiments I believe I could make it work without any attendance at all . . . . P. S. I.

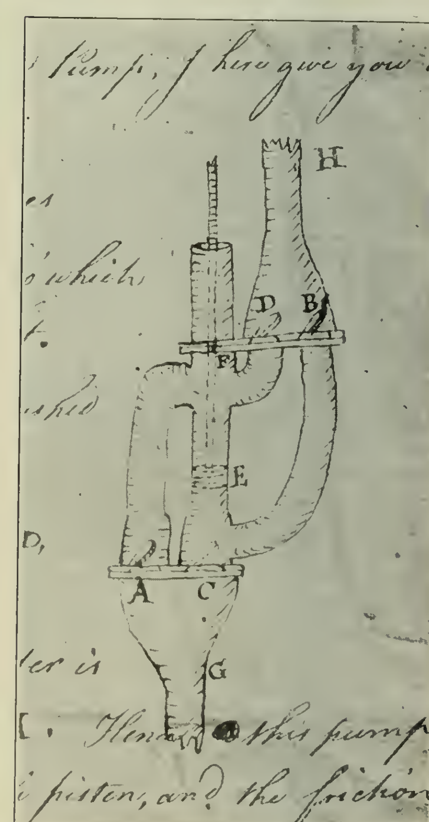


FIG. 2. "CONTINUOUS-STREAM" PUMP

> never undertake to design and give a drawing of any machine for less than five guineas.

The foregoing device was manifestly intended to perform some such task as is now done by the hydraulic ram. Some of Erskine's papers are filled with his study over a device which he terms a "quadruple Hero's fountain," by means of which he sought, "with a fall of 6 feet to raise 1/6 of the whole stream." The stream was divided among five troughs, each of which communicated with five vessels, all except one or both at the ends being air tight. Below them were five other cells piped from near their bottoms to the bottoms of the ones directly above and also piped from their tops to the upper parts of the ones above next adjacent on the left. (The reader may from this description draw his own diagram.) By this means the pressures could be accumulated from right to left so that in the upper vessel farthest to the left the water would rise 24 feet, 20 feet of which was lift. The

Prussia. Lists of installations seem to show that his machines had considerable vogue.

Robert Erskine's hydraulic proficiency must have been a valuable asset for him when, as we shall shortly learn, he came to America, for the development of water powers in northern New Jersey and southern New York was carried on extensively during colonial days. The damming of streams and collection of water in large reservoirs was then resorted to for power purposes on a scale second only to modern undertakings in the same region to supply cities with water. Furthermore, it was

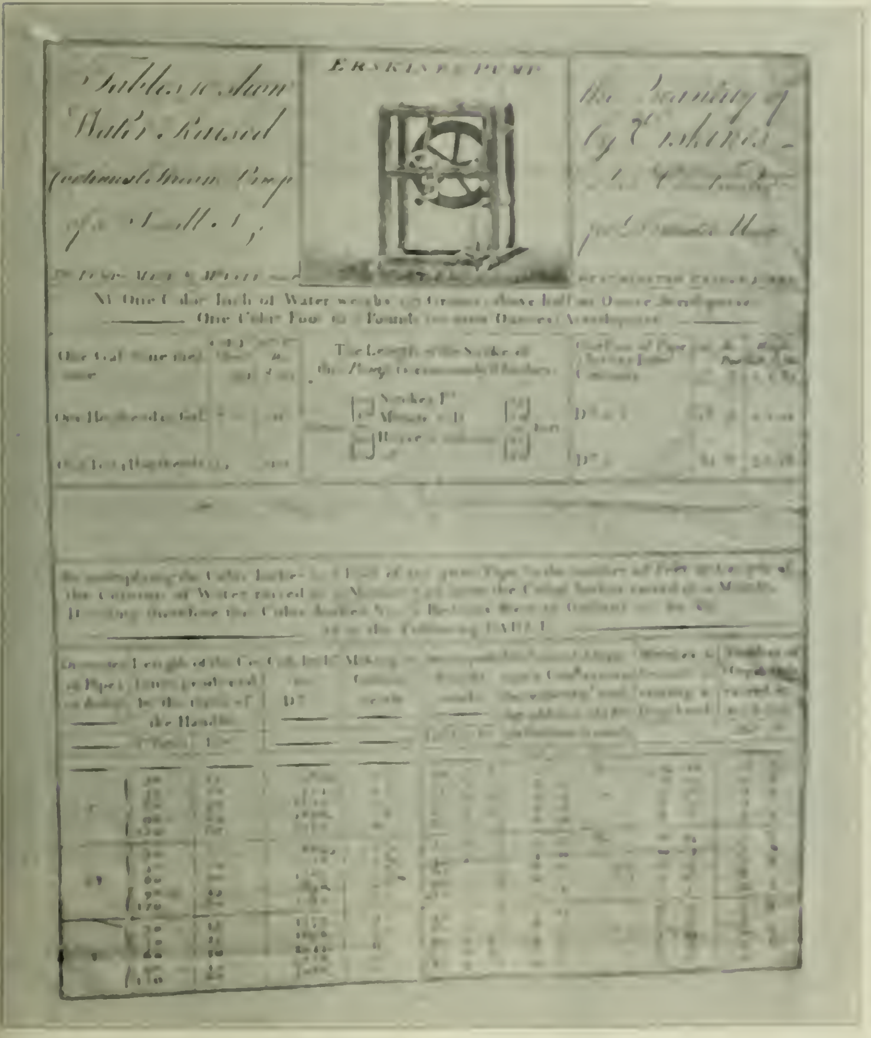


FIG. 3. DATA SHEET OF "CONTINUOUS-STREAM" PUMP

biographer assumes no responsibility for a complete explanation of the details of the machine, nor for its performance according to contract.

Altogether, Mr. Erskine's pumps displayed considerable variety in type and purpose, and in motive power, which might be hand, horse or hydraulic. Characteristic of his engineering activity was the design of plants to meet particular conditions of raising water on gentlemen's estates. Draining mines was another utility. Among orders received by 1765 was one for a large centrifugal engine (pump) to be used in salt works of the king of

a priori requisite of a mine operator that he should know how to handle pumps.

But Erskine's ingenuity was not confined to hydraulics. He invented a horizontal windmill and a conduit [illegible]. The [illegible] drawings [illegible] designs of [illegible] or mathematical instruments [illegible]. His [illegible] is suggested by a letter to the London Chronicle on [illegible]. His [illegible] is shown by the fact that he was made a fellow of the Royal Society. Whatever may have been, or failed to be, the financial [illegible] of his technical skill, he won a high reputation for integrity and ability, as is proved by

the enterprise for a position of great responsibility on the continent. He was engaged, about 1770, to go to America and retrieve the failing fortunes of an iron trust. His salary was to be £250 a year, with sundry additional allowances.

The New York and New Jersey Iron Works, American Company, or London Company, as variously called, was a British concern possessing industrial interests to the value of nearly a quarter of a million dollars at Ringwood, Long pond (now Greenwood lake), and Charlottenburg, N. J., and Cortlandt Furnace, N. Y. The plant that figures most prominently was that of Ringwood, within the limits of the present Passaic county, N. J., close to the New York line. The nucleus of the industrial estate had been established by the Ogdens, a famous New Jersey ironmaster family, who had purchased the land in 1740 and sold out in 1764 to the London company, organized by an alert German, Baron Peter Hasenclever, one of the most distinguished colonial ironmakers. He [illegible] a [illegible] of stock [illegible], to which both gentlemen and ladies of high station in England subscribed, and brought over 535 persons from Germany as a laboring population. There were some 75 square miles or more of territory comprised in the undertaking. Energetically he set about enlarging the plants. By the end of a couple of years they were equipped with four [illegible] furnaces, a [illegible] and pearl-ash manufactory (on the Mohawk river), 235 workshops, stores and dwelling houses, dams for 15 mill-ponds and 15 bridges, with many miles of roads. One of his dams was [illegible] feet long and 12 feet high. But the same story, as with American manufactures, [illegible] works failed to pay, and about 1769 he went into bankruptcy, partly at least, through the misconduct of a partner. He [illegible] was lasting some years. Hasenclever received [illegible] or less vindication of his conduct. Though adventurous, he was a sincere and [illegible] man and, according to the best information, he afterward became a successful linen manufacturer in Silesia. In the management of the American business he was succeeded by John Jacob Faesch, a German, whom he had brought over, and under whom the works remained unprofitable. Hasenclever's bankruptcy does not seem to have destroyed the company, since the document that employed Erskine [illegible], at this time, in controversy with Hasenclever. Erskine used his correspondence with much [illegible] against both Hasenclever and Faesch, and he did [illegible] to [illegible] Faesch as [illegible]. Though [illegible] on this [illegible], he is open to [illegible] of [illegible]. Faesch remained in the [illegible] as [illegible] with [illegible], and he died with a character highly esteemed.

After Erskine had held the management for a few months, he was asked to report on the advisability of selling the works at a sacrifice. His advice, though given with caution, was adverse to such a project. "I am but a taming the Forgemen," he wrote, "though there are several ways in which your expenses may be lessened and your profits increased." He alluded moreover to his intention of trying the sulphury ore in the furnace and to his belief that another body of ore might be found near Charlotteburg. Manifestly, his counsel to hold the works prevailed.

After taking charge, Mr. Erskine adopted the plan of writing long letters to the company or interested individuals at home describing the state in which he found things and the methods of his management. Some letters he regarded as of so confidential a nature that he felt it necessary to write and copy them with his own hand, which he esteemed quite a burden. Today a correspondence equal in magnitude and importance would be dictated to a stenographer or a phonograph between puffs of a cigar.

These reports make an interesting picture of so multifarious an industry as a large ironworks of colonial times. It was a little self-sufficient world, utilizing the products of the soil in many different ways, with a systematic division of labor. In his control of ore and fuel supplies, transportation facilities, etc., Erskine was a primitive Carnegie. He was not, however, like Carnegie, at liberty to work up his pig and bar iron into finished products. If his company had announced the erection of a steel furnace or of a rolling mill beside Long pond, such as, upon a memorable occasion, Carnegie proposed to build at Conneaut, by Lake Erie, the concern would not have been bought out by its competitors with 5 per cent. first mortgage bonds, but would have fallen into the clutches of the law. For the policy of the British government was to reserve the manufacture of finished iron materials as a home monopoly against the colonists, by a principle much like that which the United States follows in some of its dealings with the Philippine islands. A parliamentary act of 1750 had forbidden the erection in America of any new steel furnace or rolling or slitting mill, etc. After that, none could be put up unless to operate by the moonshine method, like the slitting mill of Samuel Ogden, at Old Boonton, which, it is said, ran under the innocent guise of a grist mill.

"The concerns of the company for which I am engaged," wrote Erskine to one of his correspondents, "are very great. The amount of their inventories at New Year in iron, goods, cattle and movables alone was upward of £30,000 currency; the annual circulation of cash and supplies is between £20,000 and £30,000. . . . . I have eight clerks, about as many overseers, forgemen, founders, colliers, wood cutters, carters and laborers to the amount of five or six hundred."

"I design to follow," he remarked, in beginning a report to the proprietors, "the natural order of things as they arise. Wood, Charcoal and Ore are the First in Course the furnace, its Construction and appurtenances, the Roasting, mixing and smelting of ore into pig metal come next, together with a variety of other articles which may occur during (the time when the furnaces) are in Blast, then come the forges with all their connections, which will include the processes of the Manufactory of Bar Iron faults improvements. etc. Provisions and necessaries, Farms, Horses, Cattle, Carriages, Roads, Mills, Dams, Houses, etc., must follow."

Among other subjects requiring discussion were his system of bookkeeping and his relations with labor. He outlines the various time- and piece-work methods by which are paid the different sorts of workman—carters, blacksmiths, coalstockers, furnace fillers, founders, miners, forgemen, managers, clerks, overseers. The lower grade he has found hopelessly in debt to the company store, and describes how he has won the gratitude of some carters by raising their wages £5 a year to a total of £60. The company, he suggests, would better have contented employees than a deceptive balance in its favor, and from other quarters than pinching the hard-earned wages of the laborer he is sure the proprietors would wish their profits to arise. Yet he favorably contrasts the lot of even the poorest with that of their equals in Scotland and Ireland. The necessities of the cheaper workmen keep them bound to the company stores, but the more highly paid, such as the forgemen, do better by purchasing provisions from neighboring farmers. The company itself obtains supplies from these farmers and Erskine denounces their extortion in demanding New York prices for their produce.

"Faesch gave me all the trouble he could," wrote Erskine somewhat later. "The founder at Charlotteburg almost overset [?] the furnace (to appearance on purpose) for which I put him in jail till he found security to answer an action of £200 damages I brought against him. He [Faesch?] decoyed away some of our Forgemen too, to work in some forges adjacent to his furnace which they hired and most of the poor Creatures have been kept without work at the top of all the money they earned at your work, and are now come and earning again very thankful to be employed and will make the better hands than ever."

"The last time I was in Charlotteburg," remarked Erskine in one of his letters, "a bar of iron was tried on purpose to see how many strokes it would take to break it, when it bore above fifty blows of a sledge hammer upon an anvil before it gave way." Again, he is gratified to note that his iron has acquired among the country blacksmiths a reputation for being "plaguy tough." Iron from Charlotteburg, after trial, was marked cold with a star of five rays, from Ringwood with one of six and from Long pond with one of seven.

Fame has fastened upon the steam engine erected at the Schuyler copper mine, near the Passaic river, New Jersey, by Josiah Hornblower, 1753-55, as the first one installed in America. It would appear that Erskine imported engines only a few years later, since in a letter which he must have penned early in 1772 he states: "I hope the Fire Engines are finished and on the way which I mentioned last autumn." "Fire engines," as we should be aware, meant, in that day, steam engines. It is not to be inferred that Erskine ceased to depend chiefly on water power to drive his blowers and other machinery. Doubtless his engines were intended for pumping mines at a distance from any stream.

The term "fire engine," however, was also applied in the modern sense, to pumps for extinguishing fire. In that day they were, of course, driven by hand power. As long ago as 1719, the city of Philadelphia paid "for ye ffire engine." It is entirely possible that the machines imported by Erskine were intended to check the spread of conflagrations in the numerous buildings of his works. Whether they were of this sort or were truly steam engines, may be left as one of the great unanswered riddles of history.

It is significant to peruse Mr. Erskine's letters to his employers as noises of the awakening insurrection of the colonies began to be heard and until correspondence was broken off by the progress of the revolt. Candidly he interpreted to them the sounds of disturbance and gave them due warnings of what was coming. In June, 1774, he said: "I have no doubt that a total suspension of commerce to and from Great Britain will certainly take place. Such I know are the sentiments of those who even wished a chastisement to Boston."

He writes under date, August 2, 1775, that the British man-of-war "Asia," is turning back boats with produce and iron from the Jerseys, in consequence of the restraining act. He will forward as much iron as possible before the tenth of September, when exportation ceases. On October 31 he advises of the probability that the seat of war will be transferred to New York and the business of the works be interrupted. February 10, 1776, he writes, inclosing his cash account for January.

As it proved, the works were kept in operation during the war, since they were within the lines of the insurgents, for whom they became a prolific source of munitions, including some of the iron work of the Hudson river obstructions. Preponderant sentiment in New Jersey and New York hardly sustained the wisdom of the rebellion, yet Erskine eventually threw in his fortunes with it. He organized the employees of the works into a company of militia which he equipped at his own expense. The rebels, moreover, made him geographer and surveyor general to their "Continental army." There is said to be in existence somewhere a letter received by Erskine from Mr. Washington, the leader of the insurgent bands, asking him if he considered himself the proper sort of man for the above-mentioned job. In entering upon this office he again reminds us of Mr. Carnegie, who undertook public service as Eastern superintendent of military railways and telegraphs in the war between the States.

That Erskine was an honest man is evidenced by the books of accounts which he continued to keep with the proprietors of the iron works, whom we may assume still to be the English ones, and to whom, although cut off by the war, he acknowledged a persisting business obligation. The salary with which he credited himself jumped from £370 in 1777 to £1125 in 1778 and £1110 in 1779, which would look like an attempt to make hay while the sun shone did not the inflation of the currency suffice to explain the apparent raise.

Robert Erskine did not live to see the rebellion successful. He died October 2, 1780, the day that Major Andre was hanged and was buried at Ringwood. Mr. Washington came from the gallows at Tappan to attend his funeral. It may be presumed that after the end of the war, if not before, the iron works were sold by the State of New Jersey under confiscation proceedings. These were one of the methods of persecution by which the victorious party took revenge against the loyalist fellow countrymen. Non-resident Britishers, such as the London Company, would not be likely to fare better. The estate may have been split up at this time. It was manifestly divided in ownership a few years later when it was visited by a French author known as the Marquis of Crevecoeur. He found the Ringwood and Charlotteburg plants in the hands of separate managers to whom he refers as proprietors. The master of Ringwood was a Mr. Erskine, who was doubtless a son or nephew of the great engineer. A few extracts from Crevecoeur's narrative are pertinent to quote:

"The proprietor of these [Ringwood] works, Mr. Erskine, had, as we knew, spent three years in Europe visiting the principal forges of Scotland, Sweden and Germany. His operations, although less extensive, seemed to us no less interesting. The construction of the different machines intended to simplify the work was even more perfect than what we had seen at Sterling. A large *movement* for flattening and slitting the iron into rods appeared to Mr. Herman a *chef d'oeuvre* of simplicity, but what rendered it yet more curious was the flour mill by which it was surmounted, and which could be lowered when it was wanted for use and raised when the grinding was finished. . . . [Regarding the forests in this part of the country, one of visitors remarked to Mr. Erskine]:

"'If your posterity preserves these beautiful woods it will for many centuries enjoy the precious advantages of having the charcoal necessary for making iron, facilities for repairing buildings and dams, and all the power required.'

"'You are right,' said Mr. Erskine, 'it is probable that this will come to pass, since the entire chain has long been the property of a few individuals extremely interested in the preservation of the forests.'

"Next day we came across a very mountainous country to Charlotteburg. The works here had been erected before the Revolution by an English company, which the war had ruined. The . . . proprietor was absent. . . . The water reservoir was immense."

The preservation of natural resources was a consideration even in the eighteenth century. It is true now, as it was then, that the Ramapo mountain country is largely held in single ownerships amounting to many thousands of acres each. The hills are remarkably wild for a region only thirty or fifty miles from New York city hall, though I do not venture to say how much of the wood is primeval forest or merchantable timber. At villages not far from Paterson the wildcats are so tame that they come and eat out of the ash barrel. Charcoal burning has ceased to be a necessary industry, but the water powers of the region ought to be valuable. It is probable, however, that the available water will all be needed for municipal supply. A few years ago there was a project to pipe it to New York, but so many political possessions were raised in that the water would have poisoned anyone who had drunk it. One of the accompanying illustrations shows a wash-out by the bursting of a pond or reservoir at Sterlington, not far from Ringwood, in a freshet five years ago. I am told that practically all of the gulley visible was cut by the flood and that the water reached the eves of houses on the plain below.

WORK OF HYDRAULIC POWER, NEAR RINGWOOD

A little journey to Robert Erskine's grave at Ringwood was made in the course of preparing this sketch of his career. The place has long been occupied by the Cooper-Hewitt interests, who still conduct mining operations there, and the country for miles around is kept up as a magnificent residential estate. It was the home of the late Mayor A. S. Hewitt, of New York. C. S. Stoney is the courteous superintendent of the industries. A considerable stream filled with ripples that suggest hundreds of unused horsepower flows down from the north and forms a lake near which the Erskine grave is situated. As shown in the photograph, the slab at the right is Erskine's, while at the left is buried his clerk, Robert Monteith, also of Scotland, who preceded him in death by several years. Near the former tomb is an old stump which does not look very beautiful, and the skilled photographer conveniently kept it out of the field of the picture. Information has since been acquired that the tree was planted there by Mr. Washington (no doubt as a penance for cutting down the cherry tree), but the reader may be regarded too callous to see it by a reiterated assurance that it is quite an ordinary stump and not a bit more worth looking at than those which are planted by the hand of nature.

A vainglorious tree insisted upon posing for her picture.

Testing and Adjusting Watt-Hour Meters

Practical Methods of Handling Westinghouse Instruments, with Wiring Diagrams Showing Proper Connections for Best Results

BY O. F. DUBRUIEL

Every well-equipped power station, in order to get satisfactory performance by its watt-hour meters, should have its own meter department, provided with the best appliances possible for overhauling, testing and checking the meters. The premises containing this department should be absolutely free from vibration and equipped with solid, substantial testing racks. These racks should be suitably provided with lampboards, switchboards and resistances so arranged that the loads through the meters can be easily changed and each load can be maintained at a constant value while readings are being taken.

In testing, a constant voltage is essential and this voltage should be that which is applied to the meter terminals when the meter is installed. To obtain the various voltages for the testing racks a potential regulator is a most convenient piece of apparatus. A transformer with a number of loops brought out from the secondary winding to binding posts will, however, accomplish the same results, but the former is always to be preferred.

It is essential for accurate work that the best standard instruments should be obtained, for good results cannot be secured with inferior instruments. These standard instruments may consist of voltmeters, standard integrating watt-hour meters, standard indicating wattmeters and stopwatches.

There are two methods of checking a watt-hour meter calibration. The first method is by comparing the meter to be checked with a standard indicating wattmeter. When using this method the instruments should be connected to the circuit and a constant load applied; by timing the disk a composition load can be obtained. The second method is by comparing with a standard integrating watthour meter; by this method it is only necessary to notice which of the two instruments was in synchronism to determine whether the wattmeter in question is in correct calibration. A well-equipped station should have the necessary instruments to check by either method.

To Test a Westinghouse Type A Two-wire Single-phase Meter

Connect the wattmeter in circuit with a standard indicating wattmeter as indicated in Fig. 1, being careful to make the connections exactly as shown. Load the circuit until the desired reading is obtained on the indicating wattmeter and keep it at a constant value while the integrating watt-hour meter is being read. Time the number of revolutions of the disk with a stopwatch, commencing to count when the spot on the disk has made one revolution (after the watch has been started), and count the revolutions for at least one minute to arrive at the number of watt-hours registered by the meter. Use the following formula:

$$\frac{K \times R}{S} = watts,$$

where R = number of revolutions made by the disk, S = time to make revolutions and K = constant, which is equal to the volts multiplied by the amperes (as marked on the counter) and multiplied by 1.2. When this type of instrument is used with series transformers, and checked without them, K = volts as marked on the counter multiplied by 6. For wattmeters used with series and shunt transformers but checked without them K = 600.

When testing with the standard integrating watt-hour meter connected as shown in Fig. 2, when more than one meter is to be checked against the standard, it should be connected as shown in Fig. 3, but only one meter can be run with the standard at a time; otherwise the meter nearest the line connection will measure the energy taken by the shunts of those nearest the standard.

Type B Single-phase Meter

The formula for this meter is the same as before, but in this case, with the two-wire meter, K = volts × amperes (as marked on the counter) × 2.4. For meters used with series and shunt transformers, but checked without them, K = the rated watts × 5 × 2.4, since these meters have five-ampere series windings.

For Type B three-wire single-phase self-contained meters used with acid transformers, K = constant or volts × amperes (as marked on counter) × 4.8, and for Type B three-wire single-phase meters used with transformers, K = volts (as marked on the counter) × 12.

For Type C three-wire single-phase

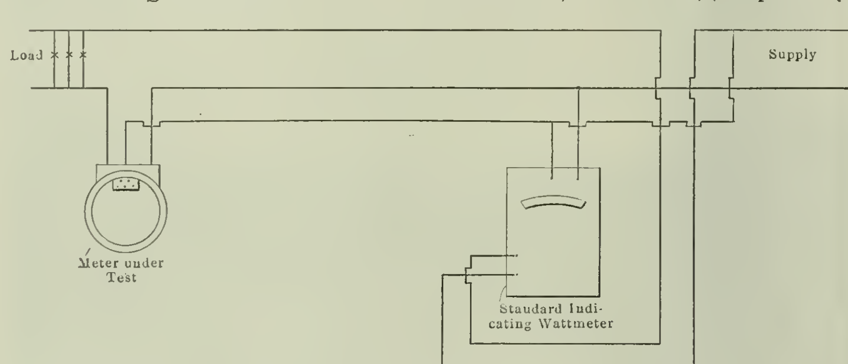


FIG. 1

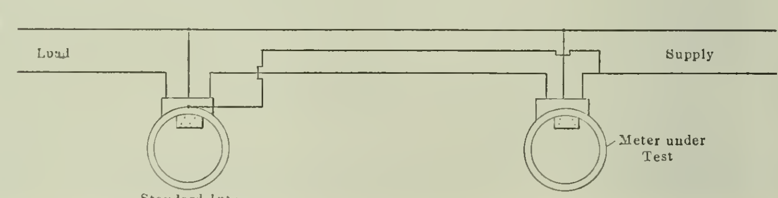


FIG. 2

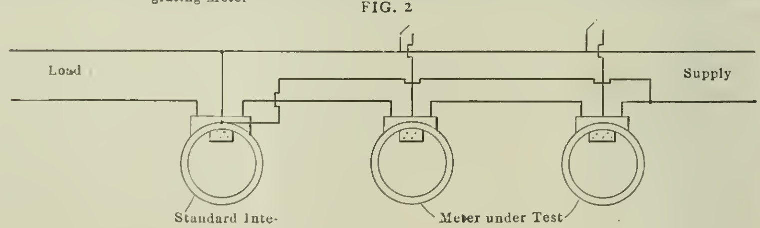


FIG. 3

meters up to 40 amperes capacity, $K =$ volts (between outside wires as marked on the counter) $\times$ 2.4, and for Type C polyphase meters, without series or shunt transformers, $K =$ volts $\times$ amperes $\times$ 4.8; for meters used with series transformers only (but checked without them) $K = 5$ $\times$ volts (as marked on the counter) $\times$ 4.8, and $K = 2400$ for meters used with shunt and series transformers, but checked without them.

In checking polyphase meters it is best to check them as single-phase meters; that is, check over one element of the time. See Figs. 4 and 5.

To check a polyphase meter as a single-phase meter connect the current coils in series and the potential coils in parallel.

Type F Long Scale Indicating Wattmeters for Alternating Current

For accuracy in using these indicating wattmeters the following should be taken into account. In all indicating instruments there are two kinds of error, an initial error independent of the load, which is due to traces of friction, parallax, coarseness of the divisions on the dial, etc., and an error proportional to the reading due to inaccuracies in calibration errors in the standards used, and causes varying the constants of the instruments. In the Type F instrument the former error amounts to five-tenths of one per cent. of the full scale reading, and the latter to five-tenths of one per cent. of the actual reading; therefore, to find the total error at any point within which the readings may be relied upon, the following formula should be used:

$$\textit{Per cent. total error} = \frac{0.005\,A + 0.005\,a}{a},$$

in which $A =$ full scale capacity and a the actual reading. Any visible zero error should be allowed for in reading.

In the lamp-testing wattmeters the initial errors amount to one-tenth of 1 per cent. of the full scale reading and the proportional error to two-tenths of 1 per cent. of the actual reading. Therefore, to find the total error at any point within which the readings may be relied upon, the following formula should be used:

$$\textit{Per cent. total error} = \frac{0.001\,V + 0.002\,v}{v},$$

in which $V =$ full scale capacity and v the actual reading; any visible zero error should be allowed for in the reading.

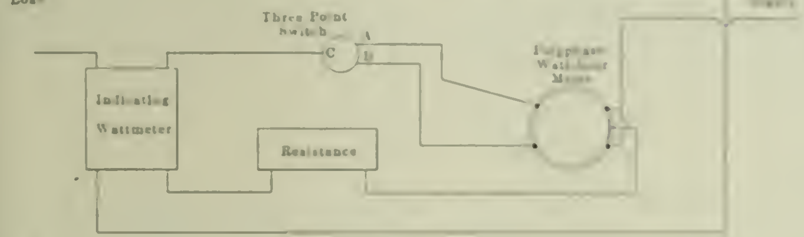


FIG. 4

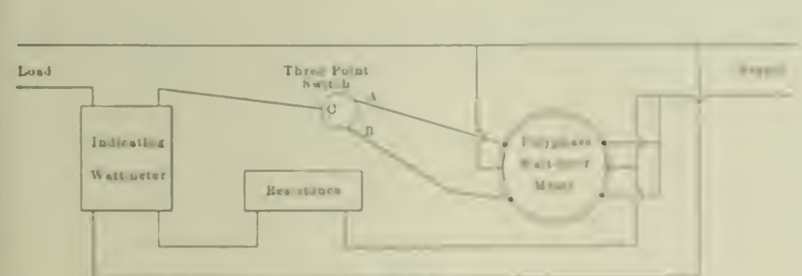


FIG. 5

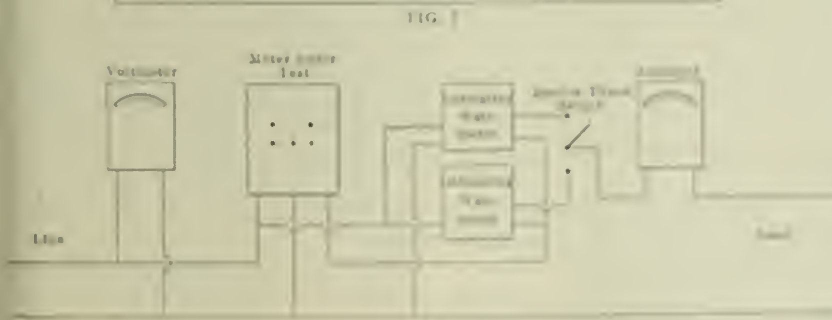


FIG. 6

Portable Long Scale Indicating Wattmeters for Alternating Current

The accuracy of the calibration of this instrument may be stated by saying that the errors of full scale reading amount to two-tenths per cent. and those of the actual reading two-tenths per cent. Therefore, to find the error of calibration at any point the following formula may be used:

$$\textit{Per cent. error} = \frac{0.2\,W + 0.2\,w}{w},$$

in which $W =$ full scale capacity, and w the actual reading. Any visible zero error should be allowed for in the reading. For example take a [illegible]-kilowatt instrument indicating 30 kilowatts:

Per cent. error of calibration =

$$\frac{0.2 \times [illegible] + 0.2 \times 30}{30} = [illegible]$$

per cent.

Wishing to find the number of seconds S in which the disk should make the test number of revolutions with a certain load, use the following formula:

$$\frac{K \times R}{P} = S,$$

where

$K =$ Constant,
$R =$ Number of revolutions in test,
$P =$ Watts indicated by indicating wattmeters.

The value of K may also be found by transposing the formula, thus:

$$K = \frac{P \times S}{R}$$

Connect the polyphase meters as shown in Figs. 4 and 5. This connection shows the meter in a single-phase two-wire circuit with a standard indicating wattmeter. Be sure that the connections are made exactly as shown in the sketch. Both shunt circuits of the integrating watt-hour meter are connected with the main circuit; however, the current passes through only one series coil at a time by connecting the point C to either A or B. When this one circuit of the meter is fully loaded the rotating element will make one-half the number of revolutions which it makes with full load on both circuits. Now pass through the circuit a given number of watts which must be kept as constant as possible while the reading is being taken. After the test has been made on one side the same test should be made on the other side. If C is connected to A in the former test, connect it to B, and vice versa, the shunt connections remain the same as in the first test. The main current is now, however, passed through the other circuit, the first series circuit being entirely disconnected. Be sure that both shunts are connected when testing.

Fig. 6 shows the connections that will be made on a testing board where direct and alternating watt-hour meters are tested by the use of a voltmeter, two indicating wattmeters, a double-throw switch and an ammeter. When testing direct-current meters use a voltmeter [illegible] and an ammeter, and for alternating current use a voltmeter and an indicating wattmeter. Two indicating meters are used, one with a small range and the other with a large range, in order to avoid errors in reading a small load at the lower end of the scale of a large instrument.

Calculating Strength of Riveted Joints*

A New and Original Method Dispensing, by the Use of Diagrams, with the Labor Involved in the Usual Calculation

BY S. F. JETER

The purpose of the present article is to show how most of the labor involved in the calculations of riveted joints, as generally applied to boiler construction, may be dispensed with. The method of doing this is by the use of diagrams, and while those shown in connection with this article are all based on tensile strength of the plate, shearing strength of the rivets and crushing strength of the rivets, of 55,000, 42,000 and 78,000, and 95,000 pounds per square inch, respectively, the methods used in constructing the diagrams will be explained fully and the formulas given, so that those who are concerned with the design of such joints, or who may frequently have to calculate their efficiency, can construct diagrams to suit their special requirements as regards the above mentioned values.

After the principles are thoroughly understood, it will be found a very easy task to construct the diagrams, and the writer has found that the labor involved may be greatly reduced by making use of standard cross-section paper, a very convenient size being 16x21 inches divided in tenths. This can be procured from any dealer in drawing materials for five cents per sheet. It is, of course, not essential to have the form of joint shown in the corner of the sheet, but it was done in the present case merely as an aid in explaining the diagrams; a written description of the joint would answer equally as well. It is impossible to explain the diagrams or the method of their construction without the use of formulas or the aid of analytic geometry; it is, however, not necessary that the reader be versed in either the use of formulas or analytic geometry to make full use of the diagrams in shortening the calculations necessary to determine the efficiency of the various joints considered.

The method, about to be described, of determining the probable mode of joint failure directly without calculation and comparison of values is entirely original with the writer, and as far as he can ascertain it is different from any method which has been previously published on the subject. The principle may be stated thus:

With a given diameter or area of rivet and fixed values for the tensile strength of the plate and crushing and shearing strength of the rivets, straight lines or curves may be drawn, representing values of pitch of rivets or thickness of plate, or both, at which either of the two compared possible modes of failure would be equally probable. Representing the pitch of the rivets by distances on the axis Y and the thickness of the plate by distances on the axis X, or *vice versa,* lines may be drawn representing comparisons between all of the possible modes of joint failure for a given rivet diameter, and the most likely mode of failure, for a given pitch of rivets and thickness of plate, can be determined without calculation by noting the direction in which the point of intersection of the lines, representing the

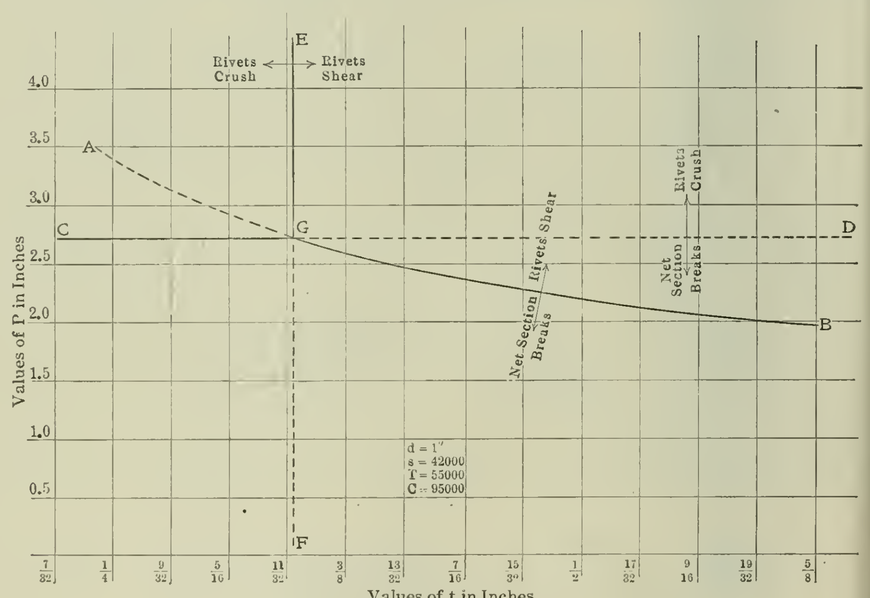


FIG. 1. DIAGRAM FOR A SINGLE-RIVETED LAP JOINT

pitch of the rivets and the thickness of plate lie, with respect to the lines denoting equally probable failure.

In the following explanation for all forms of joint the notations given hereafter will be adhered to.

T = Tensile strength of plate per square inch, in pounds.

S = Shearing strength of rivets per square inch, in pounds, when subjected to double shear.

s = Shearing strength of rivets in pounds per square inch, when subjected to single shear.

C = Crushing strength of rivets in pounds per square inch of projected area of contact between rivets and plate.

P = Pitch of rivets, in inches.

d = Driven diameter of rivet, or diameter of hole, in inches.

t = Thickness of plate, in inches.

In joints that have more than one pitch, P always represents the greatest pitch of rivets. The dimensions corresponding to P, d and t are given on the drawings illustrating the forms of joints in the upper corner of each diagram.

Bearing in mind the notations just given and considering a single-riveted lap joint, the three modes of possible failure, as given in the previous article on page 28 of the July 7 number of POWER AND THE ENGINEER, would be represented as follows:

Breaking of net section between rivet holes

$$t\ T\ (P - d) \qquad (1)$$

Shearing of rivets

$$0.7854\ d^2\ s \qquad (2)$$

Crushing of rivets

$$C\ d\ t \qquad (3)$$

By making (1) and (2) equal to each other and solving for P, the following would result:

$$t\ T\ (P - d) = 0.7854\ d^2\ s,$$

or

$$P = \frac{0.7854\ d^2\ s}{t\ T} + d.$$

Substituting in this equation the values of 55,000 for T and 42,000 for s, it would become:

$$P = \frac{0.6\, d^2}{t} + d. \qquad (4)$$

Now if values for t and P are laid off on the axes of X and Y, respectively, and this equation is plotted with any fixed value for d, a curve would be obtained, and if the pitch and thickness indicated by any point on this curve was used in constructing a single-riveted lap joint, the probability of failure by breaking the net section or shearing the rivets would be the same, and since an increase in pitch would strengthen the net section, without adding strength to the rivets to resist shearing, all points lying above this curve would denote corresponding values for pitch of rivets and thickness of plate that would cause joint failure by shearing of the rivets rather than breaking of the net section of the plate, and conversely, points lying below this curve would indicate breaking of the net section of the plate, rather than shearing of the rivets. Again, if equation (1) is made equal to equation (3), the following results are obtained:

$$t\ T\ (P - d) = C\ d\ t$$

or

$$P = \frac{C d}{T} + d,$$

which reduces to

$$P = 2.73\ d \qquad (5)$$

when $T = 55{,}000$ and $C = 95{,}000$.

This equation represents a line parallel to the axis of X and at a distance $2.73\,d$ above it; a joint designed with this pitch of rivets would be equally as strong to resist rupture by crushing of the rivets or breaking of the net section of the plate with any fixed value for d, and since an increase in pitch of rivets would add strength to the net section of the plate, without adding to the strength of the rivets to resist crushing, all points lying above this line would represent pitches which would cause the crushing of the rivets to be more likely than breaking of the net section of the plate and conversely those values of P lying below it would indicate joints where the net section of the plate would be weaker than the rivets.

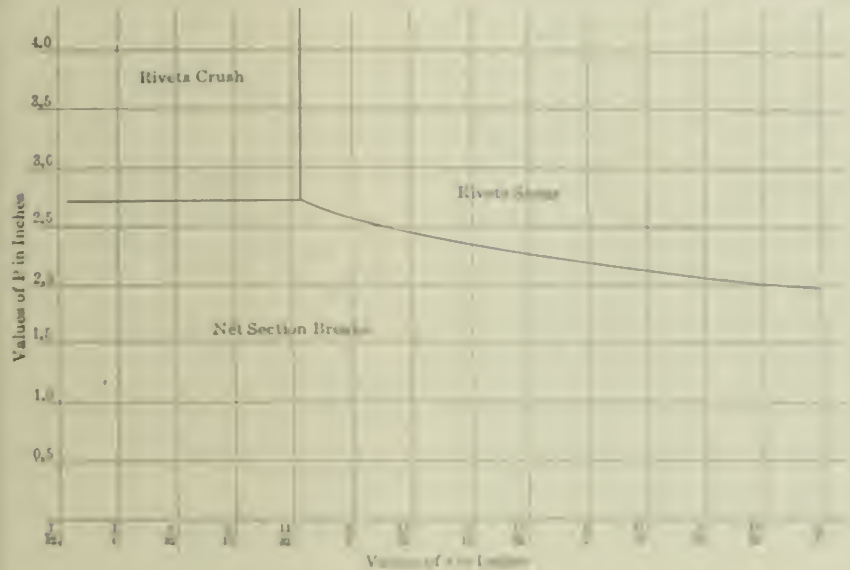


FIG. 2. DIAGRAM OF FIG. 1 SIMPLIFIED

Making equations (2) and (3) equal each other, which is the last comparison possible, the following results are obtained:

$$t = \frac{0.7854\ d\ s}{C},$$

or

$$t = 0.347\ d \qquad (6)$$

when $C = 95{,}000$ and $s = 42{,}000$. This equation represents a line parallel to the axis of Y and at a distance $0.347\ d$ from this axis, and since an increase in the thickness of the plate increases the capacity of the rivets to resist crushing, but does not add to their resistance to shearing, all values to the right of this line would indicate joints which would fail by shearing of the rivets rather than by crushing them, and conversely, those to the left would indicate crushing of the rivets rather than shearing them.

FIG. 1. DIAGRAM FOR THE [illegible]

In Fig. 1 equations (4), (5) and (6) have been plotted, assuming a value of 1 inch for d. Line $A B$ represents equation (4), line $C D$ equation (5) and line $E F$ equation (6). The lower line represents the axis X, while the axis of Y and the origin are $\frac{7}{16}$ inch or seven units of thickness to the left of the last vertical line on the left. As may be noted, the three lines representing the equations intersect in a common point G, and if a joint should be constructed of one-inch rivets and with the pitch of rivets and thickness of plate equal to that indicated by this point, failure would be equally probable by shearing of the rivets, crushing of the rivets or breaking of the net section of the plate and this would also be a joint of maximum efficiency.

The arrows pointing from each side of the three lines denote the mode of probable failure for values of P and t each side of the line in the directions indicated. Since all values lying to the left of $E F$ would give joints in which the rivets would crush instead of shearing, the portion of the line $A B$ denoting comparisons between the breaking of the net section and shearing of rivets, which lies in the area $A G$, can be dispensed with, for in estimating the strength of joints, it is necessary to compare only the strength of the portion most likely to fail with the strength of the solid plate. Since all of the area to the left of $E F$ denotes joints which would crush the rivets rather than shear them, the only comparison which would be of value in this area would be that between the crushing of the rivets and the breaking of the net section of the plate, which is represented by the line $C G$. For similar reasons, the line denoting comparisons of the strength of the net section of the plate with the crushing strength of the rivets, lying to the right of $E F$, or $G D$ can be removed; the lower portion of line $E F$, or $G F$, has no significance, as the area below $C G B$ indicates pitches and thicknesses of plate where the net section of the plate is weaker than either the shearing or crushing of the rivets, and therefore there is no need of determining the relative probability of failure by these two methods in this area. Removing the dotted portions of the various lines, a diagram like Fig. 2 will result, and all corresponding values of P and t which lie in each of the three divisions, would indicate joints which would fail in the manner noted in Fig. 2.

The previous description of the principles involved in making a diagram for a single-riveted lap joint holds good for all forms of joints with one pitch of rivets, as all equations of such joints, giving comparative values between the different modes of possible failure, are of the same form as (4), (5) and (6).

It will be noted that the equation of equality between the breaking of the net section of the plate and the shearing of the rivets, equation 4, is that of a hyperbola, and since it is very tedious to plot such a curve, the value of this method of shortening the labor involved in the calculation of joints would be greatly lessened if there were no way of obviating this difficulty, but a very simple expedient may be made use of, so that all equations may be represented by straight lines. This may be accomplished by laying off the values of t along the axis of X, equal to the reciprocals of the thicknesses instead of directly equal to them, and then equation (4) becomes

$$P = \left(\frac{1}{t}\right) 0.6\, d^2 + d,$$

or a straight line cutting the axis Y at a distance d above the axis X. Since the intersection of the lines representing equations (5) and (6) give another point of this line, it is only necessary to join the two points by a straight line to obtain all intermediate values.

In the accompanying diagrams the origin is to the right of the sheets, and the reciprocals of thickness were multiplied by six, so that the line representing ¼-inch plate is 24 inches to the left of the origin. This scale of thickness for the range covered by the diagrams will be found very convenient. Two different scales are used for the pitch, one twice as great as the other, and the bottom line does not represent the axis of abscissas in all diagrams, because the diagrams could be made more compact and to a more readable scale in the space available by making such variations. The drawing in the upper corner of each sheet represents the type of joint for which the diagram is constructed, and the small diagram immediately below the joint is a guide to aid in the use of the main diagram, which may be illustrated as follows:

Assume that we have a double-riveted lap joint with a plate thickness of ⅜ inch and 13/16 inch diameter rivet holes, pitched 3 inches apart, and that we wish to know what efficiency this joint will have. Starting at the bottom of the sheet for this type of joint (page 00) at the line denoting a plate thickness of ⅜ inch, follow up this line until the line denoting a pitch of 3 inches intersects it, and holding a pencil on this point, look for the line denoting a rivet diameter of 13/16 inch. It will be noted that this point lies in the upper right-hand section of the diagram formed by the lines denoting 13/16-inch rivets, and it is shown by the guide diagram that points in this area indicate that the rivets would shear, so that to find the efficiency of the joint it is necessary only to estimate the shearing strength of the rivets and divide the result by the strength of the solid plate. If the rivet holes had been ⅞ inch in diameter instead of 13/16 inch, the point of intersection of pitch and thickness of plate would lie in the area denoting that the net section was weak, and the efficiency of the joint could be obtained by dividing the length of the net section by the pitch.

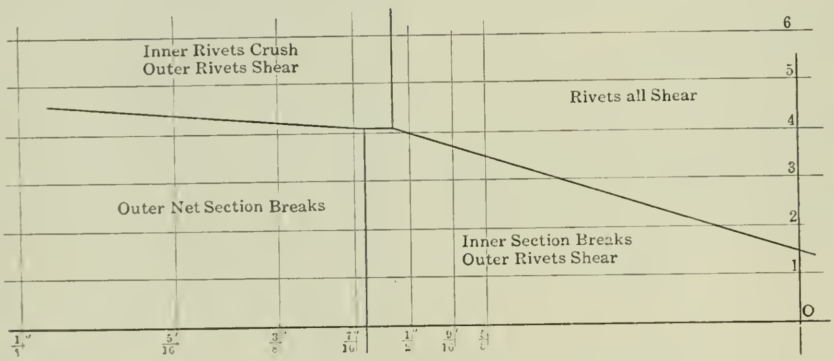


FIG. 4. OMITTING THE DOTTED PORTIONS IN FIG. 3

The following are the equations for the various lines used in the diagrams for joints of one pitch; the letters indicating the lines refer to those shown on the guide diagrams in the corners of the sheets.

SINGLE-RIVETED LAP JOINT

Line O K:

$$P = \frac{C d}{T} + d.$$

Line O L:

$$t = \frac{0.7851\, d\, s}{C}$$

Line O M:

$$P = \frac{0.7854\, d^2\, s}{t\, T} + d.$$

DOUBLE-RIVETED LAP JOINT

Line O K:

$$P = \frac{2\, C\, d}{T} + d.$$

Line O L:

$$t = \frac{0.7854\, d\, s}{C}.$$

Line O M:

$$P = \frac{1.5708\, d^2\, s}{t\, T} + d.$$

TRIPLE-RIVETED LAP JOINT

Line O K:

$$P = \frac{3\, C\, d}{T} + d.$$

Line O L:

$$t = \frac{0.7854\, d\, s}{C}.$$

Line O M:

$$P = \frac{2.356\, d^2\, s}{t\, T} + d.$$

SINGLE-RIVETED BUTT JOINT

Line O K:

$$P = \frac{C\, d}{T} + d.$$

Line O L:

$$t = \frac{0.7854\, d\, S}{C}.$$

Line O M:

$$P = \frac{0.7854\, d^2\, S}{t\, T} + d$$

DOUBLE-RIVETED BUTT JOINT, ONE PITCH

Line O K:

$$P = \frac{2\, C\, d}{T} + d;$$

Line O L:

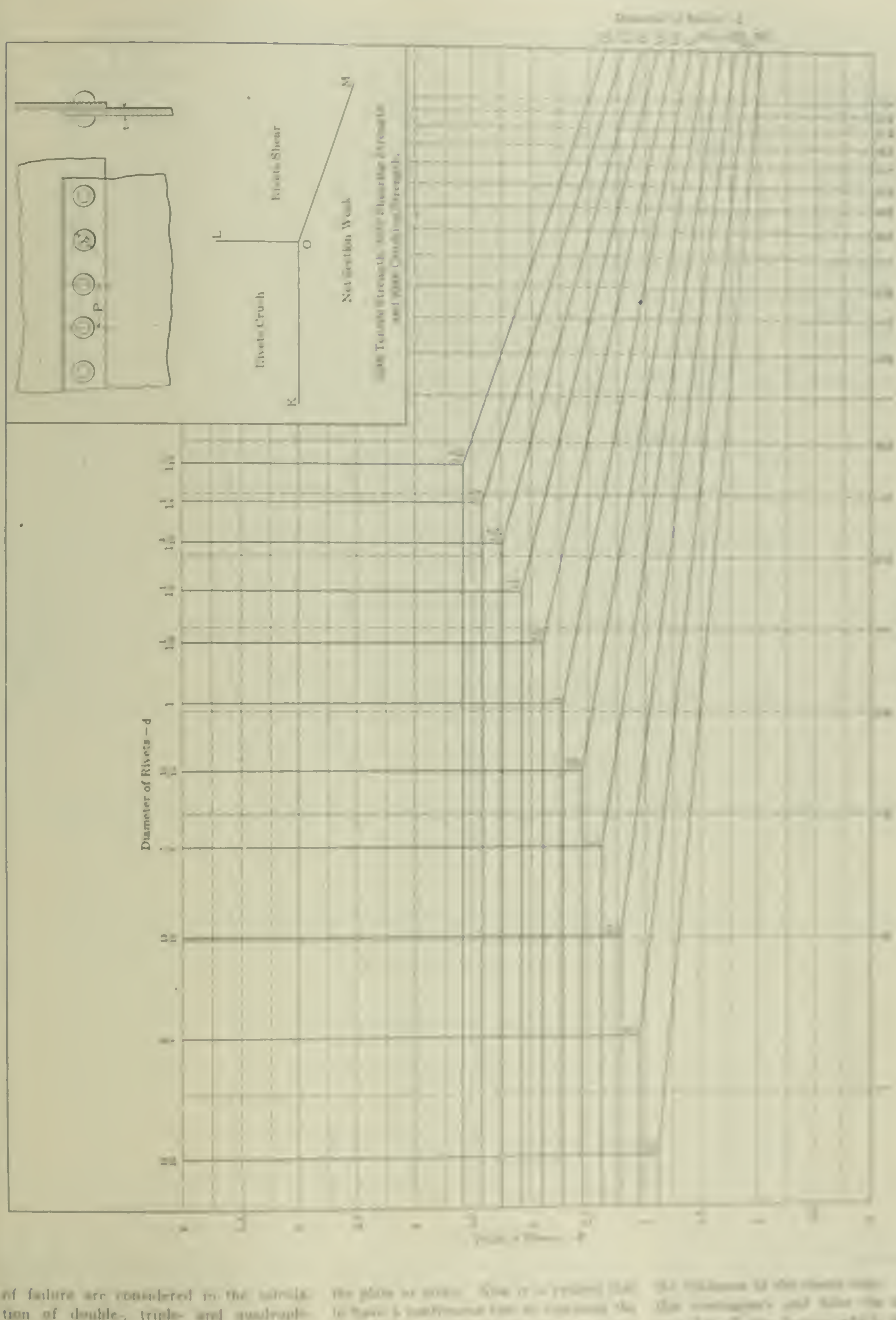
$$t = \frac{0.7854\, d\, S}{C}$$

Line O M:

$$P = \frac{1.5708\, d^2\, S}{t\, T} + d.$$

BUTT TYPE OF JOINTS WITH MORE THAN ONE PITCH

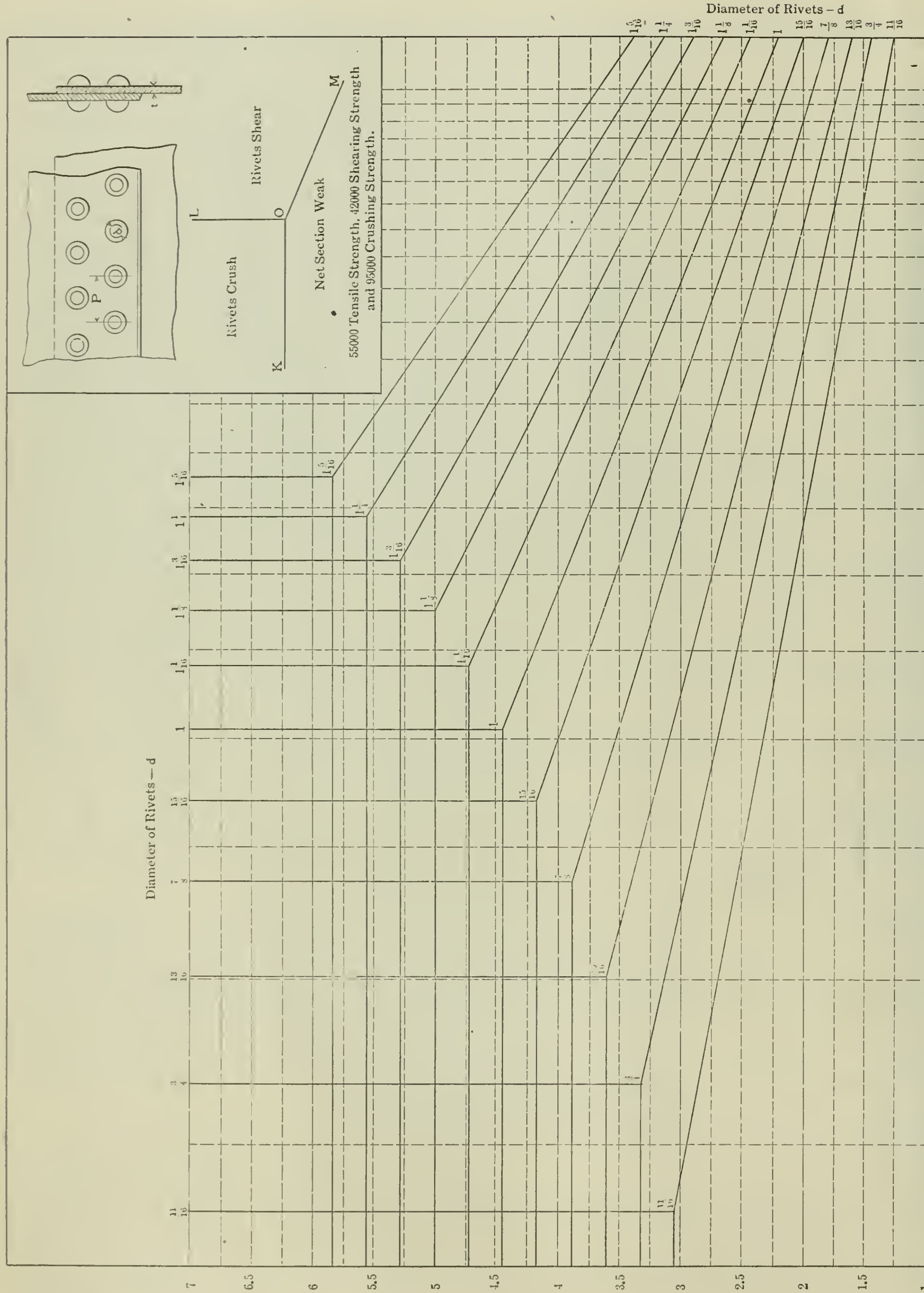
For the butt type of joint where more than one pitch of rivets is used, obtaining the equations and plotting the diagrams is a little more complicated. However, their use is just as simple as for the other joints, and the labor saved by the use of the diagrams is many times greater, as can readily be appreciated by anyone who has plodded through the uninteresting task of obtaining desired results in designing this type of joint by the old cut-and-try method. It will be noted on pages 31 and 32 of POWER AND THE ENGINEER, July 7, that six probable modes



of failure are considered in the calculation of double-, triple- and quadruple-riveted butt joints, as illustrated in Figs. 18, 19 and 20 of that article. Two of the possible modes of failure hinge on the crushing of the rivets in the outer rows in

the plate to crush. [illegible]

[illegible]



DOUBLE-RIVETED LAP JOINT

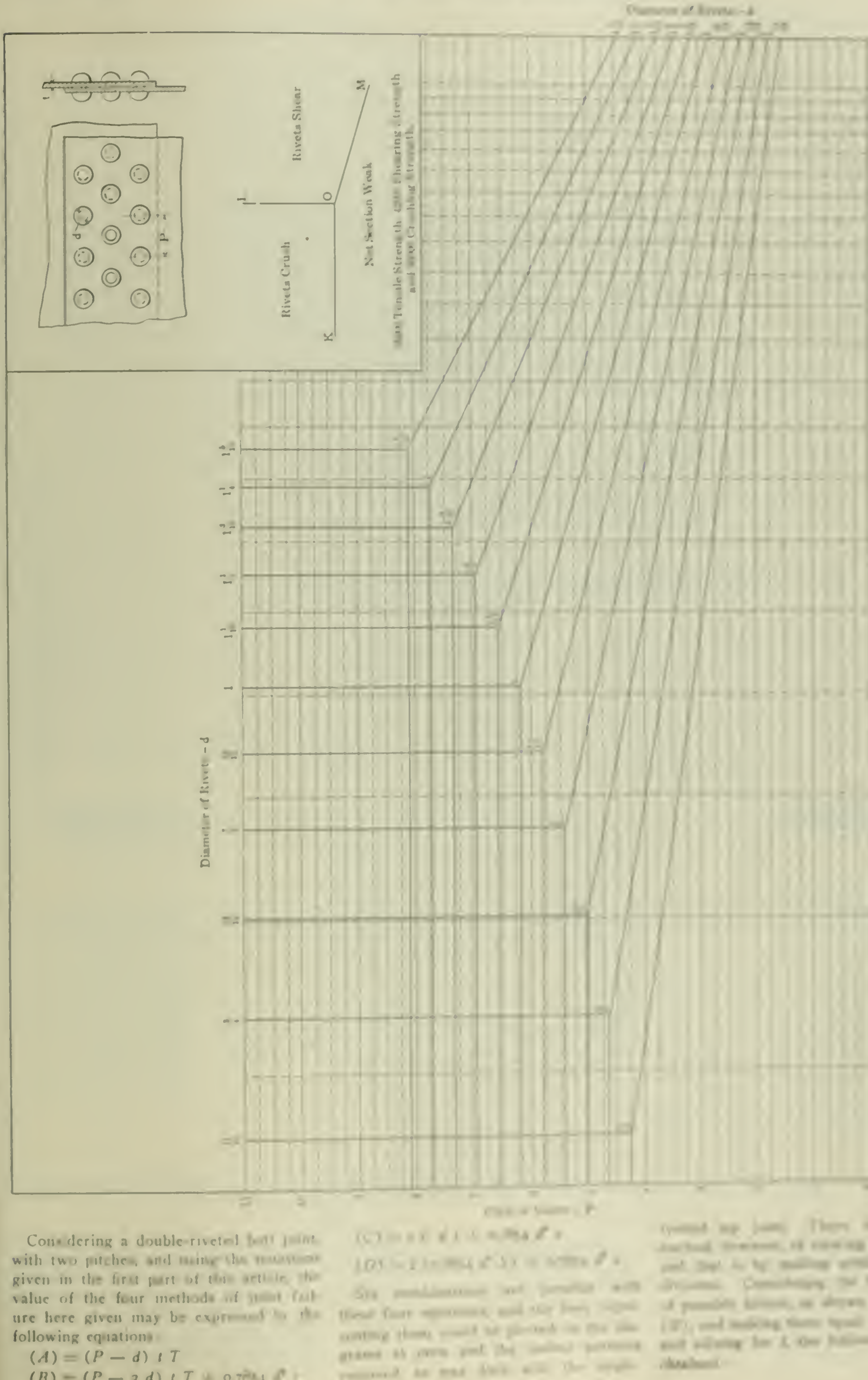
ing of the rivet or shearing in single shear would be equally probable, and as they extend to the right from this point, it is only necessary in using the diagrams to see that the thickness of the straps and plate come within this range, to make the diagrams hold good. It will be found that all practical boiler joints of the double-strapped butt type come well within this range. This expedient also reduces the modes of possible failure to four, which are:

(*A*) Breaking of outer net section.

(*B*) Breaking of the inner section and shearing outer rivets single shear.

(*C*) Crushing of inner rivets and shearing outer rivets single shear.

(*D*) Shearing all rivets, both double and single shear.



Considering a double-riveted butt joint with two pitches, and using the notations given in the first part of this article, the value of the four methods of joint failure here given may be expressed by the following equations:

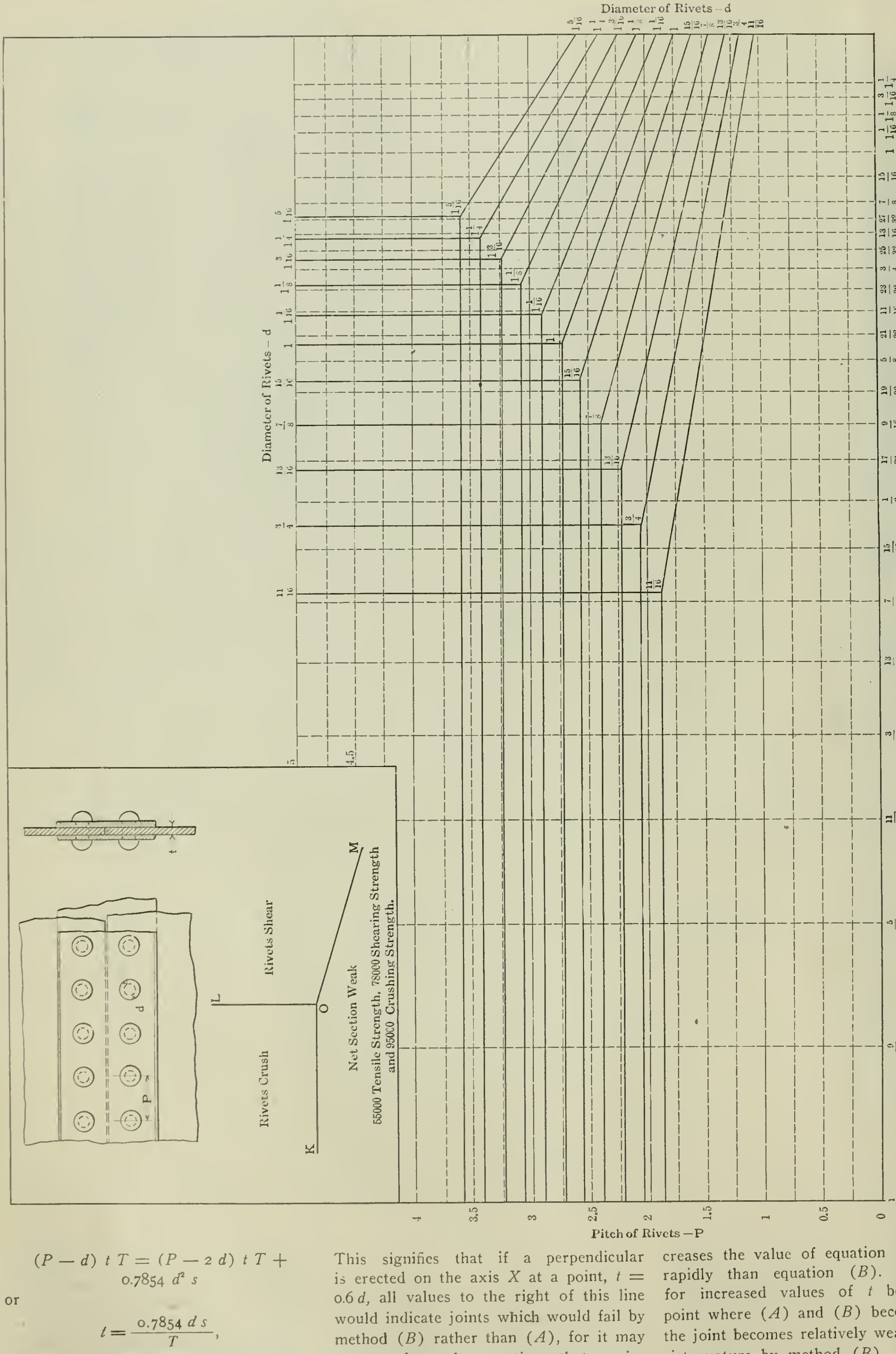
$(A) = (P - d)\ t\ T$

$(B) = (P - 2\ d)\ t\ T + 0.7854\ d^2$ [illegible]

(C) [illegible]

(D) [illegible]

Six combinations are possible with these four equations, and the lines representing them could be plotted on the diagrams [illegible] as was done with the single-riveted lap joint. There is a simpler method, however, of solving the problem, and that is by making [illegible] diagrams. Considering the [illegible] methods of possible failure, as shown by (A) and (B), and making them equal to each other and solving for [illegible] the following result is obtained:



SINGLE-RIVETED DOUBLE-STRAPPED BUTT JOINT

$$(P - d)\ t\ T = (P - 2\ d)\ t\ T + 0.7854\ d^2\ s$$

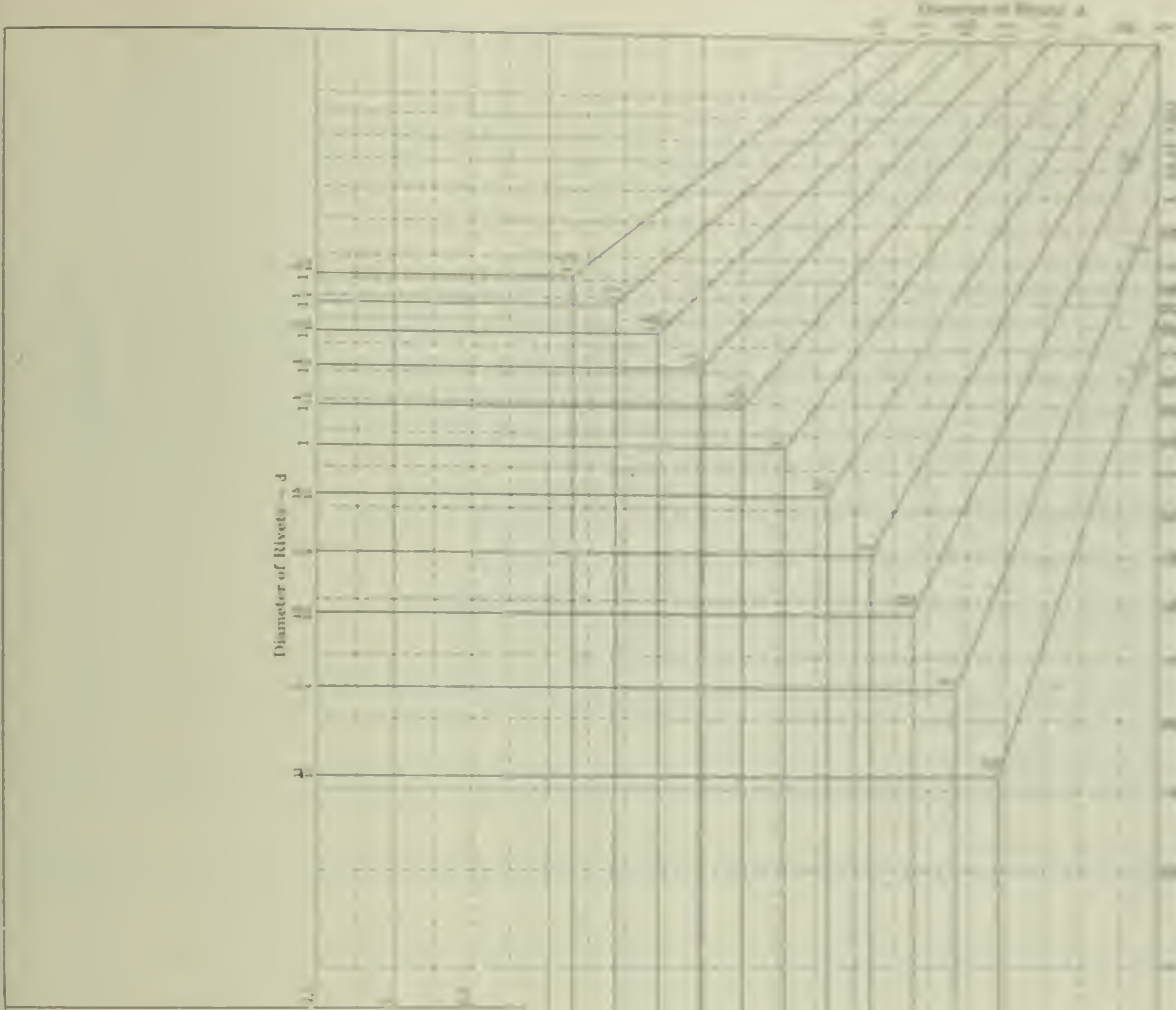
or

$$t = \frac{0.7854\ d\ s}{T},$$

and when $T = 55{,}000$ and $s = 42{,}000$,

$$t = 0.6\ d.$$

This signifies that if a perpendicular is erected on the axis X at a point, $t = 0.6\,d$, all values to the right of this line would indicate joints which would fail by method (B) rather than (A), for it may be seen from the equations that an increase in the thickness of plate, or t, increases the value of equation (A) more rapidly than equation (B). Therefore for increased values of t beyond the point where (A) and (B) become equal, the joint becomes relatively weaker to resist rupture by method (B). Since this is true, the lines denoting the relation be-

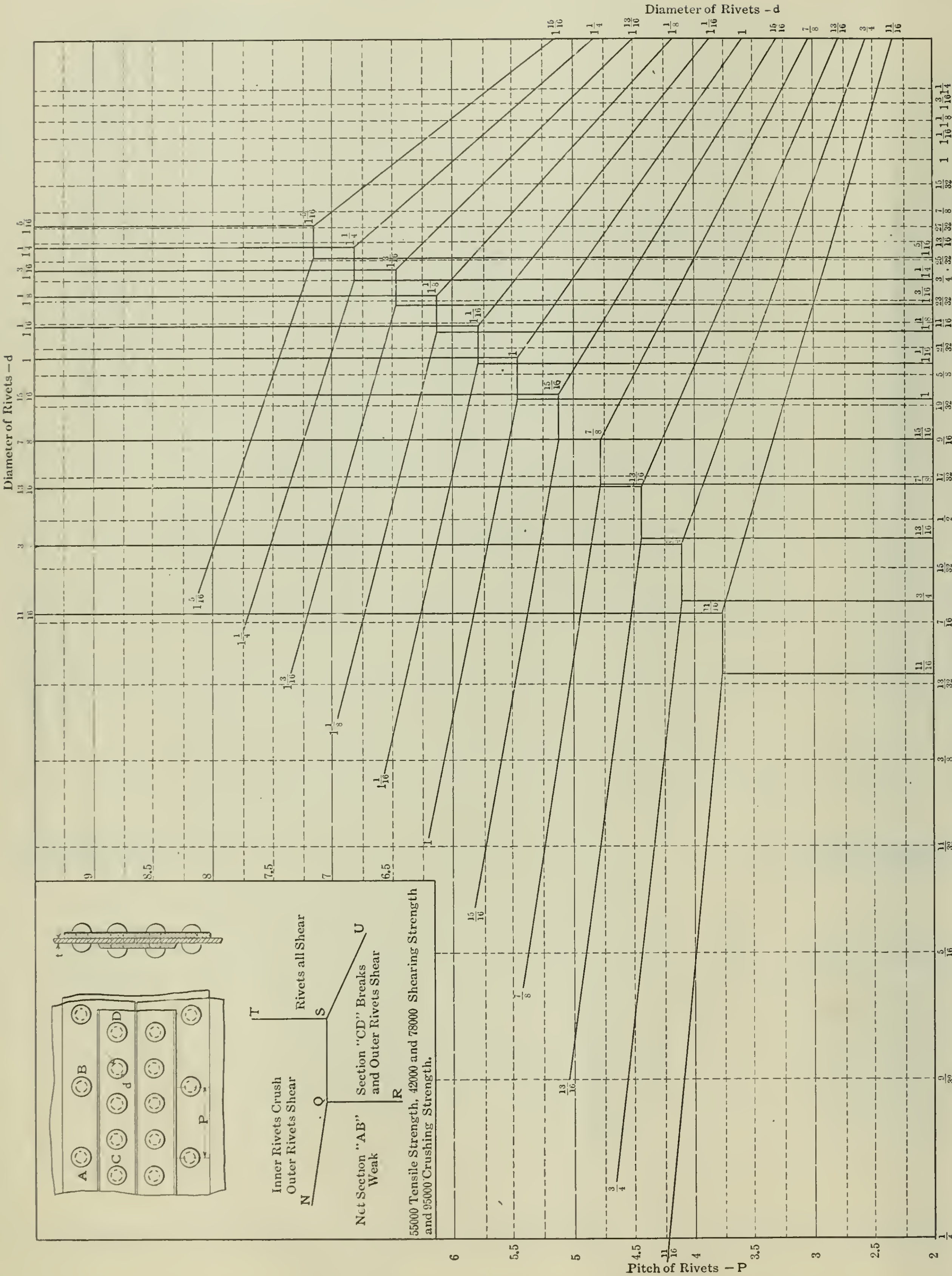


tween the various modes of failure can be plotted in the area to the right of $l = 0.6 d$, without regard to equation (A).

Noting equations (B), (C) and (D), it is seen that the term $0.7854 \, d^2$ is common to them all, so that for the purpose of comparison this term may be dispensed

[illegible]

[illegible]



DOUBLE-RIVETED DOUBLE-STRAPPED BUTT JOINTS WITH TWO PITCHES

origin *O*. The reason for placing the origin at the right is so that increasing values of *t* could be read from left to right, as this is more natural than the reverse.

Comparing equations (*B*) and (*C*),

$$(P - 2d)\,t\,T = 2\,C\,d\,t,$$

and solving for *P*

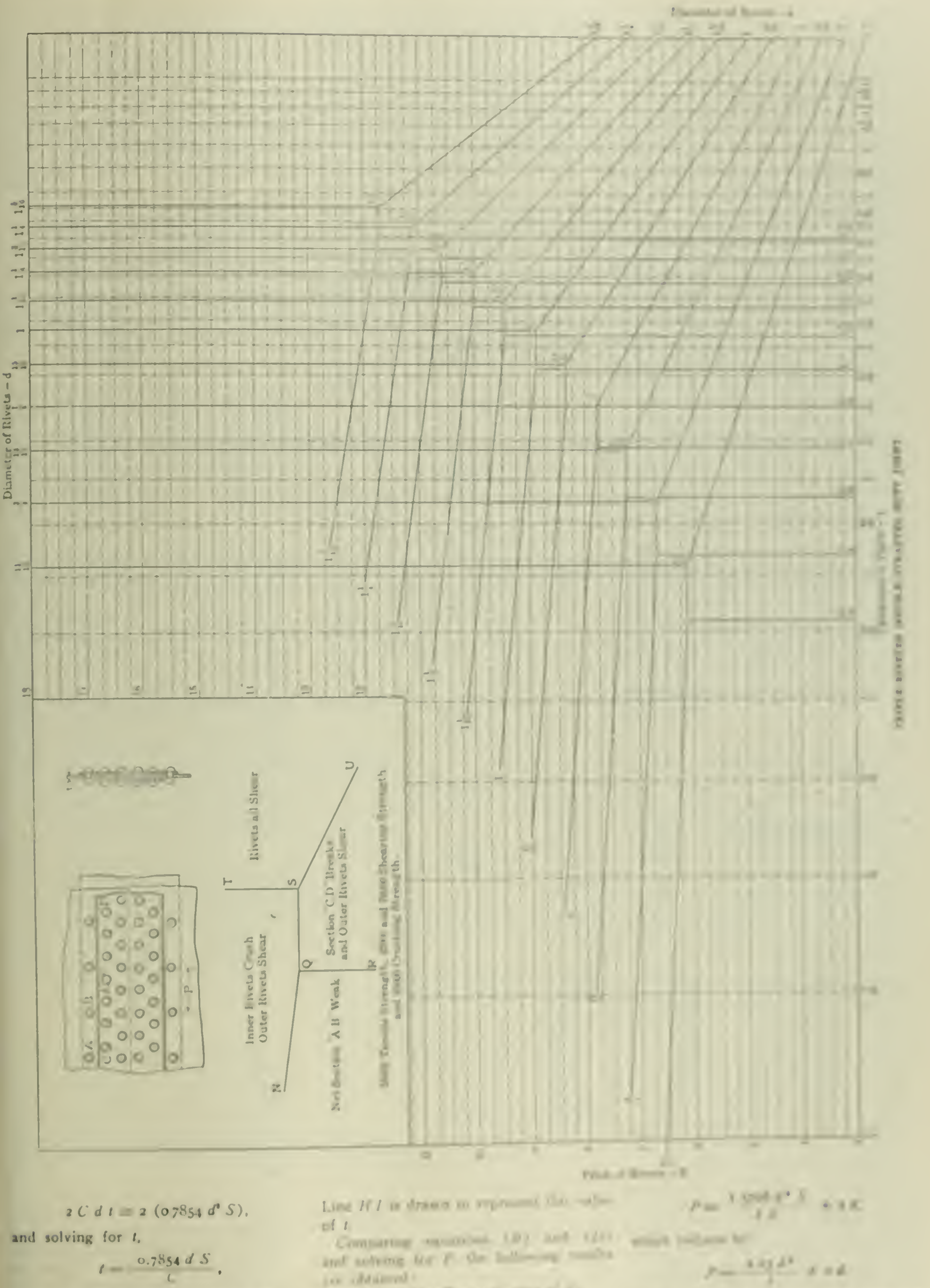
$$P = \frac{2\,C\,d}{T} + 2\,d,$$

or

$$P = 5.45\,d,$$

when $C = 95{,}000$ and $T = 55{,}000$. Line *FG* is drawn at a suitable hight above *X* to represent this value of *P* when $d = \frac{3}{4}$ inch.

Comparing equations (*C*) and (*D*), the following result is obtained:



$$2\,C\,d\,t = 2\,(0.7854\,d^2\,S),$$

and solving for t,

$$t = \frac{0.7854\,d\,S}{C},$$

or when $S = 78{,}000$ and $C = 95{,}000$

$$t = 0.645\,d.$$

Line $H\,I$ is drawn to represent the value of t.

Comparing equations [illegible] and [illegible] and solving for P the following results are obtained:

[illegible]

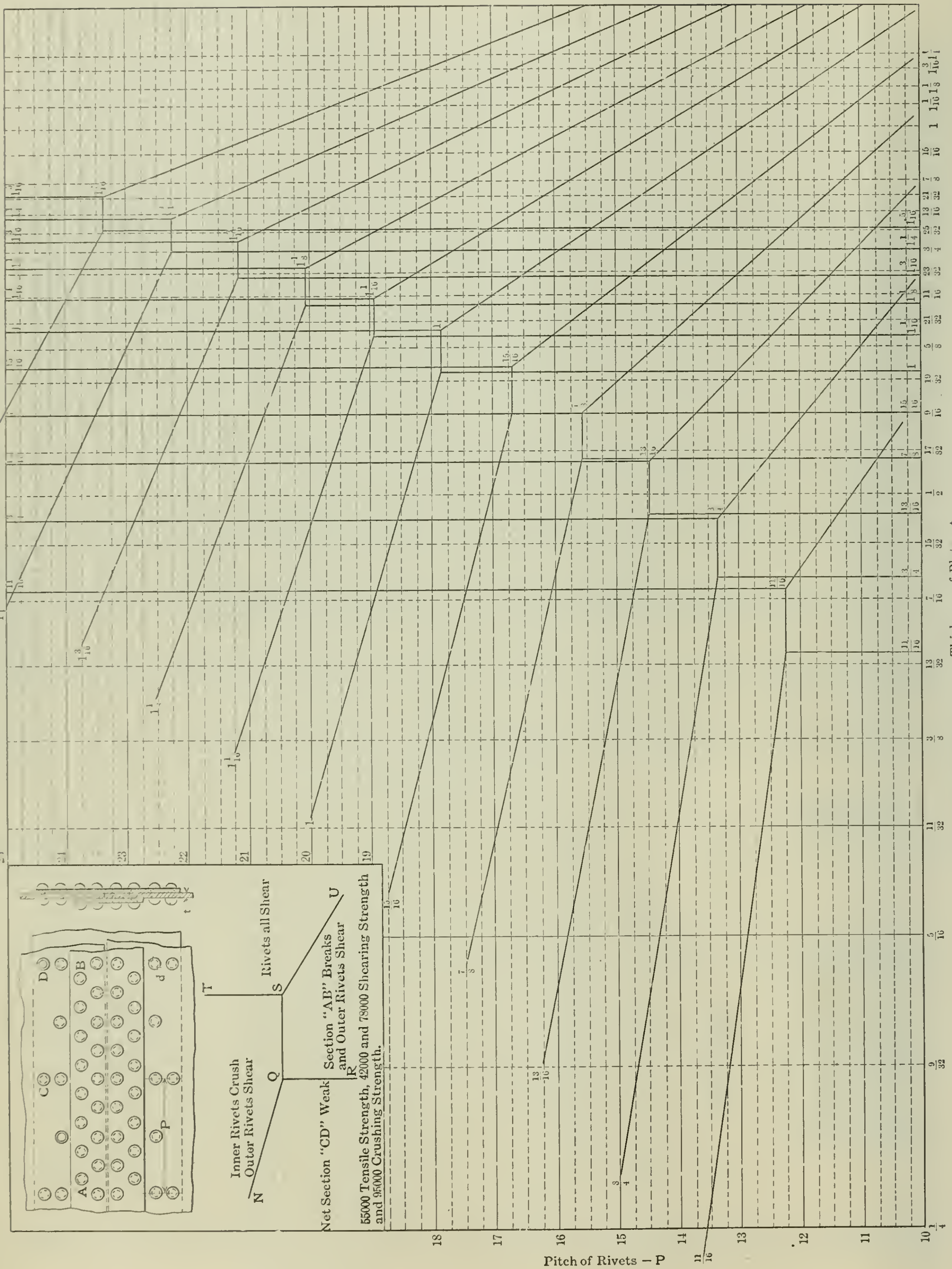
or

$$P = \text{[illegible]}$$

which reduces to

$$P = \text{[illegible]}$$

This line starts the same [illegible]



QUADRUPLE-RIVETED DOUBLE-STRAPPED BUTT JOINT

above the axis X, or at K in Fig. 3. Another point on this line is at the intersection of $F G$ and $H I$ at L, and the line $M K$, drawn through these points, represents the last equation. For the same reasons explained in describing the construction of Fig. 1, the dotted portions of lines $H I$, $F G$ and $M K$ are superfluous.

Returning to the original equations (A), (B), (C) and (D) to plot the diagram to the left of $D E$, the equation (B) is of no further use, since values for it in this area would be high as compared with (A). Now since the line $H I$ represents equal values for joint failure by method (C) or (D), and the value of (C) increases or decreases with that of t, while equation (D) is not affected by variations in t, it is evident that in the area to the left of HI, which represents decreasing values of t, that failure by method (D) need not be considered, and since the area to the left of HI also includes all of the area to the left of DE there remains only one comparison to be made to complete the diagram, which is that between equations (A) and (C) as follows:

$$(P - d)\ t\ T = 2\ C\ d\ t + 0.7854\ d^2\ s$$

or

$$P = \frac{2\ C d}{T} + \frac{0.7854\ d^2\ s}{t\ T} + d,$$

or when $s = 42{,}000$, $T = 55{,}000$ and $C = 95{,}000$

$$P = \frac{0.6\ d^2}{t} + 4.45\ d$$

It will be noted from this equation that when t is given a value of $0.6\ d$, corresponding to line DE, Fig. 3, that $P = 5.45\ d$, or is equal to the value of P for the line FG. Therefore the point F is one of the points on the line

$$P = \frac{0.6\ d^2}{t} + 4.45\ d,$$

and another point is where it cuts the axis Y at N, which lies $4.45\ d$ above the axis X. It is only necessary to join the points N and F by a straight line extending beyond F as NP. The dotted portion of this line FN has no significance, as only comparative values lying to the left of DE are being sought. The diagram is now complete with the exception of explaining that the dotted portion of DE has no bearing on the methods of failure in the area in which it lies, since it represents comparative values between modes of failure, designated by equations (A) and (B), and all values for these equations lying above PF and FG are greater than for (C) or (D).

The line FP is terminated at a value for t which would make the rivets equally as liable to crush or shear, single shear, or in the same position occupied by the vertical lines representing rivet diameters in the lap-joint diagrams, which is

$$t = \frac{0.7854\ d\ s}{C}$$

or $0.347\ d$, when $s = 42{,}000$ and $C = 95{,}000$. The diagram would be correct for all thicknesses of straps or plates above this thickness. For ¾-inch rivets this thickness would be 0.26 inch, or slightly more than ¼ inch; for 15/16-inch rivets and the same values for C and s, this value of t would be between 7/16 and 15/32 inch. It will be found that the proportions between rivet diameters and thickness of plates is such in practical boiler construction that the points will fall well within the limits of the diagrams. Redrawing Fig. 3 with the dotted portions of the lines omitted, the result would be like Fig. 4, in which the probable method of joint failure is indicated in the different sections of the diagram.

The diagrams for triple- and quadruple-riveted joints are derived in a similar manner to the above, and the equations for the several lines in the three types of joint are as follows. As before, the letters designating the lines refer to those on the small guide diagram in the upper corner of each sheet.

DOUBLE-RIVETED BUTT JOINT WITH TWO PITCHES

Line QN:

$$P = \frac{0.7854\ d^2\ s}{t\ T} + \frac{2\ d\ C}{T} + d$$

Line QR:

$$t = \frac{0.7854\ d\ s}{T}$$

Line QS:

$$P = \frac{2\ C\ d}{T} + 2\ d$$

Line ST:

$$t = \frac{0.7854\ d\ S}{C}$$

Line SU:

$$P = \frac{1.5708\ d^2\ S}{t\ T} + 2\ d$$

TRIPLE-RIVETED BUTT JOINT WITH TWO PITCHES

Line QN:

$$P = \frac{0.7854\ d^2\ s}{t\ T} + \frac{4\ d\ C}{T} + d$$

Line QR:

$$t = \frac{0.7854\ d\ s}{T}$$

Line QS:

$$P = \frac{4\ C\ d}{T} + 2\ d$$

Line ST:

$$t = \frac{0.7854\ d\ s}{C}$$

Line SV:

$$P = \frac{3.1416\ d^2\ S}{t\ T} + 2\ d$$

QUADRUPLE-RIVETED BUTT JOINT WITH THREE PITCHES

Line QN:

$$P = \frac{2.356\ d^2\ s}{t\ T} + \frac{8\ d\ C}{T} + d$$

Line QR:

$$t = \frac{0.7854\ d\ s}{T}$$

Line QS:

$$P = \frac{8\ C\ d}{T} + 4\ d$$

Line ST:

$$t = \frac{0.7854\ d\ s}{C}$$

Line SU:

$$P = \frac{6.28\ d^2\ S}{t\ T} + 4\ d$$

Attention is called to a point in the diagrams for butt joints which is slightly confusing, this being that the values of C, T, s and S, for which the diagrams are constructed, are so related that the lines corresponding to tC and sE, in Fig. 5, for ¾-inch and 15/16-inch rivets come in line with each other, and also coincide with the line for 9/16-inch plate thickness. This line is therefore marked ¾-inch rivet at the top of the sheet, and 15/16-inch rivet and 9/16-inch plate at the bottom, but with care in the use of the diagrams, when these particular values are required, no trouble should ensue.

To illustrate the use of the diagrams for butt joints with more than one pitch of rivets, suppose that it was desired to know the smallest size of rivet which would be required in a double-riveted butt joint of ½-inch plate and rivets to be pitched 5 inches apart, so that the net section between the outer rows would be the most likely point of failure; placing a pencil point at the intersection of the lines denoting ½-inch plate and 5-inch pitch on the diagram for this joint, it is seen that a rivet 15/16 inch in diameter or greater would be required, and if a 15/16-inch rivet were used in this joint the crushing of the inner rivets and the shearing of the outer ones would be the weakest mode of possible failure, or if ¾-inch rivets were used the joint would fail by shearing all rivets. It should be distinctly understood that when the diameter of rivets is spoken of, the diameter after driving or the diameter of the rivet hole is the one referred to.

The Country's Fuel Supply

According to the report recently made public of the sections of proceedings of the National Conservation Commission, the available and easily accessible supplies of coal in the United States aggregate approximately 1,400,000,000,000 tons. At the present increasing rate of production this supply will approach exhaustion before the middle of the next century. From the beginning of coal mining in this country down to the close of 1907 there were mined [illegible] tons, and it is estimated that for every ton produced half a ton has been lost or wasted, so that the gross production represents an exhaustion of the coal supply of [illegible] tons.

The first step in extending the life of our fuel supply should be to lessen the waste in mining, handling and burning.

The known supplies of petroleum, natural gas, iron and high-grade phosphate rock cannot be expected to last much beyond the middle of the present century.

One of the advantages attributed to the use of larger boiler units is the reduction in attendance and amount of coal burned and of water evaporated.

How to Use Riveted Joint Diagrams*

Thorough Instructions on the Practical Use of the Diagrams, Illustrated by a Complete Set of Examples, with Answers, on Each Type of Joint

BY S. F. JETER

The following explanation and instructions for the use of the diagrams, given in the article on calculating strength of riveted joints, are for those readers who do not care to follow the mathematical reasoning given in connection with the construction of the diagrams, but who wish to use them as an aid in caluculating the strength of such joints.

It is assumed that the article on page 28 of the July number of POWER AND THE ENGINEER, giving the detailed method of calculating the different joints, is thoroughly understood. In that article it was shown that in all joints of either the lap-riveted or the butt-strapped type, in which the rivets were arranged to give only one pitch, there were three possible modes of joint failure; consisting of breaking of the net section of the plate, shearing of the rivets, or crushing of the rivets. It was necessary to find the numerical value of each one of these modes of failure in order to determine which one was the weakest of the three, and the value of this weakest mode of failure was alone used in obtaining the efficiency of the joint.

DIAGRAMS OF SINGLE-PITCH JOINTS

The purpose of the diagrams is to make it necessary to calculate only the weakest mode of failure, as by their aid this may be selected without calculation as follows: Taking the diagram for a single-riveted lap joint for illustration, it is seen that below the drawing showing the type of joint in the upper right-hand corner of the sheet, there is a small diagram which will be known as a guide diagram, consisting of three lines, *OK*, *OL* and *OM*. These three lines represent any similar set of three full lines in the main diagram, which is seen to contain eleven sets, and each set of these lines represents a given rivet diameter, the particular diameter represented being noted at the intersection of the lines, at the upper end of the vertical lines and at the right-hand end of the inclined lines. In addition to the sets of full lines in the main diagram, it will be noted that there are also dotted and dashed horizontal lines and dotted vertical lines, extending across the sheet in each direction; the former represent pitch of rivets in inches and quarters, the numbers at the left-hand side of the sheet giving the value represented by each line. The lines representing even inches are made with long dashes to permit the eye more readily to distinguish them from lines representing half and quarter inches. The vertical dotted lines represent thickness of plate, and the particular thickness represented by each line is printed under its lower extremity.

To determine the weakest mode of failure for a given joint, it is only necessary to find in which section of the diagram, with reference to the full lines indicating the given rivet diameter, the intersection of the lines corresponding to the pitch of rivets and thickness of plate lie, and when this is found the method of failure printed in the corresponding section of the guide diagram is the one sought. It should be remembered that in using the diagrams in this way for a particular size of rivet, that all other full lines representing other sizes of rivets have no significance whatever, and they should be considered as not existing for the time being. Thus with a rivet diameter of 1 inch, all points of intersection between lines denoting pitch of rivets and thickness of plate, lying to the right of the vertical line for 1-inch rivets and above the inclined line corresponding to *OM* of the guide diagram, would denote that joints composed of such pitches of rivets, thicknesses of plate and with 1-inch diameter rivets, would fail by shearing the rivets. Values of pitch and thickness of plate given by lines on the diagram for a single-riveted lap joint (page 00) whose intersections would lie in this area, would be as follows: 3/8-inch plate, and any pitch of rivets of 2 3/4 inches or more; 13/32, 7/16- or 15/32-inch plate, and any pitch of rivets of 2 1/2 inches or more; 1/2-inch plate, and any pitch of rivets of 2 1/4 inches or more, and so on as far as the diagram extends. All joints containing the above relative values of pitch of rivets and thickness of plate, where 1-inch rivets are used, would fail by shearing the rivets.

Intersections of pitch and thickness of plate, which lie in the area corresponding to that marked "net section weak" in the guide diagram, would indicate that this method of failure would be the most likely one in joints constructed with similar values. Such intersections would be for 1-inch rivets, 2 1/2-inch pitch and any thickness of plate up to and including 3/8-inch plate; or 2 1/4-inch pitch and any thickness of plate up to and including 15/32-inch plate; or 2-inch pitch and any thickness of plate up to and including 19/32-inch plate, and so on. If the intersections lay in the area corresponding to that marked "rivets crush" this would be the most likely mode of joint failure; for 1-inch rivets such values would be represented by any pitch of rivets 2 3/4 inches or greater and any thickness of plate up to and including 11/32 inch.

From the foregoing it is seen that to calculate the efficiency of any joint, it is only necessary to find in which section of the diagram, with reference to the lines denoting the rivet size, the intersection of lines denoting pitch of rivets and thickness of plate lie, and calculate the value of the particular mode of failure printed in the corresponding section of the guide diagram, and divide this by the value found for the strength of the solid plate. The result is the true efficiency of the joint.

For example, assume a single-riveted double-strapped butt joint, in which the rivets are 3/4 inch diameter and pitched 2 1/4 inches apart, and a plate thickness of 3/8 inch. By referring to the diagram for this type of joint, it is seen that the intersection of the lines corresponding to 2 1/4-inch pitch of rivets and 3/8-inch thickness of plate, lies in the area (with respect to the lines denoting 3/4-inch rivets) corresponding to that marked "rivets crush" in the guide diagram. Therefore, the efficiency would be .

$$\frac{\textit{Diameter of Rivets} \times \textit{Thickness of Plate} \times 95{,}000}{\textit{Pitch of Rivets} \times \textit{Thickness of Plate} \times 55{,}000};$$

or since the thickness of plate is common to both numerator and denominator, it would cancel out, leaving

$$\frac{3/4 \times 95{,}000}{2 1/4 \times 55{,}000} = 57.6$$

per cent. efficiency.

If the other methods of failure had been considered, the results would be as follows: Breaking of net section, 62.2 per cent. efficiency; or for shearing of the rivets, 74.2 per cent. efficiency, and since these two latter values are higher than the first, the method of failure indicated by the diagram gives the true efficiency of the joint.

It follows that since the lines representing rivet diameters, which correspond to *O M* in the guide diagram, lie between the area denoting shearing of the rivets, or the breaking of the net section of the plate, that where the lines for thickness of plate and pitch of rivets intersect on this line, joint failure is equally liable by either method. For example, the line corresponding to $O M$ for $1\frac{1}{16}$-inch rivet diameter (in the diagram for single-riveted lap joints) apparently passes through the point of intersection of lines denoting 2½-inch pitch and 15/32-inch plate, and if a joint of this type should be constructed with these dimensions, it would be as likely to fail by breaking the net section of the plate between the rivet holes, as by shearing the rivets, and the value of either of these methods of failure might be used in obtaining the efficiency of the joint. Calculating the value of the two modes of failure would result as follows: For shearing of the rivets,

$$0.8866 \times 42{,}000 = 37{,}237$$

pounds, and for the strength of the net section of the plate,

$$(2\tfrac{1}{2} - 1\ 1/16) \times 15/32 \times 55{,}000 = 37{,}061$$

pounds. It is seen that there is a difference of 175 pounds in these two values, and if the diagram was made to a larger scale and absolutely accurate, the line for 1 1/16-inch rivet would be seen actually to pass above the intersection of lines for 15/32-inch plate and 2½-inch pitch of rivets. However, the diagrams are sufficiently accurate for all practical purposes, for when using the shearing strength of the rivets in obtaining the joint efficiency, it is found to be 57.77 per cent., while by using the strength of the net section of the plate, it is 57.5 per cent., so that practically it would make no difference which method of failure was used in the calculation.

If any value of thickness coincided with a vertical line for rivet diameter, it would indicate that the value of the crushing strength of the rivets or their shearing strength could be used indiscriminately in obtaining the efficiencies of joints made with this thickness of plate and diameter of rivet, where the rivets were spaced so that the lines indicating the pitch crossed the vertical line indicating rivet diameter. There is no thickness of plate shown on the diagram for single-riveted lap joints, which actually coincides with any line representing rivet diameter, the lines for 13/16-inch rivets and 9/32-inch plate coming the nearest. The actual thickness which would exactly coincide with the vertical line for 13/16-inch rivets would be 0.28213 inch, and with this thickness of plate and 13/16-inch rivets, and any pitch 2¼ inches or greater, the joint efficiency could be obtained by using the value of either the crushing or shearing of the rivets, as the value of both would be the same and less than the strength of the net section of the plate between the rivet holes.

If any horizontal line denoting pitch of rivets should coincide with a horizontal line for any rivet diameter, a joint consisting of this particular size of rivet and pitch would have an equal value for joint failure by crushing the rivets or breaking the net section of the plate for any thickness which crossed the horizontal line indicating the rivet size. For example, in the double-riveted double butt-strapped joint with one pitch (page 60), 1⅛-inch rivets were used and pitched 4¼ inches apart, any thickness of plate up to and including 21/32-inch thickness would give a joint which would be as likely to fail by the rivets crushing as by the breaking of the net section of the plate, and therefore either could be used in estimating the strength of the joint.

It follows from the foregoing that if the thickness of the plate and the pitch of the rivets were such that the lines which would represent them should intersect at the same point as those denoting any rivet diameter (as O in the guide diagram), a joint constructed of these values for pitch of rivets, thickness of plate and diameter of rivets, would be likely to fail by either of the three methods of joint failure and this would also represent a joint of maximum efficiency. In the single-riveted lap joint, values of 2¼-inch pitch, 9/32-inch plate and 13/16-inch rivets, come very near fulfilling these conditions, although the crushing strength of the rivets is a little the weakest mode of failure.

The instructions for the use of the diagrams given thus far apply to all forms of joint, both lap-riveted and butt-strapped, in which only one pitch to the rivets occurs, and it will be noted that the diagrams for all these joints are alike in form.

Joint Diagrams with Two or More Pitch Values

The following instructions are for the use of the diagrams constructed for the butt-strapped type of joint in which two or more pitches of rivets occur. The general principles for the use of the diagrams are the same as for single-pitch joints, that is, the area in which the intersection of lines denoting pitch of rivets and thickness of the plate lie, determine the weakest mode of joint failure as indicated by the guide diagrams, and if the intersections happen to fall on the lines indicating the rivet diameter for the given joint, either of the modes of failure noted in the adjacent areas may be used in determining the efficiency of the joint.

Taking the diagram for the triple-riveted butt joint for illustration, it is seen that it differs from the first diagrams in that the full lines denoting rivet diameter divide the space into four sections instead of three, and, as shown by the guide diagram, the two top areas denote joint failure by crushing of the inner rivets and shearing the outer rivets, or the shearing of all the rivets. The two lower areas indicate joint failure by breaking of the outer net section between the rivet holes, or the breaking of the inner net section and the shearing of the outer rivets.

It will be seen that the lines indicating rivet diameters, corresponding to the line $S O$ of the guide diagram, do not extend to the left-hand side of the charts, as was in the case of the 11/16-inch rivet. The explanation for this is, that for mathematical reasons it is required that the two methods of joint failure in which the crushing of the rivets in the outside rows is involved for this type of joint, be eliminated, leaving only the four modes of failure, as shown in the guide diagram. This could be accomplished by making the diagrams apply only to joints in which the thickness of plate and straps are such that the lines indicating the plate thickness cross, at some point, those indicating the rivet diameter used. For example, in joints in which ¾-inch rivets are used, the diagrams would hold good for thicknesses of plate or straps of 5/16 inch or more, but not for thicknesses less than 5/16 inch. If 1⅛-inch rivets were used, the plate and straps must be 13/32 inch or more, and so on, the last vertical line to the left indicating plate thickness, which crosses the full line representing the rivet diameter, being the minimum thickness of plate or straps for which the diagrams are constructed. This limit to the range of the diagrams will not interfere with their usefulness in the least, for the range covered includes all practical boiler joints.

The rivet sizes to which each set of full lines apply are given at the extremities of the vertical lines and the angular lines, and also at the intersections corresponding to the point S in the guide diagram. Using a ¾-inch rivet for illustrating the use of the diagram for a triple-riveted butt joint (page 60), it is seen that if 7/16-inch plate is used with this size of rivet and the rivets are pitched 5¼ inches apart in the outer rows, joint failure would occur by breaking the outer net section; while if the plate thickness had been 15/32 inch, the pitch remaining the same, failure would occur by breaking the inner net section and shearing the outer rivets; if ½-inch plate had been used, the failure would have been equally as likely by the breaking of the inner net section and shearing the outer rivets, or shearing all the rivets both in single and double shear; if 17/32-inch plate were used, the failure would occur by shearing of all the rivets rather than by any of the other possible modes of failure.

If a pitch of 5¾ inches were selected instead of 5¼ inches, and 7/16- or 15/32-inch plate used, the failure of the joint would occur by the crushing of the rivets passing through both straps and the shearing of the outer rivets, while if the plate thickness were ½ inch with this pitch, failure would occur by shearing all of the rivets, both in single shear and in double shear.

In using the diagrams to calculate the efficiency of a given joint it will be found to be most convenient to proceed as follows: Assuming a quadruple-riveted double-strapped butt joint in which the plate thickness is [illegible] inch and the rivets are pitched 15 inches apart in the outer row, their diameter being 13/16 inch, what would be the efficiency of this joint? Commencing at the bottom of the sheet on the line marked 17/32-inch plate, follow up the line until the horizontal line representing 15 inches pitch is reached hold a pencil or other pointer on the intersection of these two lines, leaving the eye free to locate the full lines indicating 13/16-inch rivet diameter, and it is readily seen that the point upon which the pencil is held lies in the area corresponding to that marked "rivets all shear" in the guide diagram.

After using the diagrams a few times the apparent confusion, caused by the numerous lines representing the rivet diameters, will disappear entirely; however, if it was desired, the reader could retrace the diagrams, placing only a single rivet diameter on each sheet, and the diagrams would then have the same appearance as the guide diagram, with the dotted and dashed lines representing the pitch of rivets and thickness of plate added.

There is one point in connection with the diagrams for double-strapped butt joints with two pitches that should be carefully noted, and that is the line corresponding to *Q R* of the guide diagrams, for 15/16-inch rivets, coincides with the one corresponding to line *T S* for ⅞-inch rivets, and therefore the portion lying between the intersection marked ⅞ inch up to the next set of full lines representing 15/16-inch rivets belongs to both rivet diameters, and it also represents throughout its entire length 9/16-inch plate thickness. It will be observed that the correct rivet diameter represented by the upper portion of the line is placed at the top of this sheet, while that represented by the lower portion is placed at the bottom, so that by using these figures to locate the lines, rather than those given at the intersections of the lines given in the center of the diagrams, when ⅞- or 15/16-inch rivets are used, confusion will be avoided.

It should be thoroughly understood that the diagrams shown are only correct for a tensile strength of plate of 55,000 pounds per square inch, shearing strength of rivets of 42,000 pounds per square inch for single shear and 78,000 pounds per square inch when in double shear, and 95,000 pounds per square inch crushing resistance of the rivets. When rivet diameters are spoken of, the driven diameter of the rivet or the diameter of the rivet hole is referred to.

A feature of the quadruple-riveted double-strapped butt joint, which was not brought out in the July 7 article, may be properly mentioned here. This is, that the failure of this type of joint by the breaking of the plate along the second row of rivets and shearing the rivets in the outer row need not be considered, because it can never be weaker than both the failure by breaking of the outer net section and that of breaking the inner net section and shearing the rivets in the two outer rows, but its value will always lie between these two. Consequently when they become equal to each other, it also is equal to them. Thus, if the line indicating the plate thickness for a given joint of this type should coincide with the line corresponding to *O R* for the rivet size used in the joint, failure would be equally liable by either of the three methods, but for all other values of thickness of plate, one of the two latter methods would be the weaker of the three. As may be seen from the diagram, a joint of 9/16-inch plate and 15/16-inch rivets, with any pitch up to and including 16½-inch, would render failure equally liable by either method.

EXAMPLES FOR PRACTICE

The following questions and answers will be found a convenient aid in becoming familiar with the use of the diagrams. The answers are given separate from the questions, but both are numbered alike, and the reader may write his own answers to the questions and then compare them with the answers given, and in this way test his ability to use the diagrams correctly. Eight questions are asked for each type of joint; the first five relating to the use of the diagrams in obtaining joint efficiencies, and the three last to illustrate other uses for the diagrams.

Single-riveted Lap Joint

What method of joint failure should be compared with the strength of the solid plate to ascertain the efficiency of the following joints?

(1) ⅜-inch plate, 2½-inch pitch and 1-inch rivets.

(2) 13/32-inch plate, 2½-inch pitch and 1-inch rivets.

(3) 7/16-inch plate, 2½-inch pitch and ¾-inch rivets.

(4) 7/16-inch plate, 2¾-inch pitch and 15/16-inch rivets.

(5) 5/16-inch plate, 2¾-inch pitch and 15/16-inch rivets.

(6) What is the smallest rivet diameter that could be used, if the pitch were 2¼-inch and plate thickness 9/32-inch, to insure that the joint would fail by breaking the net section of the plate?

(7) If a joint were made with 13/16-inch rivets and 7/16-inch plate, what would be the smallest pitch of rivets that would cause the joint to fail by shearing the rivets?

(8) With 1 1/16-inch rivet diameter, what thickness of plate would make failure by crushing the rivets impossible?

Double-riveted Lap Joint

What would be the weakest mode of failure for the following joints?

(1) 11/32-inch plate, 3-inch pitch and ¾-inch rivets.

(2) 19/32-inch plate, 3-inch pitch and 1-inch rivets.

(3) ⅝-inch plate, 2½-inch pitch and ⅞-inch rivets.

(4) 7/16-inch plate, 2¾-inch pitch and 11/16-inch rivets.

(5) 13/32-inch plate, 2¾-inch pitch and 13/16-inch rivets.

(6) With 5/16-inch plate, what is the smallest pitch and diameter of rivets which would cause joint failure by crushing the rivets?

(7) With 17/32-inch plate and 13/16-inch rivets, what would be the longest pitch that could be used and insure that the joint would fail by breaking the net section of the plate between the rivet holes?

(8) With ⅞-inch rivets, what pitch would be required if the crushing of the rivets was to be one of the possible methods of joint failure? What thickness of plate would this method of joint failure hold good for?

Triple-riveted Lap Joint

What method of joint failure would be most likely in the following joints?

(1) ⅜-inch plate, 3-inch pitch and 11/16-inch rivets.

(2) 11/32-inch plate, 3-inch pitch and 1-inch rivets.

(3) 23/32-inch plate, 3¼-inch pitch and 15/16-inch rivets.

(4) 23/32-inch plate, 3¼-inch pitch and 1-inch rivets.

(5) 13/32-inch plate, 3¼-inch pitch and ¾-inch rivets.

(6) Would it be practical to design a joint with values for rivet diameter and thickness of plate as given in the diagram, in which failure would occur by crushing the rivets?

(7) What would be the least pitch shown on the diagram that would cause joint failure by crushing the rivets, if the plate thickness was ¼ inch and the rivet diameter ¾ inch?

(8) With 21/32-inch plate and 11/16-inch rivets, what would be the least pitch that would cause the rivets to shear?

Single-riveted Double-strapped Butt

What method of joint failure should be compared with the solid plate, in estimating the efficiencies of the following joints?

(1) ⅜-inch plate, 2½-inch pitch and ¾-inch rivets.

(2) ½-inch plate, 2-inch pitch and ¾-inch rivets.

(3) ½-inch plate, 2¼-inch pitch and 13/16-inch rivets.

(4) 21/32-inch plate, 2¼-inch pitch and ¾-inch rivets.

(5) ¾-inch plate, 3-inch pitch and 1-inch rivets.

(6) There are only two possible modes of joint failure for all thicknesses of plate and rivet diameters shown on the diagram up to and including 7/16-inch plate. What are they?

(7) How would all joints with ⅞-inch rivets and 2½-inch pitch or over fail, if the plate thickness were 9/16-inch?

(8) Would rivets crush in any joint made of plate 17/32-inch or over, if the rivet diameters were not over 13/16-inch?

DOUBLE-RIVETED DOUBLE-STRAPPED BUTT JOINT WITH ONE PITCH

What would be the most likely mode of failure in the following joints?

(1) 19/32-inch plate, 3¾-inch pitch and ⅞-inch rivets.

(2) 7/16-inch plate, 3-inch pitch and 11/16-inch rivets.

(3) 17/32-inch plate, 3¼-inch pitch and 1 1/16-inch rivets.

(4) 7/16-inch plate, 3½ inch pitch and ¾-inch rivets.

(5) ¾-inch plate, 4-inch pitch and 13/16-inch rivets.

(6) For any thickness of plate up to and including 21/32-inch, and where 1 1/16-inch rivets are used and pitched 4¾-inch apart, what would be the most likely mode of failure?

(7) If the thickness of the plate were not over 7/16-inch, could joint failure occur by shearing the rivets for any rivet size shown on the diagram?

(8) If 1 inch rivets were used in a joint, what would be the lightest plate that would cause the shearing of the rivets to be a possible mode of joint failure?

DOUBLE-RIVETED DOUBLE-STRAPPED BUTT JOINT WITH TWO PITCHES

What would be the weakest mode of failure in the following joints?

(1) 19/32-inch plate, 4-inch pitch and 1-inch rivets.

(2) 19/32-inch plate, 4-inch pitch and ¾-inch rivets.

(3) 9/16-inch plate, 5 inch pitch and ⅞-inch rivets.

(4) 15/32-inch plate, 5 inch pitch and 13/16-inch rivets.

(5) 25/32-inch plate, 4¾-inch pitch and ⅞-inch rivets.

(6) How would joints fail, having ⅞-inch rivets and pitched 4¼ inches or less and the plate thickness being 9/16 inch?

(7) What would be the maximum thickness of plate, where 1 inch rivets are used, if the breaking of the outer net section must be one of the possible modes of joint failure?

(8) If 15/16-inch rivets were used in 1-inch plate, what would be the least pitch that could cause joint failure by the shearing of all rivets?

TRIPLE-RIVETED DOUBLE-STRAPPED BUTT

What would be the probable method of joint failure in the following joints?

(1) ½-inch plate, 6¼-inch pitch and ¾-inch rivets.

(2) 11/16-inch plate, 7½-inch pitch and 1-inch rivets.

(3) 17/32-inch plate, 8 inch pitch and ⅞-inch rivets.

(4) 17/32-inch plate, 7½-inch pitch and 15/16-inch rivets.

(5) 11/32-inch plate, 6 inch pitch and 1 1/16-inch rivets.

(6) With 1 inch rivets pitched 7½ inches, what would be the maximum thickness of plate that could be used and have the net section between the outer rows of rivets the weakest?

(7) If 1⅛-inch rivets were spaced 8 inches apart, what would be the thinnest plate that would cause all of the rivets to shear?

(8) With ¾-inch plate thickness and 1¼-inch rivets, how would joint failure occur for any pitch up to and including 11-inch pitch?

QUADRUPLE-RIVETED BUTT DOUBLE-STRAPPED JOINT

What would be the most likely mode of failure in the following joints?

(1) ⅝-inch plate, 14-inch pitch and 1⅛-inch rivets.

(2) ½-inch plate, 14½-inch pitch and 13/16-inch rivets.

(3) ½-inch plate, 14½-inch pitch and ¾-inch rivets.

(4) 19/32-inch plate, 15½-inch pitch and 15/16-inch rivets.

(5) ⅞-inch plate, 14-inch pitch and 13/16-inch rivets.

(6) If it was required to design a joint with 1¼-inch rivets pitched 16 inches apart, and have the net section between the rivets of the outer row the weakest, what would be the maximum thickness of plate that could be used?

(7) With a pitch of rivets of 17½ inches, how thick would the plate be to make all rivets shear, when the rivet diameter is 1¼ inches?

(8) What is the thinnest plate to be used with 1¼-inch rivets, to make failure by the breaking of the inner net section and the shearing of the outer rows of rivets one of the possible modes of joint failure?

ANSWERS TO QUESTIONS

SINGLE-RIVETED LAP JOINT

(1) Breaking of net section.
(2) Shearing of rivets.
(3) Shearing of rivets.
(4) Shearing of rivets.
(5) Crushing of rivets.
(6) ⅞-inch diameter.
(7) 1¾-inch pitch.
(8) Any thickness of ½-inch or over.

DOUBLE-RIVETED LAP JOINT

(1) Shearing of rivets.
(2) Breaking of net section.
(3) Shearing of rivets.
(4) Shearing of rivets.
(5) Either shearing of rivets or breaking of net section.
(6) 4½-inch pitch and 15/16-inch rivet diameter.
(7) 4½-inch pitch.
(8) 4-inch pitch or over, any thickness up to and including 9/32 inch.

TRIPLE-RIVETED LAP JOINT

(1) Shearing of rivets.
(2) Breaking of net section.
(3) Shearing of rivets.
(4) Breaking of net section.
(5) Either breaking of net section or shearing of rivets.
(6) No, because the least possible pitch would be too great to permit of a tight joint.
(7) 4½-inch pitch.
(8) 2-inch pitch.

SINGLE-RIVETED DOUBLE-STRAPPED BUTT

(1) Crushing of rivets.
(2) Either shearing of rivets or breaking of net section.
(3) Crushing of rivets.
(4) Shearing of rivets.
(5) Shearing of rivets.
(6) Crushing of rivets or breaking of net section.
(7) Either by crushing the rivets or shearing the rivets, both methods of failure being equal.
(8) 2½.

DOUBLE-RIVETED DOUBLE-STRAPPED BUTT JOINT WITH ONE PITCH

(1) Either breaking of net section or shearing of rivets.
(2) Breaking of net section.
(3) Breaking of net section.
(4) Crushing of rivets.
(5) Shearing of rivets.
(6) Either crushing of rivets or breaking of net section.
(7) No.
(8) 21/32-inch plate.

DOUBLE-RIVETED DOUBLE-STRAPPED BUTT JOINT WITH TWO PITCHES

(1) Breaking of outer net section.
(2) Shearing of all rivets.
(3) Crushing of inner rivets and shearing the outer rivets, or shearing of the rivets.
(4) Crushing the inner rivets and shearing the outer rivets.
(5) Shearing of all rivets.
(6) By breaking inner section and shearing outer rivets.
(7) 19/32-inch plate.
(8) 4-inch pitch.

TRIPLE-RIVETED DOUBLE-STRAPPED BUTT

(1) Shearing of all rivets.
(2) Breaking of inner section and shearing outer rivets.
(3) Crushing inner rivets and shearing outer ones.
(4) Breaking of outer net section.
(5) The diagram does not hold good for this combination of rivet diameter and thickness of plate.
(6) 19/32-inch plate.
(7) 1-inch plate.
(8) By breaking outer net section or by breaking inner section and shearing outer rivets.

QUADRUPLE-RIVETED DOUBLE-STRAPPED BUTT

(1) The diagram does not hold good for this combination of rivet diameter and plate thickness.
(2) Inner rivets crush and outer rivets shear.
(3) All rivets shear.
(4) Inner section breaks and outer rivets shear.
(5) Rivets all shear.
(6) 1 1/16-inch plate.
(7) [illegible]
(8) 11/16-inch plate.

New Turbine Plant at Allentown, Penn.

An Uptodate Alternating-current Plant with Special Facilities for Handling Coal and Ash and an Ideal Location for Obtaining Water

BY JOHN I. BAKER

On account of the increasing demand for light and power and the inadequacy of their old plant, it became imperative for the Lehigh Valley Transit Company to build a new power station. A site near the old plant was selected, and the location is ideal for the receiving of coal and for obtaining water for condensing

FIG. 1. POWER HOUSE FROM THE LEHIGH RIVER

and other purposes. The building is of concrete construction, walls, floors and roof, all reinforced with Thacher bar reinforcement, and is 228 feet 3 inches long, 107 feet 6 inches wide and about 60 feet to the apex of the trusses. A concrete division wall extending from basement to roof forms a turbine room 228 feet 3 inches long by 52 feet 4 inches wide, and a boiler room 228 feet 3 inches long by 55 feet 2 inches wide. The concrete walls are 12½ inches thick from sub-base to roof. The columns supporting the trusses are on 18-foot 3-inch centers, and in order to make the building fireproof in all respects, the doors and window frames are of steel, made by David Luptons Sons Company, of Philadelphia. Wire glass is used throughout; the majority of the panes are 14½ inches long and 22½ inches high. A ventilator, 48 feet wide, having louvres on the boiler-room side and pivoted glass sash on the opposite side, extends the full length of the building.

The Boilers

The boiler equipment consists of ten 525-horsepower Babcock & Wilcox boilers arranged in batteries of two, each battery being 30 feet wide and about 23 feet 5 inches long. A space of 6 feet 6 inches between settings gives ample room for the steam-piping connections to the main header, for operating blowoff valves and for cleaning purposes. The distance from the floor to the top of the steam-outlet flange is 19 feet 9 inches.

Each boiler consists of three drums, 42 inches in diameter and 23 feet 3 inches long, placed above and connected to a set of 21 sections, each section containing 12 tubes 4 inches in diameter and 18 feet long. The drums are three sheets long; each sheet is ½ inch in thickness and all joints are butt-strapped. The superheaters are of the double-loop type; each superheater is made up of 42 groups of four 2-inch seamless drawn-steel tubes and contains 1100 square feet of heating surface. The boilers are guaranteed to evaporate 10½ pounds of water per pound of dry coal from and at 212 degrees Fahrenheit, the coal to contain 14,800 B.t.u. Each boiler contains 5242 square feet of heating surface. The original tubes were hot-drawn and made of No. 10 gage, but on account of occasional rupture, all replacements have been made with No. 9 gage, cold-drawn tubes.

The boilers are equipped with Roney stokers, driven by two 4½x4-inch Westinghouse standard engines. As there is space provided for two additional boilers, the stoker engines are so located that each engine will eventually drive the stokers for six boilers. The line shaft operating the stokers is $1\frac{15}{16}$ inches in diameter and makes four revolutions per minute. An auxiliary engine of the same make is in reserve, and the exhaust from both engines is utilized at the heaters.

Natural draft is furnished by an Alphons Custodis radial brick stack, located directly north of the boiler room, having an octagonal base and an internal diameter of 14 feet at the base with a taper to 8 feet at the top. The total hight of the stack is 226 feet above the foundation, or about 207 feet above the stokers. At the rear of the boilers is a brick flue 9 feet wide and 14 feet high, having an internal area of 126 square feet. Throughout its entire length the flue has these same dimensions. A steel-plate damper is controlled by a Collins damper regulator. The temperature of the flue gases at the base of the stack is 525 degrees Fahrenheit. Structural supports for a future economizer installation were erected with the building and are located above the main flue.

The plant has been in operation since May, 1908, and during that time the greatest overload in the boiler house occurred one evening when nine boilers, for a period of two hours, were operating on a 43 per cent. overload. At the time of the writing Burrows automatic feed-water regulators were being installed.

FIG. 2. COAL HANDLING FROM CAR TO PLANT

Coal and Ash Handling

Coal is received by rail, the main line of the Lehigh Valley Railroad Company passing in front of the power house. If

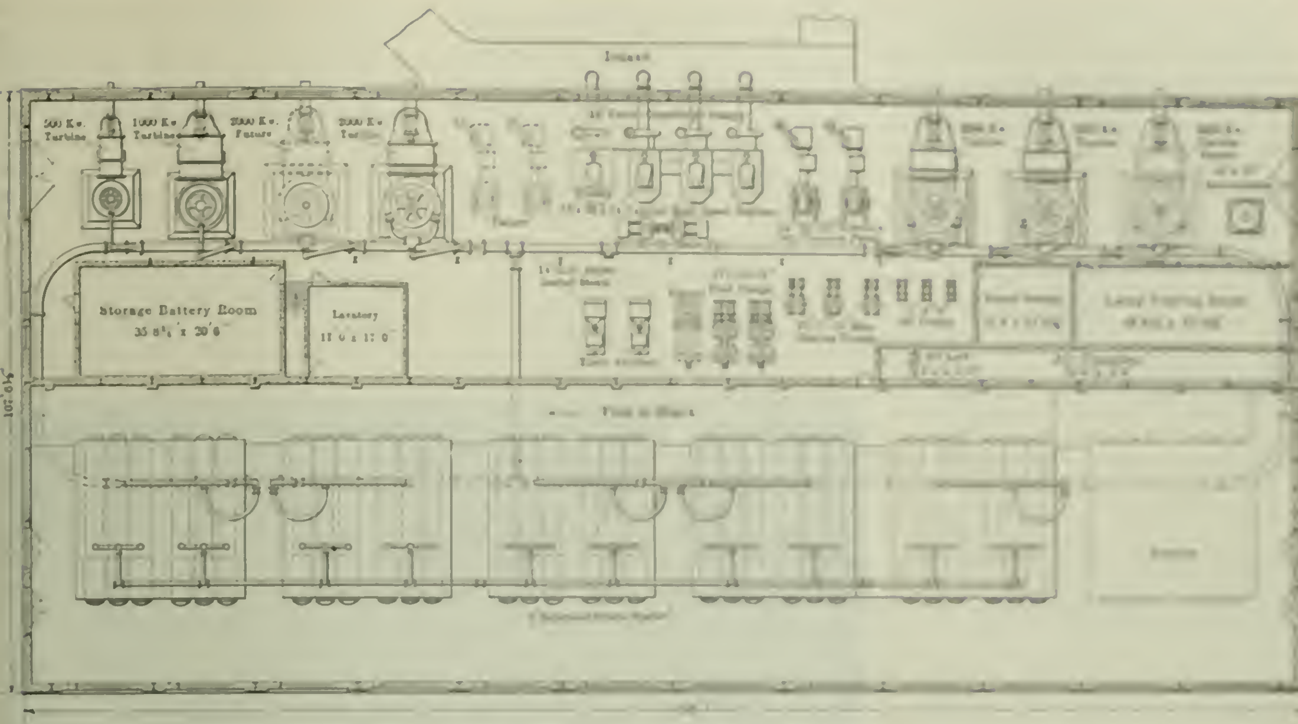


FIG. 3. GENERAL PLAN OF POWER PLANT

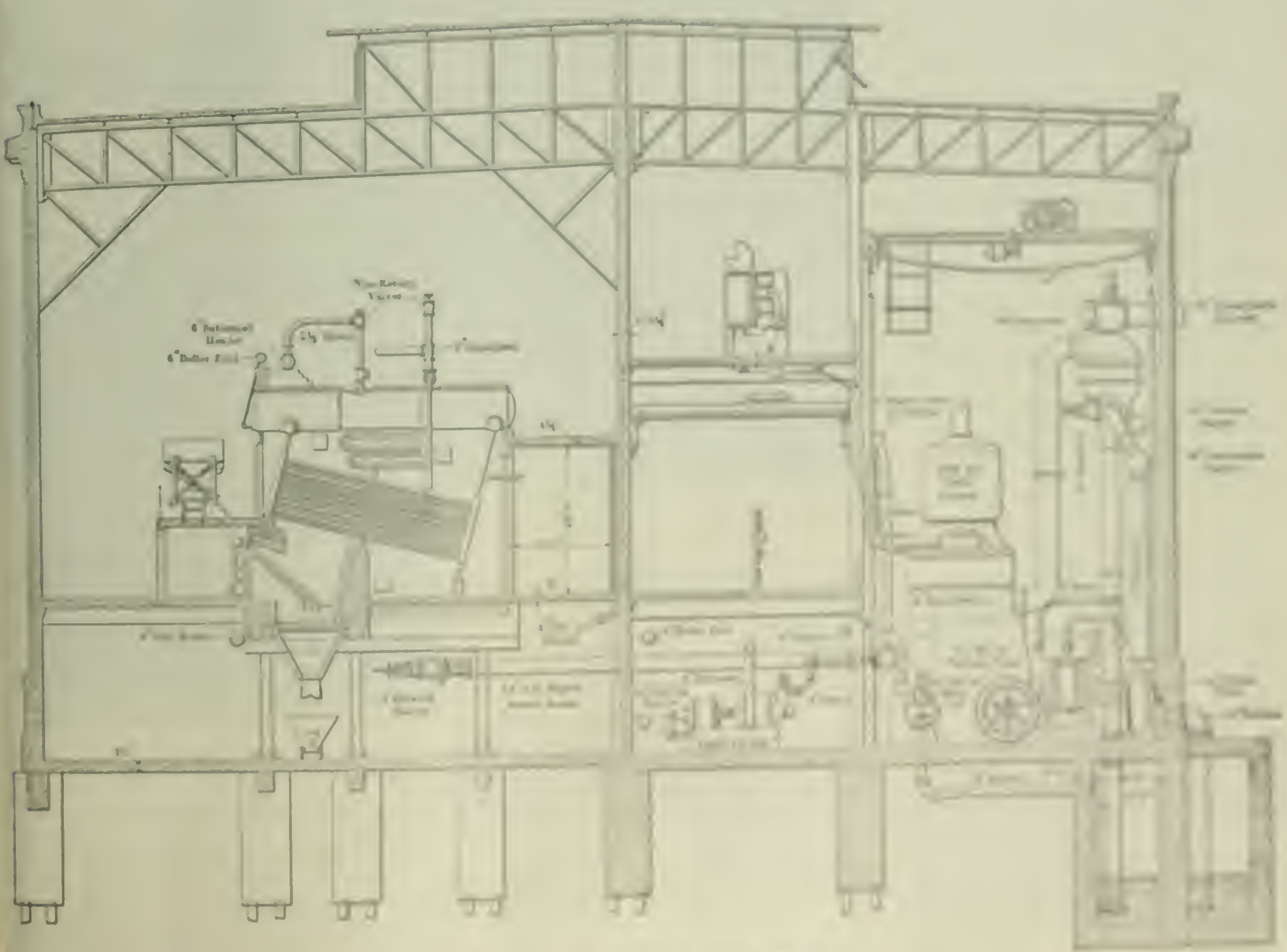


FIG. 4. SECTIONAL ELEVATION OF POWER PLANT

occasion required it, anthracite could be delivered by water, as the Lehigh river and canal are about 500 feet east of the power house. Along Front street there are at present eight reinforced-concrete coal-receiving pits, and the removal of the old power house will give space for three additional pits. Standard-gage railroad cars are run in on a track over a small pit at the side, having a slanting bottom and allowing the coal to slide down into the larger pockets, which are 12 feet wide, 15 feet deep and 19 feet long. Thus the cars can be immediately emptied and returned.

By means of a Gantry crane, built by the Browning Engineering Company, a grab bucket, with a capacity of 2 cubic yards, can take coal directly out of the cars, if necessary, but usually transfers the coal from the large coal pits to a steel-plate hopper attached to the crane, or in the space between the pits and west wall of the boiler room. This hopper will hold about 25 tons, and 6500 tons have been stored in front of the building. One rail for the Gantry crane is along the wall of the coal-receiving pits, while the other rail is supported by a girder at the top of the west building wall. Both rails are 60-pound A. S. C. E. section, and the distance from center to center of the rails is 88 feet 9 inches. One leg of the Gantry crane has a wheel base of 35 feet and the other 24 feet. The crane has a rated capacity of 100 tons per hour.

Extending along the boiler fronts and the west wall of the boiler house, there is a continuous, 19-inch gage track made of 20-pound, standard-section rails. A coal larry, built by the C. W. Hunt Company, and operated by storage batteries, takes coal from the hopper of the Gantry crane and delivers the coal to the small chutes above the stokers. The average capacity of the larry is 5200 pounds. The present coal consumption in 24 hours is from 100 to 125 tons. A bituminous medium-grade Kennerly coal, having the following analysis, is used: Moisture, 1.19 per cent.; volatile matter, 16.41 per cent.; fixed carbon, 70.98 per cent.; ash, 11.42 per cent.; B.t.u. per pound of coal, 13,808.

Motor-driven crushing rolls are located in the large receiving bin attached to the Gantry crane. The operator of the larry fills his car by opening the duplex valves on the hopper, and then runs the car along the front of the building and before entering the boiler room, weighs the coal on a Fairbanks scale having a capacity of 8000 pounds.

In case of accident to the Gantry crane a skip car and hoisting engine, built by the C. W. Hunt Company, have been provided. The skip car empties direct into the larry, and was in use until the Gantry crane was installed. It is now held as a spare.

The ashpits are made of reinforced concrete, and at the bottom of each ashpit there are duplex valves as illustrated herewith. Directly under the ashpits and extending the full length of the boiler-room basement, there is a narrow-gage track, 19-inch gage, made of 20-pound rails. The push-car for handling the ashes has a V-body, 55 inches wide, 40 inches long and 34 inches deep, and is of the double-side dumping type, made by the C. W. Hunt Company. Ashes are used for filling-in purposes, or can be loaded into cars. The narrow-gage track runs up an easy incline to the top of a car. One man takes care of all the ashes and has time to help at other odd jobs.

Prime Movers

The plant has a nominal capacity of 7750 kilowatts. For railway service there are two four-stage Curtis turbines, each of 2000 kilowatts rated capacity, operating at 750 revolutions per minute and delivering three-phase alternating current at 25 cycles frequency. For lights and motors there are one four-stage Curtis turbine, 2250 kilowatts rated capacity, 900 revolutions per minute; one four-stage Curtis turbine, 1000 kilowatts rated capacity, 1200 revolutions per minute, and one two-stage Curtis turbine, 500 kilowatts rated capacity, 1500 revolutions per minute, these three machines delivering alternating current at 60 cycles frequency.

The old plant consists of four 30x48-inch simple Cooper Corliss engines, running 80 revolutions per minute, each engine having a band wheel 20 feet in diameter and 57 inches face and driving by means of a 48-inch three-ply leather belt a 500-kilowatt Bullock generator. Jet condensers of the Worthington type are installed with each engine. For an emergency in railway service, two of these engines are available.

FIG. 5. METHOD OF HANDLING COAL IN BOILER ROOM.

Condensers and Auxiliaries

All condensers are of the barometric-tube type, made by Henry R. Worthington. By means of a reinforced-concrete intake, 7 feet high and 6 feet wide, water for condensing purposes flows from the Lehigh river, 500 feet away, through the intake and up to and along the eastern wall of the turbine room. Three 18-inch volute Worthington centrifugal pumps take water from the intake through 20-inch suction pipes and discharge into 18-inch pipes into the side of a 30-inch water header located directly above the pumps and at an elevation of 51.915. The pumps are direct-connected to 13x22x14-inch Bates vertical automatic high-speed engines, running at a maximum speed of 240 revolutions per minute and equipped with Schutte & Koerting Company angle-trip throttle valves.

[illegible] and to 12 inches at the 500-kilowatt unit. The [illegible] connections to the turbine are 4½ inches, [illegible] inches and [illegible] inches to the 500-, 1000- and 2000-kilowatt units, respectively.

Since the plant has been in operation trouble has been experienced with [illegible] water coming over into the [illegible] [illegible]. The [illegible] connections to the large turbines are taken from the top of [illegible] [illegible]; the [illegible] long-radius [illegible] bends giving flexibility to the line. The [illegible] steam header is [illegible] inches in diameter [illegible] flanges and flanged fittings.

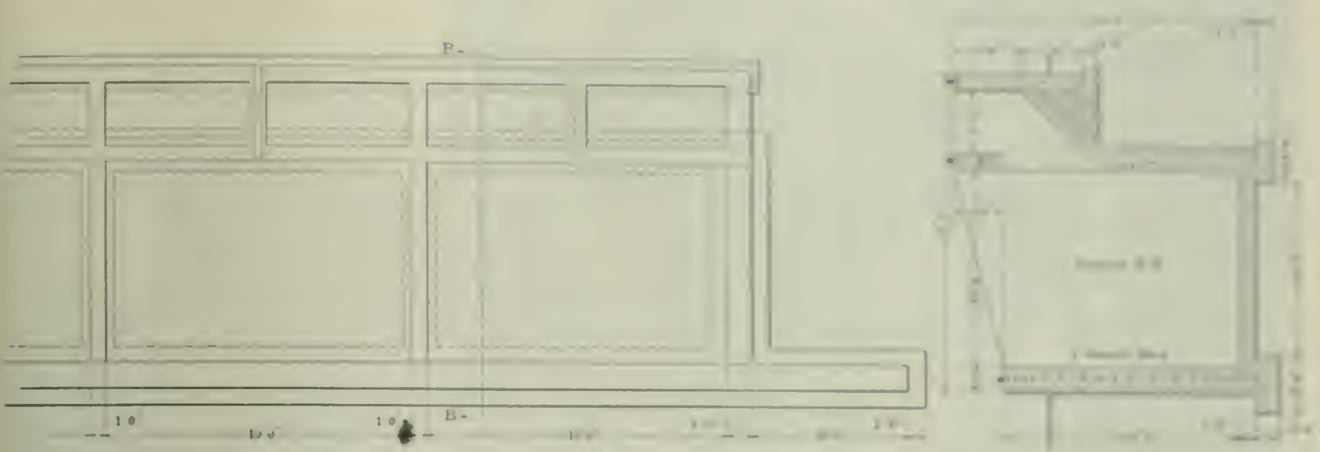


FIG. 6. COAL RECEIVING PITS

The water header extends along the east wall of the turbine room, is supported by brackets attached to the building columns and is 30 inches in diameter where the centrifugal pumps discharge into it, but reduces to 24 inches at the 2000-kilowatt turbine and to 12 inches at the 500-kilowatt unit. From this main header there is a 10-inch injection connection to the 500-kilowatt turbine, a 14-inch injector to the 1000-kilowatt turbine and a 16-inch to the 2000-kilowatt turbine. Ordinary chain passing over

FIG. 7. ASH HOPPER AND CAR

sheaves on the valve stems, and reaching down to handwheels and pedestals on the first floor, allow the attendants to control the injection.

There are two 14x[illegible]x18-inch Worthington steam-driven rotative dry-vacuum pumps attached to a 16-inch [illegible] header, reducing to 8 inches at the 500-kilowatt

pipe, and in order to put a stop to the [illegible] make-up pieces 18 inches high have been put in on every condenser. The exhaust connections from the turbine to the condenser are of steel plate construction with flanges made of steel castings. On the 2000-kilowatt units the rectangular exhaust pipe is 2 feet wide and 8 feet long. The free exhaust pipes are very short, extending just outside of the building with Blake automatic exhaust-relief valves of angle type are used on all units. Bundy steam traps are attached to the exhaust connections of all turbines and vary in size from No. [illegible] for the smallest to No. 104 on all of the 2000-kilowatt turbines. A vacuum of 28 inches is maintained. All steam-driven auxiliaries are running [illegible] [illegible], the exhaust going to the heaters.

The Piping System

The general arrangement of [illegible] steam piping is shown in the plan view of the station. The main steam header is [illegible] inches in diameter and forms a continuous loop extending along the turbine room and beneath the boilers. All flanges are of steel and all fittings are steel castings. Van Stone joints are used throughout. The steam is superheated [illegible] degrees Fahrenheit above the temperature corresponding to [illegible] pounds gage, which would be [illegible] degrees, making the total temperature of the superheated steam at the boilers [illegible] degrees Fahrenheit. Copper and steel gaskets were [illegible] [illegible] and [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] ing Company.

The connections from the header for superheated steam are [illegible] inches in diameter.

[illegible] extra-heavy gate valves are used and a brand of rubber packing called "Torpedo." Saturated steam is used to operate the centrifugal pump engines, rotative dry-vacuum pump, feed pump, step-bearing pumps, oil pumps, turbo-exciters and two of the Corliss engines in the old plant. Connections to the saturated-steam header are [illegible] inches in diameter. Both saturated and superheated connections are equipped with Schutte & Koerting Company automatic-stop check valves, angle type, with bodies of steel castings.

[illegible] Water [illegible]

By means of a [illegible] Worthington duplex-piston make-up pump, water is taken from the discharge conduit and

FIG. 8. [illegible]

delivered to two [illegible] Cochrane feed-water heaters with [illegible] [illegible] in the basement below the boiler room. There is also a [illegible] [illegible] [illegible] [illegible] connected [illegible] [illegible] and located as shown in the [illegible] [illegible] drawing. Both pumps are [illegible] [illegible] [illegible] [illegible] [illegible]. The

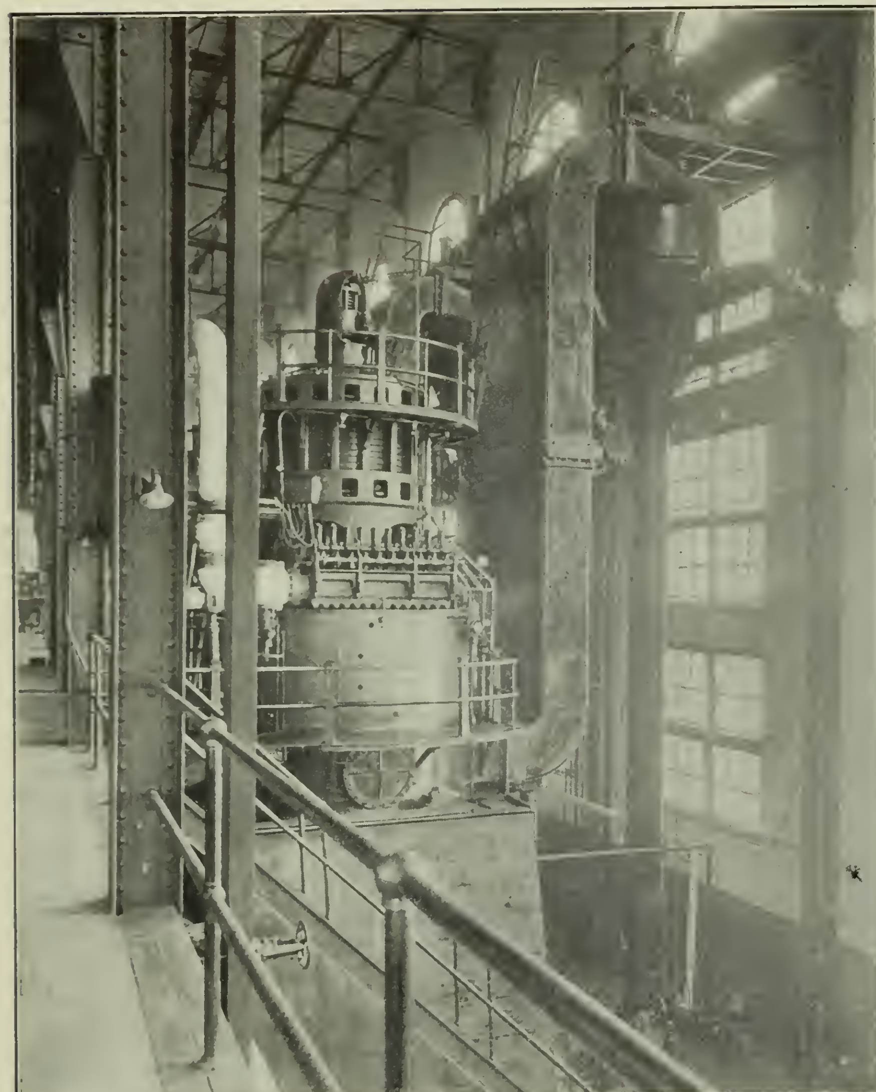


FIG. 9. ONE OF THE 2250-KILOWATT CURTIS TURBINES

feed water, which has a temperature of 208 to 210 degrees Fahrenheit, flows by gravity to two 17x10x15-inch Worthington duplex-plunger feed pumps equipped with Fisher pump governors. The heaters can also take water from an 8-inch connection to the city water line. The boiler-feed header is 6 inches in diameter.

Step-bearing and oil pumps

There are three 12x3x10-inch Worthington duplex-plunger pumps supplying water pressure for the step bearings of the turbines. These pumps are also equipped with Fisher pump governors and so are the oil pumps. The pressure gages show that it takes 200 pounds per square inch for the step bearing of the 500-kilowatt machine and about 435 pounds for the 2000-kilowatt turbine. In case of accident to these pumps a 16x17-foot R. D. Wood & Co. hydraulic accumulator can supply sufficient pressure to keep the turbines running 15 minutes. For oiling the top and middle bearings of the turbines and also the throttles, there are three 6x2x6-inch Worthington duplex-plunger oil pumps.

Electrical Equipment

The two 2000-kilowatt turbine units generate alternating current at 13,200 volts. The old switches between the turbines and buses are located on the second gallery which extends the full length of the power house. To the busbars there are attached five transmission lines as follows: Two on the Philadelphia line, sending 13,200 volts to the substations at Coopersburg, Sellersville, Landsdale and Ambler; one to Siegersville and Slatington, one to Catasauqua and one to Bethlehem and Hecktown.

The southern end of the switchboard gallery contains the substation for the Allentown lines, consisting of nine transformers having a capacity of 185 kilowatts each. The transformers are delta-connected on both high- and low-tension sides, and are air-cooled by two 55-inch Buffalo Forge fans direct-connected to 4-horsepower induction motors running 690 revolutions per minute and guaranteed to furnish 10,000 cubic feet of air per minute at ¾ ounce pressure. At the transformers the current is stepped down to 430 volts. By means of three 25-cycle rotary converters, each of 500 kilowatts capacity and running 500 revolutions per minute, this alternating current is converted into direct current at 600 volts for railway service. The equipments of the other substations are similar to the one just described, with the exception that the voltage is stepped down to 370 volts at the transformers and the converters are of 300 kilowatts capacity each.

For lighting purposes there are three

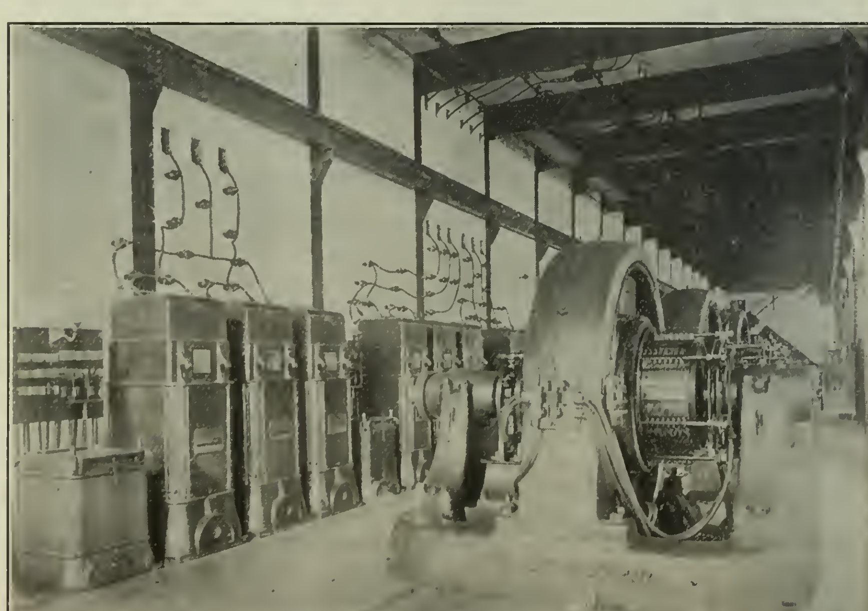


FIG. 10. ROTARY CONVERTERS AND TRANSFORMERS

units of 500, 1000 and 2250 kilowatts rated capacity, generating alternating current at 2300 volts and of 60 cycles frequency. By means of three transformers, each having a capacity of 200 kilowatts, the current is stepped up to 13,200 volts. Transmission lines extend to the towns of Bethlehem and Slatington. A rotary converter of 300 kilowatts capacity and synchronous motors driving arc machines; three generator panels, 60 cycle; two exciter panels; one storage-battery panel, two 2000-kilowatt 25-cycle panels, five 25-cycle 13,200-volt panels, one 300-kilowatt 60-cycle panel for rotary converter, three 500-kilowatt 25-cycle panels for rotary converters, two motor-circuit feeder panels, one motor-circuit panel,

FIG. 11. SWITCHBOARD CONTAINING 57 PANELS

running 900 revolutions per minute converts this current into 600 volts direct current, supplying commercial power and the power for the Gantry crane.

For the 650 arc lamps in Allentown and neighboring towns there are on the second gallery eight Brush arc generators, each having a capacity of 125 lamps. Four 140-horsepower three-phase 2300-volt synchronous motors are direct connected to the arc generators, one motor mounted centrally between two generators.

Exciters and Storage Batteries

On the first floor there are two turbo-exciters operating at 2400 revolutions per minute. These machines are of 75 kilowatts capacity, and one machine can be used as a booster to charge the storage batteries. The storage-battery room, located on the first floor, contains 75 Type G 11 chloride accumulator cells furnished by the Electric Storage Company, and there are always 57 cells floating on the exciter buses.

The switchboard consists of 57 slate panels about 2 inches thick and 7 feet 6 inches high. The total length of switchboard is 81 feet 4 inches and is made up as follows: Ten single-phase feeder panels, 2300 volts; one three-phase panel, 2300 volts; three transmission-line panels, 60 cycle, 13,200 volts; one panel for three low-volt panels, eight [illegible] feeder panels and the remainder are [illegible] to be used when future railway [illegible] are added. The voltage at the switchboard is about 600 volts. The electrical equipment throughout the entire plant was furnished and installed by the General Electric Company.

FIG. 12. BRUSH ARC GENERATORS

General

The turbine room is equipped with one 25-ton Case electric traveling crane having a span of about 47 feet from center to center of the rails. The crane girders are supported on 20-inch I-beams, which in turn are attached to the building columns. The eastern portion of the turbine room contains two galleries. The first has office rooms at one end and a substation at the other end, with the switchboard located about centrally. This gallery is served by a hand traveling crane having a capacity of 10 tons. The plant operates continuously and is run on three shifts per 24 hours. The number of men per shift is as follows: One watch engineer, one pumping engineer, one turbine engineer, one operator and helper on the switchboard (helper necessary on account of the substations on the switchboard gallery), one man, engine only, for arc machines on the second gallery; two firemen who are also water-tenders, one man for ash handling and one man for coal larry, the crane runner on the Gantry crane, and usually one boilermaker and one blower for two shifts.

The company operates 150 miles of electric railway and recently has inaugurated a trolley express service. Some freight cars, resembling outwardly the ordinary freight car, will carry freight to all points along the line. The boiler room of the old plant has been made into an in-[illegible] points. Class cars are governed by official commercial classification.

The plant was designed by the [illegible] Engineering Company, Philadelphia, Penn. The writer is indebted to the superintendent of the power house and other employees for their courtesy and help in gathering the data for this article.

The Three-Wire System with One Dynamo

The Reason Why the Neutral Wire Is Necessary. Methods Used for Compensating Unbalanced Load. Size of Motor Compensator Needed

BY CECIL P. POOLE

If an ordinary dynamo be connected to a group of incandescent lamps arranged in series multiple, as indicated diagrammatically by Fig 1, its voltage will have to be twice that for which each lamp is made, that is, if 110-volt lamps are used, the voltage of the dynamo must be 220 (disregarding line losses for the present). Such a system would be even more economical than the three-wire system, and would have been adopted instead of the three-wire system but for one serious defect—the lamps would have to be installed, lighted and extinguished in pairs. Consequently, a customer who wanted 5 lamps would have to take 6, and he could not control his lamps singly.

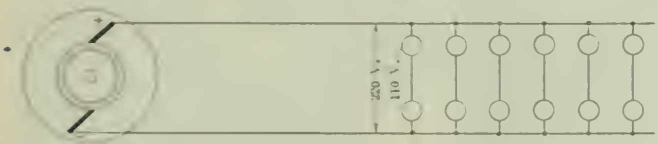


FIG. 1

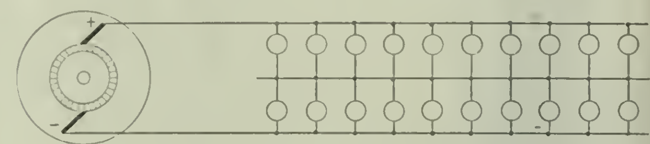


FIG. 2

If, to the arrangement shown in Fig. 1 a third wire were added, connected between each pair of lamps, as shown in Fig. 2, part of the original difficulty of control would be overcome. With this arrangement, any one lamp on one side of the middle wire could be lighted or extinguished, provided one of the lamps on the other side was simultaneously lighted or extinguished. So long as the number of lamps on one side was equal to the number on the other side, it would not matter just which lamps were lighted and which were out. But this would require turning on and off 2 lamps every time, and, worse yet, the consumer would have to know which lamps were on one side and which on the other side of the system, which makes it utterly impractical. The reason for having to keep the same number of lamps lighted on both sides of the same will be evident upon consideration of Fig. 3. Here 10 lamps are shown on one side and 8 on the other. If the resistance of each lamp were 220 ohms, which is a common value for 110-volt lamps, the joint resistance of the group of 10 would be $220 \div 10 = 22$ ohms and that of the 8 lamps would be $220 \div 8 = 27\frac{1}{2}$ ohms. The total resistance of both groups, therefore, would be $22 + 27\frac{1}{2} = 49\frac{1}{2}$ ohms, and the current flowing through the groups would be $220 \div 49\frac{1}{2} = 4.44$ amperes. Now the proper current for the 10 lamps would be $110 \div 22 = 5$ amperes, and the proper current for the 8 would be 4 amperes; consequently, the group of 10 lamps would get too little current and the group of 8 lamps too much.

In order to correct this defect in the arrangement shown, it is necessary to provide means for taking the surplus current from the smaller load on one side and transferring it to the greater load on the other side. This is called "compensating" the lack of "balance" in the circuit. (When the load, or number of lamps on one side of the middle wire is equal to the load on the other side, the circuit is said to be "balanced;" any other condition makes the circuit "unbalanced.") One of the simplest methods of compensating for unbalancing is to connect a secondary battery between the two main wires and connect the middle or "neutral" wire to the middle point of the battery, as in Fig. 4. Here 10 lamps are shown on one side and 6 on the other; the flow of current is indicated by the arrows. Under the conditions shown, the half *A* of the battery will deliver just enough current, if the voltages are suitably proportioned, to supply one-half of the excess or unbalanced load on the heavy side of the system. The dynamo supplies the other half of the excess current, and this half comes in on the neutral with the current supplied by the section *A* of the storage battery and passes back to the dynamo through the section *B* of the battery, charging that section. This proportion holds good for any degree of unbalancing; that is, that part of the battery on the heavily loaded side will send out one-half of the current in the neutral wire and the other half will go through the part of the battery that is on the light load side of the neutral.

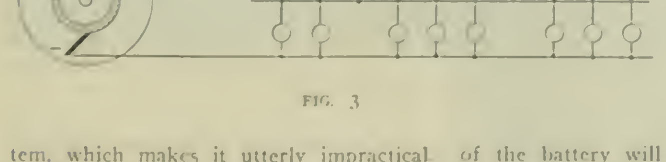


FIG. 3

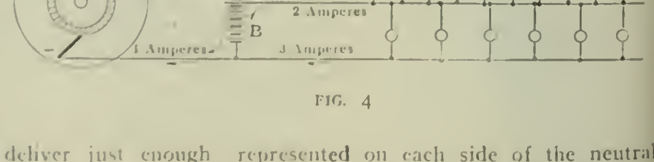


FIG. 4

This arrangement, though apparently ideal in simplicity on paper, is not so attractive in practice because a rather troublesome regulator is needed in conjunction with the battery in order to prevent it from exhausting itself when the load is heavy or drawing too heavily from the line when it is light. Moreover, the two halves of the battery cannot be kept in equal condition, because one side would do more work than the other, unless the circuit could be unbalanced alternately and equally on first one side and then the other. This difficulty can be met, however, by exchanging the two sections at regular intervals, say once a week.

A more practical method of compensation is by means of what is commonly termed a "motor-balancer," but is more correctly a motor-compensator. This consists of two small motors exactly alike in all respects, their shafts rigidly coupled together and their armatures connected one on each side of the neutral wire, as indicated in Fig. 5, where 120 lamps are represented on each side of the neutral wire. Here it is assumed that the motor armatures require one ampere to drive them, or 220 watts (110 watts each), and for simplicity the current required by their field windings is ignored. So long as the load is balanced, the two armatures will take current from the main wires only.

and will revolve idly. If more load is added to one side, however, or some load taken off the other side, the equilibrium between the voltages of the two sides will be upset; the voltage at the brushes of the motor on the lightly loaded side will be higher than that at the brushes of its mate, and it will drive the latter at a speed beyond that due to the circuit voltage, making a dynamo of it, and forcing it to carry the unbalanced part of the heavier load on the circuit. This is illustrated in Fig. 6, where 120 lamps are shown on one side and 60 on the other, each of the circles representing 10 lamps, taking ½ ampere each. What causes the distribution of current shown is this: When the load in the *B* division is reduced the voltage rises, because the losses in the dynamo and circuit wires are reduced; the voltage between the neutral and the negative wires rises more than that between the positive and neutral, because the resistance there is higher—all the reduction of load has occurred in that division of the circuit. The armature *B*, therefore, speeds up, dragging the armature *A* with it until the voltage of the latter increases above that of its side of the circuit sufficiently to carry half of the excess load on that side, minus the power required to drive the two machines. This power was assumed to be 220 watts, the current taken by the two armatures in series in Fig. 5 being one ampere and the total voltage 220. Here, one of the armatures does all the work, so that the whole 220 watts must be applied to it, in addition to an amount of power equal to that being delivered by the armature *A* working as a dynamo. As the armature *B* takes its current now from the unbalanced current coming in on the neutral wire, it works at 110 volts and therefore requires 2 amperes to overcome the losses in the two machines (the losses in the windings are ignored to simplify the problem); the neutral wire must carry 30 amperes because the 60 lamps in the negative division will pass only 30 amperes. Deducting the 2 amperes for motor losses leaves 28 amperes, which divides between the two machines, 14 amperes supplying the motor with the energy necessary to produce 14 amperes from the armature now driven as a dynamo.

Another way to arrive at the division of current is as follows: The main dynamo must supply all of the energy represented in the circuit; all that the compensator does is to transfer the surplus energy from one side of the circuit to the other—it cannot supply any additional energy because it is driven by energy taken from the main circuit. Now the lamps take each ½ ampere at 110 volts, or 55 watts; there are 180 lamps, requiring 180 × 55 = 9900 watts. The compensator requires 220 watts to overcome its internal losses, the watts losses in line being ignored for the present. The lamps and compensator together, therefore, require a total of 10,120 watts. Ignoring line losses, the generator works at 220 volts, and in order to deliver 10,120 watts it must deliver 10,120 ÷ 220 = 46 amperes. Since the lamps in the positive division (*A*) require 60 amperes, the armature *A* working as a dynamo must supply 60 − 46 = 14 amperes. Consequently, of the 30 amperes in the neutral wire, 14 must have been generated in the latter machine, the other 16 to pass through the motor armature *B* to the main dynamo, as previously explained.

The exact figures in practice would not be those here stated because the line losses, the current in the field windings of the compensator and the losses in their armature windings affect the current distribution. The principle, of course, is not affected; the machine on the lightly loaded side of the system always runs as a motor and drives its mate as a dynamo, the latter supplying about one-half of the difference between the two divisions of the load, minus the power required to drive the former. The losses do affect the voltage regulation, however. If the armature windings of the compensator are of very low resistance, the voltages on each side of the neutral will be kept almost exactly equal; if the armature resistances are high, the voltage between the neutral and the outer wire which carries the heavier load will be appreciably lower than that on the other side of the system.

The regulation obtained with series compensators can be much improved by cross-connecting the field windings, as shown in Fig. 7. The result of this is that when the load on the side *A*, for example, is less than that on the other side, the voltage of the side *A* being higher than that of the side *B*, the field strength of the machine *A* will be weaker than that of the machine *B* and its speed will be higher than it would be with a simple field. The machine *B* on the other hand

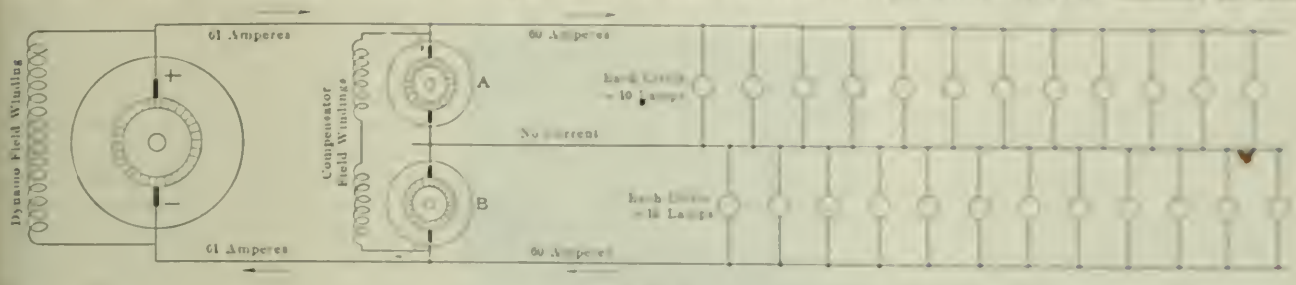


FIG. 5

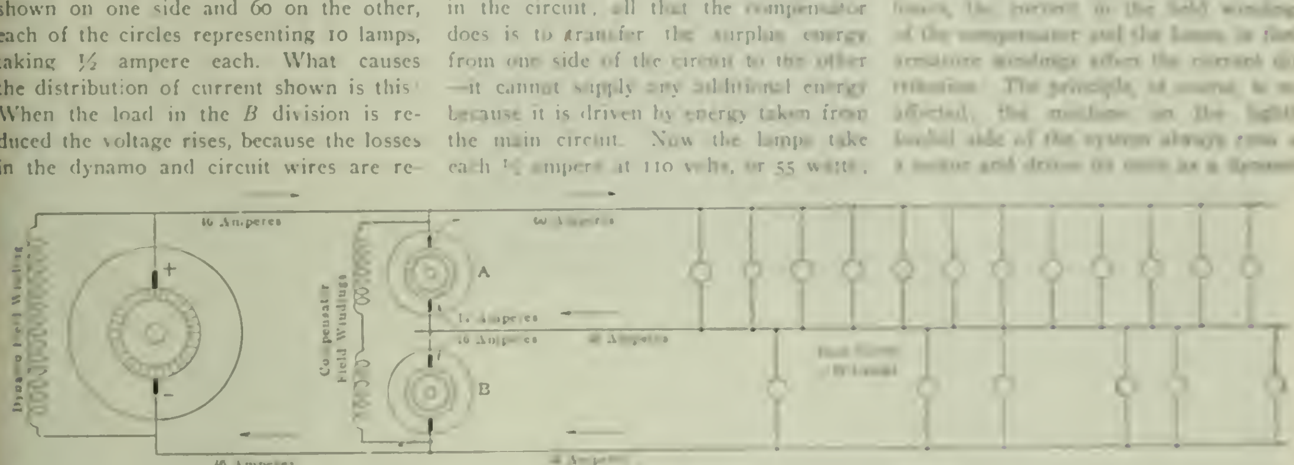


FIG. 6

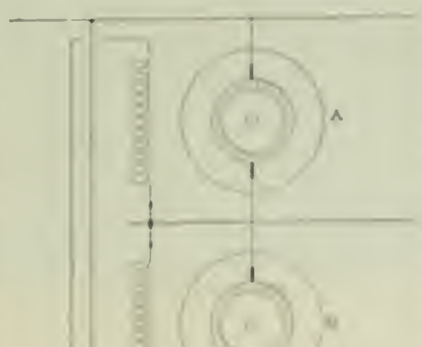


FIG. 7

driven as a dynamo, will have its field strengthened, and will deliver a higher voltage than it otherwise would. In other words, the machine which runs as a motor runs at a higher speed, giving its mate a higher voltage, and the latter will have a stronger field, augmenting its voltage still more, with the connections shown in Fig. 7 than with the more usual arrangement shown in Figs. 5 and 6. If the resistances of the armatures are made very low, however, the improvement in regulation obtained with cross-connected field windings is not great enough to justify the extra complication involved.

The armature capacity of a motor compensator, in amperes, must be equal to one-half of the current that will flow in the neutral wire when the system is out of balance by the maximum amount possible under operating conditions, plus the current required to overcome *all* losses in the two armatures at full load. The losses in small armatures range from 5 to 10 per cent. at full load; therefore, if the compensator armatures can carry 55 per cent. of the maximum current that will ever flow in the neutral wire, they will be large enough.

Reorganizing an Old Water Power

There are doubtless many plants deriving considerable water power from old developments in which both volume and efficiency could be materially increased by a complete reorganization in accordance with the most recent practice. And not only may the power end be benefited thereby, but the good results there possible of attainment may be considered in conjunction with relocation or reconstruction of the manufacturing building or buildings so as to secure the maximum of convenience and efficiency. A typical case of this nature is presented by a reorganization conducted under the supervision of Charles T. Main, of Boston, which successfully embraced both of these advantages as is evident from the following brief description.

The complete plant of the mill in question formerly consisted of three separate installations, each with its own individual dam, water wheels and buildings, all situated within about 1200 feet. The head of water at each dam varied from 10 to 18 feet, according to the changeable conditions. The improvements started with the elimination of the two down-stream dams and the selection of the remaining up-stream dam for service in the new development. By this combination a total head of 40 feet was obtained. From the up-stream location the water was carried through a steel penstock to a modern and comparatively small water wheel somewhat below the farthest down-stream dam. At this point a new manufacturing plant was erected to take the place of the scattered buildings. In this were incorporated many improvements in the way of manufacturing equipment. The old buildings at the other dams were abandoned or used for storage purposes.

The advantages of the reorganization were evidenced in two ways, by the concentration and utilization of a better-conserved water supply under a greater total head and by the grouping of the manufacturing buildings on a single building site. The expense of upkeep of the three original dams was reduced and limited to that upon one, while the loss of head between them, inevitable under the old conditions, was eliminated. By selecting the up-stream site for the single dam and carrying the water by penstock to the new site at a considerable distance down stream, the maximum head was utilized. It is evident that had the down-stream location been selected and the same head provided at the wheels a new dam would have been required. This would have required extra strength to withstand the greatly increased pressure.

The combined power at the best was relatively small, but when divided into three units, as in the original installation, the friction losses were excessive. By the adoption of the new plan it became necessary to keep only one dam tight in order to conserve the water. The excessive leakage through the other two was eliminated, as was also the amount passing by the water wheels during the night. In every way the new plant was more efficient and more easily operated. The power available at the new mill is now sufficient to run the entire plant several months of the year.

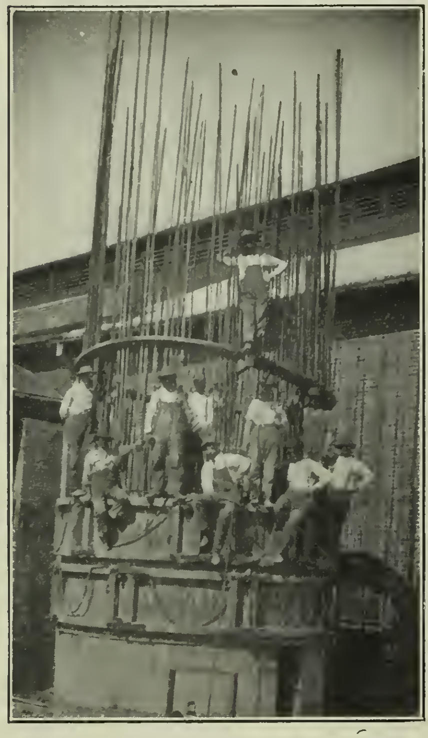


FIG. 1. METHOD OF REINFORCING CONCRETE STACK

Concrete Chimneys

By Ethan Viall

The Illinois traction system, which has a network of interurban electric lines all over central and southern Illinois, has placed concrete stacks at all of its power houses. Up to date eight of these stacks, varying in hight from 160 to 185 feet, have been built or are in the process of construction. These chimneys will average about 12 feet in diameter at the bottom and taper to 10 feet at the top, and are set on a concrete foundation 25 feet square.

Fig. 1 shows one of the chimneys and the entire construction gang, including boss and inspector. The method of reinforcing is well shown in this cut. In addition to the upright rods shown, a 5/8-inch round iron hoop is placed outside of the verticals every 18 inches, and all are firmly imbedded in the concrete. At the bottom are placed 144 uprights, and the number is gradually reduced to 12 at the top.

It will be remembered that one of the chimneys built by this company at Peoria fell with disastrous results, the cause being said to be that the concrete mixture was allowed to stand too long before being placed. Since this accident occurred, quick placing of the mixture and rigid inspection has been the rule. Fig. 2 shows one of the chimneys at the end of the fourth week's work.

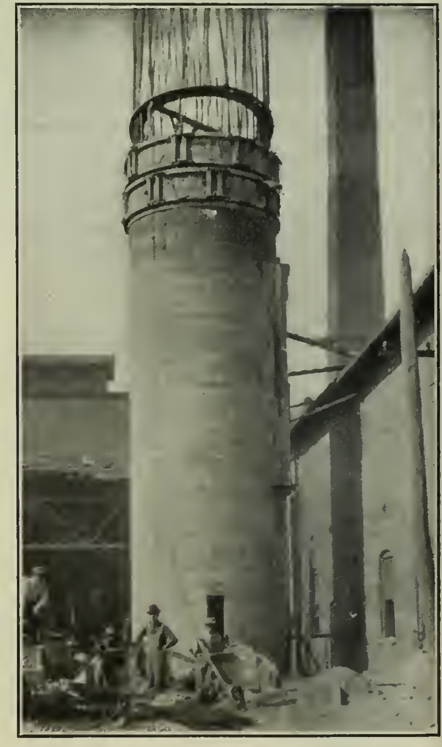


FIG. 2

Supernatural Visitation of James Watt

An Entertaining Presentation of What the "Father of the Steam Engine" Might Do and Say if He Were to Come Back to Earth Today

BY WARREN O. ROGERS

There are many subjects upon which men do not agree, some even going so far as to ridicule the beliefs or opinions of others, although they themselves have never investigated their truth or falsity.

I have no apologies to make for the wonderful experiences I have had with matters which to many may seem supernatural, I shall not attempt to convince anyone that it is possible to communicate with those who have departed this world and passed into the Great Beyond, but will content myself by merely relating my experiences and leave the reader to form his own opinion.

For years I have been a student of psychical research. I have not been content to confine myself to the foolishness of knocking on doors and tipping tables, but have harmonized my mental powers with the influence surrounding many departed spirits. Therefore, astonishing as it may seem, I have been able to enter into the state in which they exist, to some extent, and although possessing my earthly faculties I also partake of their spiritual life, and can see those with whom I am talking, although in phantom form, and converse with them in my own tongue.

The most interesting of these experiences have been those of communing with men whom the world once regarded with honor, although dead and buried for many years. These experiences have been most interesting because [illegible] of their earthly life, and many an hour have I spent in congenial conversation with James Watt, George Stephenson, Robert Fulton, and others. I mention these particularly because I am interested in the subjects they were familiar with more than any others.

My first experience with a resident of the other world was accompanied by sensations not altogether pleasant. I sat one evening, deeply absorbed, reading a treatise on the subject already mentioned. I was alone, and the stillness of the house was broken only by the frequent gusts of wind and rain beating against the window panes. Time passed [illegible]. As the clock on the mantel chimed midnight, I closed my book, with the intention of retiring, [illegible]

I SHALL NEVER FORGET THE APPEARANCE OF JAMES AS HE SAT, ONE SHADOWY LEG OVER THE OTHER, THE FRAGRANT CIGAR SMOKE ASCENDING IN WAVY COLUMNS FROM HIS THIN, BLOODLESS LIPS gineering field since he left us. Absorbed in such speculations, a power which had been developing in me for some months began strongly to assert itself, and being willing to assist, I focused my entire mental energy to bring into my presence in a tangible form that long-departed inventor to whom the world owes so much.

My first realization that another presence was with me was a faint shadow between the light and the wall. It was not a human form, and yet it was. While I gazed, I was seized with a sensation of extreme cold—fear it may have been, I know not. I tried to speak, but my lips were speechless. I tried to move, but was powerless. To add to the horror, the electric lights began to grow dim; the fury of the storm without increased, and a nameless dread possessed me. The form advanced slowly toward a vacant chair on the opposite side of the table. The deep chilly atmosphere of the grave seemed to permeate the room, and as I felt the cold, clammy hands of my visitor grasp my own, my overtaxed mind could stand no more, and I fell into a state of unconsciousness. When I regained my faculties, I heard a friendly voice say:

"Do not be disturbed; you have long wanted a visit from me, and on my part I have been just as anxious to converse with you."

As my vision grew clear, I saw that the one I had been longing to bring into my presence was indeed with me. His genial, smiling face and pleasant voice soon put me at ease, dispelling all sense of fear of the supernatural (which, I may state, has never returned).

In order to make James feel at home, I asked him what he would have, and being told a Scotch high-ball, proceeded to concoct the same, which speedily disappeared. Having thus fortified ourselves, and being comfortably seated in our chairs with fragrant Cuban "perfectos" in our mouths, I asked James to tell me about his early struggles, a subject I was not entirely familiar with.

I shall never forget the appearance of James as he sat by my library table; one shadowy leg over the other, the silver buckles on his low-cut shoes glistening in the rays of the electric light, the half-empty glass on the table (for I had refilled it again), and the fragrant cigar smoke ascending in wavy columns from his thin, bloodless lips.

"I was born," said he, "of poor but, honest parents—"

"Stop, James, stop where you are! I did not ask you to recite the beginning of one of Laura Lean Jibby's novels. I asked you to tell me something that can't be bought on every newsstand in the country. Now, start again."

He recrossed his legs, took another sip, and said in a somewhat dogged tone, I thought:

"Well, they were poor, anyway."

I nodded my approval, and he continued:

"My ancestors were all mechanics and men of genius, so you see it is nothing strange that I was endowed with an inventive turn of mind, or that I lived 150 years before my time. I was born, as you have doubtless heard, at Greenock, Scotland, January 19, 1736. It was a bitterly cold day, and father was so chilled he could hardly measure out oatmeal to his customers. He was a merchant on a small scale. He had lost all his money speculating; that is the reason I always had to work for a living. [Here James gave a sigh of regret.]

"I was a slim, puny kid up to the time I got to knocking up against the world, and then it kept me so busy looking after the £.s.d., I didn't have time to worry about my lack of muscle, and, as a consequence, I picked up."

"I don't care anything about your health, James," said I. "How about your sitting beside the fire speculating on the tea kettle and all that?"

James grinned and winked one eye at me, as he said:

"Don't you take any stock in that yarn. In those days we had the open fire-place, the crane, tea kettle, and all that. The weather in Scotland at that time—I don't know how it is now—was moist, cold and disagreeable at certain seasons of the year, and would pretty near freeze a fellow to a frazzle. [James is evidently a Republican.]

"The back of the room would be like an iceberg, while near the fire one got the other extreme. After I had been out for a few hours cutting up devilments, finishing the chores and eating my bowl of porridge, I felt like sitting near the fire to keep warm. As a general thing an iron tea kettle was hung on the crane to heat water to wash the supper dishes, and as I didn't have anything else to do, I used to sit and watch the steam come out of the cover and spout of the tea kettle, or look at the fire; but as for sitting there and figuring on getting up a steam engine, don't you think of it for a minute, my boy. I was toasting my shins, nothing more. After I improved on the steam engine and got so prominent that people were willing to give me half the sidewalk when we met, some old woman remembered me sitting before the fire toasting my shins and started the tea-kettle story." And James laughed long and loud.

I began to take a fancy to James, for I could see that he was not going to take any more credit to himself than he deserved, and he was proving a pretty jolly companion. Seeing him cast a longing gaze at the cigar box, I pushed it toward him, with an invitation to help himself, which he did. After attempting to light the fresh cigar on the electric-light bulb and evidently much astonished at his inability to do so, he said:

"When I left home I went to London, and became apprenticed to an instrument maker named Morgan. I could stand him only about a year when I skipped out and went back to Scotland, where I hobnobbed with a lot of college professors repairing their kits. Next, I tried to open an instrument-making shop in Glasgow, but the union wouldn't stand for it, seeing I had not served my apprenticeship, although to tell the truth it would have taken a mighty good man who had done better or more accurate work than I did. They thought they were 'it,' but you don't hear much about them now, do you?" And I thought I could notice a slight chestiness about James I hadn't seen before.

"However," he continued, "I was helped along by the college professors, and after awhile found myself established in the college with the cognomen of Mathematical Instrument Maker to the University. What do you know about that? The professor knew I could make instruments, while the practical man thought I was no good, because I had not worked four years for some skinflint for next to nothing while learning my trade." James spoke with considerable vehemence, I thought, considering the occurrence had happened a century and a half ago.

"While at college I made the acquaintance of some pretty learned men and dabbled in philosophy, anatomy, chemistry, electricity, etc. It was my interest in philosophy which caused me to turn my attention toward old Newcomen's engine. I met him only the other day," said James after a pause, "and he swears that he had worked out my scheme of condensing steam, but had been bothered in getting his ideas through the patent office, both at home and abroad, when I butted in. What do you think of that?" James looked at me inquiringly, but before I could answer said:

"Newcomen is only doing what others have done. Few give me credit for what I have accomplished, most people saying that my work consisted of improving what others had started, but I see that they still hold to a lot of my ideas. Now wouldn't that press your pants?"

"Tell me about your first attempt at a condenser," I said, as James flicked the ashes from the end of his cigar with his little finger.

"I am afraid I shall be obliged to postpone that for another visit, as I am not yet advanced enough in the circle of progress in my world to warrant my roaming around on earth during daylight hours, and as it is almost sunrise I shall soon be obliged to bid you 'good morning.' We have had a jolly good time though, haven't we? I'll be only too glad to come back whenever you feel like putting up with such a cold-blooded old fellow as I am."

James arose, and as he reached across the table to shake hands the morning sunlight streamed in through the eastern window, and my visitor of the night immediately faded from my sight.

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

A Study in Flexibility

The accompanying illustrations show two dry-vacuum pumps, *E* and *F*, connected to so-called "centrifugal barometric" condensers. While this arrangement is apparently simple, it caused no little discussion as to the best means of making the pumps interchangeable on either condenser. A "centrifugal barometric" condenser is a jet condenser of the barometric type, and differs only in that the vacuum is created not by the fall of a column of water but by the suction of a centrifugal pump. Its chief advantages are in the saving of head room and the avoidance of long connections.

Fig. 1 shows the piping as originally laid out, without any particular thought of interchangeability; therefore, it is difficult to understand why the valve *B* was placed in the line and, in fact, why the connections for the two units were not made entirely separate. As the sketch shows, a valve was placed in the drop tee to each vacuum pump, the valve *B*, therefore, could hardly serve any useful purpose except to separate the horizontal run into two parts.

Even had it been desired, by opening *B* and closing *C*, to allow the left-hand pump to operate with the right-hand condenser, the vacuum would still be placed on the left-hand condenser, and even though the valve in the exhaust from the engine, the circulating-water valves, the priming-water valves and the drain valves on the left-hand condenser were all closed, the numerous joints would afford an opportunity for sufficient air to leak in to cut down the vacuum on the right-hand condenser.

When piping has been [illegible] it is much easier to find any mistakes, and in this case it was seen that with comparatively few changes the arrangement could be made much more flexible. Fig. 2 shows how it was done. The valve *B* was removed from the main run, and placed in the short connection between the tee and the condenser; another valve *D* was placed similarly on the other condenser. Then by closing *A* and *D* the right-hand pump operates with the right-hand condenser; closing *B* and opening *D* the left-hand condenser is put in commission. The left-hand pump and condenser may be operated separately by closing *B* and *C* and the left-hand pump operated with the right-hand condenser by closing *D* and *C*.

George W. Martin.

Pine Bluff, Ark.

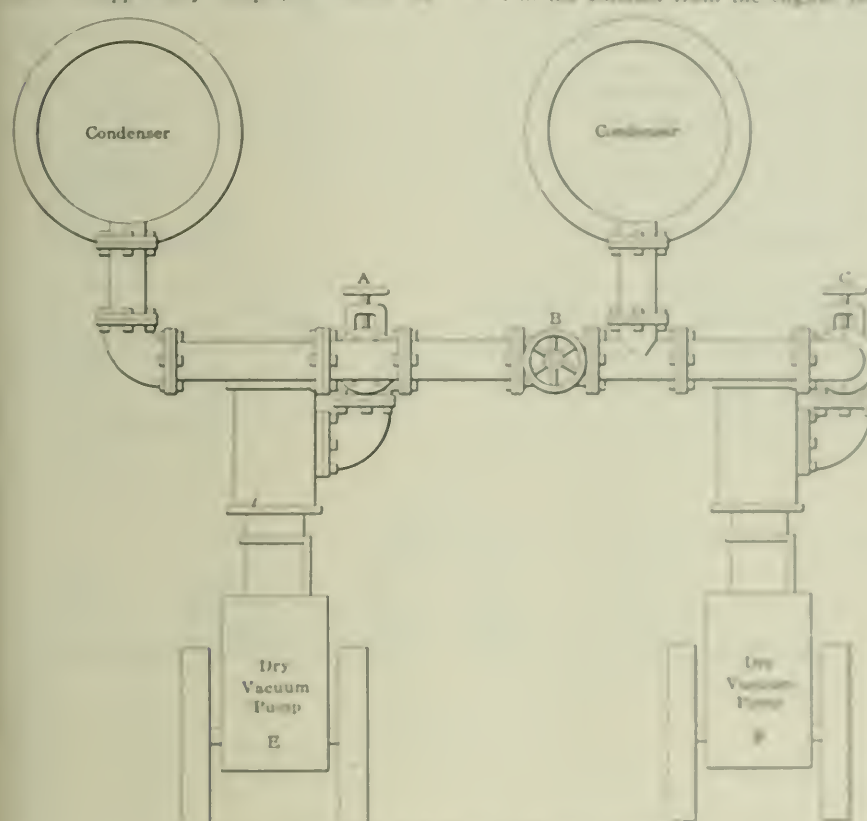


FIG. 1. SHOWING THE ORIGINAL CONNECTIONS

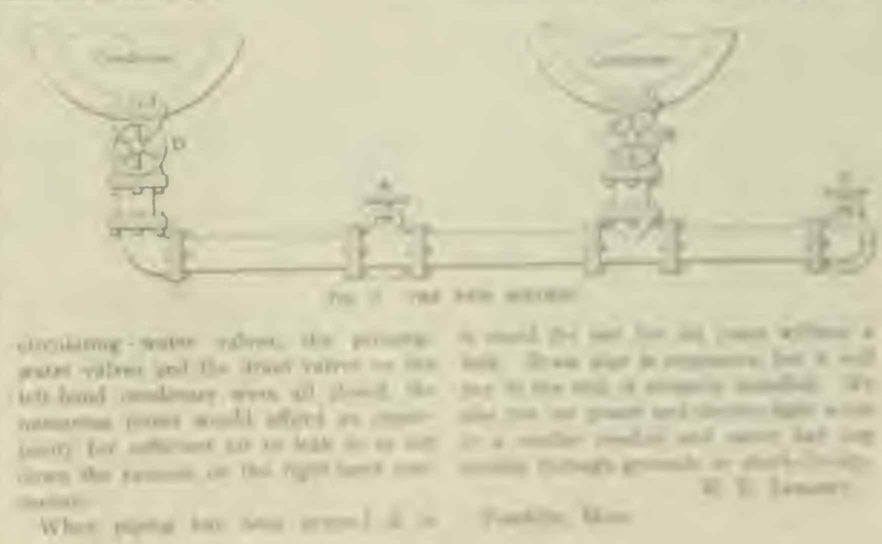


FIG. 2. THE NEW METHOD

Underground Insulation of Steam and Hot Water Pipes

In one plant I had charge of we laid 8-inch common vitrified drain pipe, being careful to have all joints flush and even, so there would be no obstruction on the inside of the pipe. All joints were made tight with portland cement mixed half and half. I used heavy brass pipe from basement to basement, having a union at each end of the conduit, so that if a leak should occur the pipe could be easily disconnected at both ends, pulled out into the basement and [illegible] without much trouble or expense.

By being careful in making joints we succeeded in getting everything tight and it [illegible] for years without a leak. Brass pipe is expensive, but it will pay in the end if properly installed. We also run our power and electric-light wires in a similar conduit and never had any trouble through grounds or short-circuits.

[illegible]

[illegible], Mass.

Exhaustion of Ignition Batteries

R. Manly Orr's query in one of the recent numbers, under the above heading, might form the text for a good deal of theorizing, since ignition batteries are a rather uncertain proposition and form a subject that seems to be but little understood by the average person. Mr. Orr, however, does not state what type of battery he has in mind, whether of the wet, dry, or storage variety.

If he refers to a wet battery, of the Edison-Lalande type, employing a caustic-soda solution as an electrolyte, and zinc and cupric oxide as the elements, he would probably find the life of his battery somewhat prolonged by doubling the speed of the engine, and thus cutting down the time element in the contact.

It could not be expected, however, that the life would be increased in direct proportion to the time element of contact, for the reason that the intermission between discharges is so exceedingly short as to give the battery practically no chance to recuperate to any appreciable extent after discharge. Furthermore, the internal resistance of a battery of this type is very low, permitting of more or less internal action when the battery is on open circuit. In consequence of this the age of the charge in the battery cuts quite a figure.

A battery of this kind generally has a very low voltage, varying from five-eighths to seven-eighths of a volt, and high initial amperage, making it possible for the battery to stand heavy discharges for short periods, with consequent long life on light-discharge service. This type of battery is built in capacities of from 150 to 600 ampere-hours, and is admirably adapted to gas-engine ignition service.

There are, however, three objections to this form of battery: their first cost, cost of renewals and low voltage: the last feature making it necessary to employ a larger number of cells in series to get the necessary six or eight volts generally used in ignition work. Under normal conditions, with no accidental short-circuits, a battery of this kind should give from 10 to 15 per cent. longer service at double the speed of contact.

With the use of dry batteries we are confronted with a different proposition. Practically all American-made dry cells use carbon and zinc as the elements, and ammonium chloride as the electrolyte. This combination results in a dry cell having an electromotive force of approximately 1½ volts, with a high internal resistance. Due, however, to the comparatively high voltage of the cell, and the close association of the active elements in the cell, there is a constant tendency toward internal action on open circuit, which would operate to shorten the life of the battery. In consequence of this, most manufacturers of standard dry cells endeavor to keep the internal resistance of the battery moderately high, and have adopted the practice of dating all their cells, claiming that they should be placed in service within sixty days of date of manufacture, to insure average life.

The idea is pretty general among combustion-engine users that a dry cell in order to be good must have a high initial amperage, and some refuse to accept a cell unless it tests 22, 25 or even up to 30 amperes on short-circuit through an ammeter.

This is all wrong. The initial amperage is merely an indication of the internal resistance of the battery, and has nothing whatever to do with the life of service. A battery showing a high initial amperage is most likely to have a filler of some inert substance having a low electrical resistance, but which serves no useful purpose in the battery. This would make the battery very short-lived, and the service would be exceedingly poor. It is to be noted that quite frequently, when a battery shows an initial amperage of from 22 to 30, if left on short-circuit for a few minutes through an ammeter, the amperage will drop rapidly, going as low in some cases as 10 or 12.

On the other hand, a good standard cell in prime condition, showing an initial amperage of 14 to 20 on short-circuit, will drop back a half ampere or so and remain there indefinitely.

It would hardly be practicable or economical to run a gas engine on dry battery for a period of six months, and get any sort of service out of it. The ideal battery for ignition service is, of course, the storage battery. This form of battery, having an electromotive force of approximately 2 volts per cell, gives an output that is absolutely constant, and under easy control. The first cost is practically the only cost, as the expense for recharging is comparatively light.

A. P. H. SAUL.

Buffalo, N. Y.

Testing Tanks for Steam Turbines

We recently had a test on one of our turbines to determine the steam consumption per kilowatt-hour. Fig. 1 is a cross-section through one of two 4x4-foot

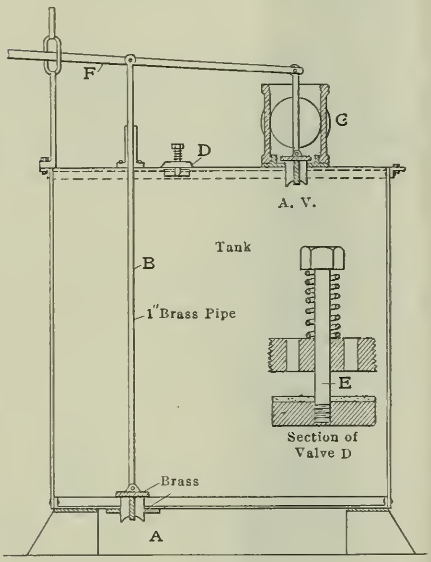


FIG. 1

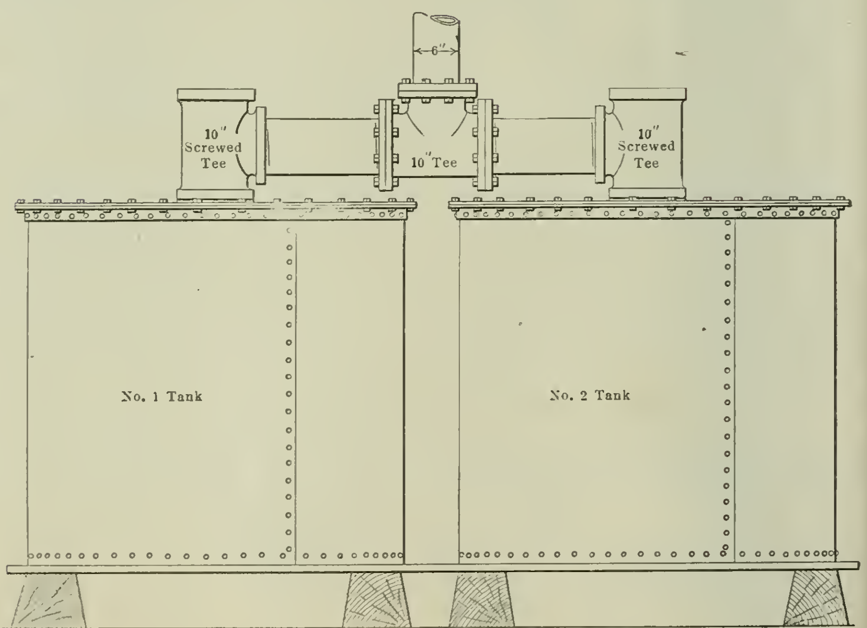


FIG. 2

tanks which were leveled up and filled with water, the water being carefully weighed in 400-pound lots. The tanks each contain practically 3110 pounds of water.

It will be seen from Fig. 1 that only one valve can be opened at a time, each valve stem being the fulcrum, by means of which the other valve is lifted from its seat. The valves are 6 inches in diameter, are made of brass and fitted with a leather washer between the seat and disk. The lower valve seat *A* is a brass plate 1 inch thick, riveted to the bottom of the tank. The valve stems are made of 1-inch pipe. The stem *B* passes up through a 1¼-inch brass pipe which acts as a guide. The discharge valve is shown open, and its construction is readily seen.

The admission valve cannot be opened until the discharge valve is closed, and *vice versa*. The upper, or admission, valve seat has a projecting ring above it, which is threaded with a standard 10-inch pipe thread to which the tee *C* is screwed, its function being shown in Fig. 2, which also shows the connection between the tanks.

The object of the snifting valve *D* is to admit air to the tank when discharging, and also to let the air escape from the tank when filling by simply pressing the hand on the valve stem. The valve opens inwardly and is ordinarily held shut by a spring. An enlarged view of the valve is shown at *E*, Fig. 1. The threaded por-

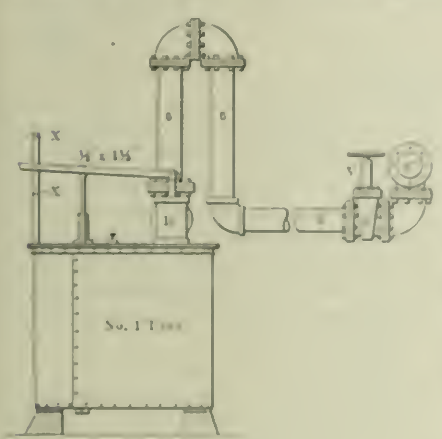


FIG. 3

tion is made of a 2-inch pipe, and the disk has a leather face. The operating lever *F* is provided with a stop, the object being to prevent lifting the valves too far from their seats.

In Fig. 2 each tank is shown connected to a short 10-inch nipple screwed into the tee. A flange on the end of each nipple is bolted to a tee, having the outlet facing upward. The 6-inch pipe represents the turbine wet-pump discharge.

In Fig. 3 is a side view of the tank and the connections to the discharge of the wet pump. The 8-inch pipe shown is a common discharge from two turbines and runs about 20 feet higher than the horizontal pipe. It discharges directly into the heaters. The discharge from the wet-vacuum pump being intermittent, we shut the valves on the heaters and all the water passes through the 6-inch pipe to the tanks. By about half closing the 6-inch valve *V* the pipe to the heaters is made a sort of air chamber on the discharge pipe from the wet pumps, and a steady flow of water is the result.

The "gooseneck" shown is to prevent air finding its way back to the wet pump over the top of the water in the discharge pipe.

While conducting the test a man was stationed at each operating lever to fill the tank, while the other is being discharged. We set the 6-inch valve about half open and shut off the valves on this line above the heaters. Then we let the water flow until the vertical pipe to the heaters was normal, when at a predetermined signal the admission valve was opened. When the man on tank No. 1 closes the admission valve preparatory to opening the discharge valve, the man on tank No. 2 must be ready to open his admission valve. This is, of course, an easy matter, for while it takes 1¼ minutes to fill a tank, the same tank can be emptied in 1 minute 20 seconds.

In closing a test we get one tank full and when the water overflows at the tees, as it did in the start, the last reading on the wattmeter is taken.

E. H. LANE.

Kansas City, Mo.

Valve Problem Solution

Herewith is a solution to George P. Pearce's valve problem, as published in the December 8 issue, page 970. As seen by his illustration, the pressure on top of the valve equals the area of a 5-inch circle multiplied by 100 pounds per square inch equals 1963.5 pounds. The total pressure downward equals

$$1963.5 + 5 = 1968.5 \text{ lb.}$$

The area of passage of seven 1-inch holes is

$$7 \times 0.7854 = 5.4978 \text{ sq.in.}$$

and

$$1968.5 \div 5.4978 = 358 \text{ lb.}$$

pressure per square inch required to raise the valve.

As soon as the pressure exceeds 358 pounds per square inch the valve rises and a much larger area than that presented by the seven 1-inch circles is exposed.

G. A. GLICK.

Madison, Wis.

The pressure is 100 pounds per square inch on top of the valve. Neglecting friction, 100 pounds per square inch on the under side of the valve will balance 100 pounds per square inch above the valve; therefore, the extra pressure is that required to lift the weight of the 5-pound valve.

It makes no difference whether the valve is 5 or 50 inches in diameter, as we are dealing with pounds pressure per square inch and the weight of the water only affects the area of the valve covering the holes in the seat. The area of the holes is 5.4978 square inches, and the total pressure to be overcome or exceeded is

$$100 \times 5.4978 + 5 = 554.78 \text{ lb.}$$

The total pressure per square inch required to lift the valve would be

$$554.78 \div 5.4978 = 100.9 \text{ lb.}$$

per square inch. This would be increased slightly on account of friction of the valve on the stem and also the water in the holes in the valve seat.

J. C. HAWKINS.

[illegible], O.

The receiving pressure will act on the whole area of the valve or 19.635 square inches, and this times 100, the pressure, equals 1963.5 pounds pressure on the valve. The valve itself weighs 5 pounds, so the total pressure acting on the receiving side will be 1968.5 pounds.

It will take this much pressure on the delivery side just to raise it, but the area that this pressure has to act on is only the area of the seven holes or

$$7 \times 0.7854 = 5.4978 \text{ sq.in.}$$

The total pressure necessary to raise the valve will be 1968.5 and the pressure per square inch will be

$$1968.5 \div 5.4978 = 358 \text{ lb.}$$

BURT A. SMITH.

Ithaca, N. Y.

Firing Stationary Boilers

In a recent article, "Firing Stationary Boilers," by F. R. Wadleigh, there is one point which I do not understand. He says: "The fireman should know that the place to regulate or shut off draft is by the stack damper and not by the ashpit doors. The latter are for the purpose of regulating the air supply."

I cannot see why the air supply cannot be regulated entirely by the stack damper, provided its design and the character of the coal will permit. A smoky coal will clog the tubes with soot a great deal more quickly with the damper partly closed than with the ashpit doors closed. It took me a long time to figure out why a certain amount of gases passing through the tubes at a certain time would not have the same velocity under both conditions. I finally decided that with the ashpit doors closed the gases were lighter, due to reduction of pressure and, therefore, had a higher velocity and carried off more of the particles of soot. So far as the simple admission of a certain amount of air to the fire is concerned, I cannot see what difference it makes whether it is regulated at the damper or the doors.

There are two good reasons why the ashpit doors should be kept open. With the doors closed there is more leakage of air above the grates through the setting, while with the ashpit doors open there is more radiation of heat which lowers the temperature of the ashpit and helps to preserve the grates.

J. F. [illegible].

Valparaiso, Ind.

How Compression Saves Coal

The article under the above caption, by M. E. Copley, does not tell why nor how he came to his conclusion. He presents a set of diagrams which I have taken a little time to analyze. The low-pressure diagram shows practically no compression, but does show a great deal of back pressure, due to the fact that there is no compression. If he would overcome the back pressure, he must make his release earlier, which means that the exhaust valve must open and close earlier in the stroke, which will give compression, something Mr. Copley does not want.

The average mean effective pressure of both ends is, say, 0.835 pound, while the average mean effective pressure would have been, say, 0.895 pound, had the valve opened earlier and the area represented by the back pressure been saved, making a saving or additional power of 0.06 pound mean effective pressure. This is worse than lost becaust it represents negative power, or power pushing against the piston tending to stop it, especially at a time when it is most needed, at the beginning of the stroke. If there is a loss of 0.06 pound mean effective pressure through loss of area in the diagram, and that amount is pushing in the wrong direction, the total loss is $0.06 \times 2 = 0.12$ pound mean effective pressure. It is true that some area would be lost through compression, but not as much as the negative pressure would cause.

It is a difficult matter to figure out how a saving is made by cutting out compression and cutting in back pressure.

Another bad feature shown by the diagrams is the great difference in the load between the high- and low-pressure sides. As the size or speed of the engine is not given, I am assuming that the ratio between the cylinders is 4 to 1. The average mean effective pressure of the high-pressure diagrams is, say, 58.29 pounds, while the average mean effective pressure of the low-pressure diagrams is 0.835 pound. Therefore, the total horsepower of the engine would be

$$58.29 + 0.835 = 59.125.$$

Now, if that work were equally divided between the two engines the mean effective pressure of the low-pressure side would be

$$59.125 \div 4 = 14.78$$

pounds, but as the actual mean effective pressure is only 0.835 pound, the low-pressure cylinder is only doing

$$14.78 \div 0.835 = 17.78,$$

or 1/17.78 part of the load. In other words, the high-pressure side is doing nearly 18 horsepower, while the low-pressure side is doing only 1 horsepower. There may be some special reason for distributing the load this way, but if not, it will be a surprise to see what a difference it will make in the coal pile by raising the receiver pressure to 18 or 20 pounds, cutting in a little compression and cutting down the back pressure.

TOTT JENKINS.

De Kalb, Ill.

Connecting Rod Design

In regard to the article on "Connecting Rod Design," in a recent issue, I wish to criticize the crank end of Mr. Willard's rod, which is herewith reproduced in Fig. 1. In the first place it is stated that as flanged brasses are used, it is necessary to have a removable end. A better design is to have the top of the rod open as shown in Fig. 2, the brasses being clamped by a lipped cover plate. In Fig. 1 the end bolt *D* is evidently subjected to the entire stress on the rod on the inward stroke of the engine, while Fig. 2 presents a solid thickness of metal at the bottom and a lipped cap at the top to resist this stress.

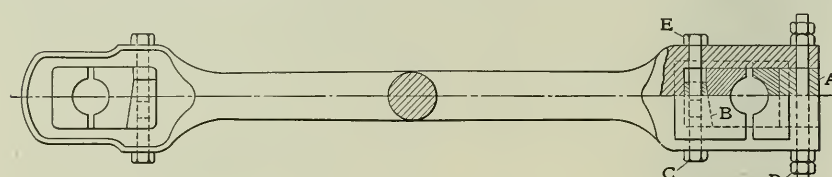


FIG. 1. (REPRODUCED)

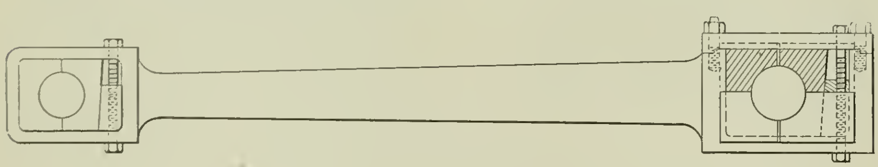


FIG. 2

It should also be noted that in Fig. 2 the adjusting wedge is outside of the the pin, while at the crosshead end it is inside, this end being practically identical to Mr. Willard's form. Such an arrangement of the means of adjustment is very necessary in order to keep the rod of the proper length, and the clearance in the cylinder equal.

In regard to cost of manufacture, it will be seen that the rod in Fig. 1 must have both ends machined on a slotter, while the crank end of the rod in Fig. 2 may be finished in any size on a planer with a corresponding reduction of time. I also differ with Mr. Willard in regard to the adaptability of such a rod to marine engines, though it is the very best type for horizontal engines, air compressors and locomotives.

H. L. DEAN.

Hyde Park, Mass.

Method of Calculating Capacity of Absorption Machinery

A very convenient method of calculating the capacity, in tons of refrigeration, of an absorption machine, is as follows: Take the revolutions per minute, or total revolutions, with a counter, of the aqua pump during the time desired for determining the load of the machine; also take the Baumé and temperature of weak and strong aqua at frequent intervals during this time. Note the back pressure on the expansion coils, also.

Determine the capacity of the aqua pump in cubic feet per revolution, taking into consideration the aqua piston rod. Correct from the table the actual Baumé readings of strong and weak aqua for temperature, i.e., reduce both readings to 60 degrees Fahrenheit. From the tables, get the per cent. of ammonia in strong and weak aqua, also the specific gravity of strong aqua, using the corrected Baumé readings.

The weight of a cubic foot of water, 62.5 pounds, times the specific gravity of strong aqua equals the weight of a cubic foot of strong aqua. The revolutions per minute of a pump times the cubic feet per revolution times the weight of a cubic foot of strong aqua equals the pounds of strong aqua pumped per minute, or *M*.

The tons of refrigeration per day of 24 hours equals

$$\frac{M\,(x-y)}{100-y} \times \frac{r}{284{,}000} \times 1440,$$

where

x = Per cent. of ammonia in strong aqua,

y = Per cent. of ammonia in weak aqua,

r = From ammonia tube, equals the value in B.t.u. of one pound of anhydrous ammonia at the back pressure of the expansion coils, allowing for the temperature of the anhydrous ammonia at the expansion valve, and the temperature corresponding to the back pressure.

This method is by no means absolutely accurate, due to slippage in the aqua pump, inaccuracy of gages, etc., but it serves as a handy check on a machine or for daily comparison.

G. A. ROBERTSON.

St. Louis, Mo.

Firing Boilers

In the December 8 number, page 955, F. R. Wadleigh has an instructive article on firing boilers. On page 959 he says, regarding the wetting of coal, "the practical reasons for wetting coal will generally outweigh the theoretical or chemical reasons for not wetting it."

Wet coal will coke better, make a hotter fire and less smoke than dry coal. At one time I held the same opinion as Mr. Wadleigh, but in looking over my table of boiler tests I saw that coal wet so as to make a good fire evaporated about 8 per cent. less water than ordinary dry coal, and I gave up wetting it. The water must be evaporated, and during the evaporation the fire is not hot enough to decompose it.

W. E. CRANE.

Broadalbin, N. Y.

Hard or Soft Condenser Tubes

On the editorial page of the December 8 issue the attention of the reader is directed to the use of hard or soft condenser tubes. Hard tubes are liable to crack, although the process of manufacture may prevent most of it. Cracked tubes are liable to occur, not only condenser tubes, but brass or alloyed pipe of all kinds, even though no work is put upon them. When a pipe is drawn through the die it becomes hard, and to be worked further it must be heated to a low red, which anneals it.

While the tube is in a hard condition a severe strain is placed upon every fiber, and if put into the annealing oven just as it comes from the die it would probably crack. To prevent this cracking, a man lifts the tube above his head and throws it violently to the floor in such manner as to bend it slightly.

When finishing a tube for power purposes it should be left semi-annealed, if not, even the best made tubing may crack in use. With pure copper tubes there is not as much trouble, but they are expensive. Brass tubes are made of different metals with different densities and expansions, and a tube left hard appears to be full of strains which mean its destruction.

With salt water, even pure copper is not free from corrosion, and it could hardly be expected that its alloys would be. It is possible that hard tubes may have incipient cracks which hasten corrosion, and that absence of these cracks may mean longer life to the semi-annealed tube.

Nickel tubes were tried, and for a time it seemed as though the right thing had been found. They could be more heavily annealed than brass tubes and still be stiff enough to work, but they were not proof against corrosion.

W. E. CRANE.

Broadalbin, N. Y.

Composite Power Generation

Recently, in an editorial on "Composite Power Generation Again," it is stated that the writer does not understand how the heat in 40 pounds of jacket water can be concentrated to evaporate 4 pounds. The accompanying sketch shows an arrangement for doing this. The water in the cylinder jacket J will be discharged at, say, 160 degrees Fahrenheit and at a pressure of 14.7 pounds absolute. As the water rises in the pipe A, the pressure, due to gravity head, diminishes until at some point C the pressure will exactly correspond to the pressure of saturated steam at 160 degrees Fahrenheit. Above this point, if no steam were formed at some point E the water would be at 4.4 pounds absolute pressure, and a temperature of 160 degrees Fahrenheit, but this is just as impossible a condition as water at 230 degrees Fahrenheit at atmospheric pressure. Under such conditions part of the water will be evaporated at the expense of the heat in the remainder, so that when the water has risen to point D, its temperature will have been reduced to [illegible] degrees Fahrenheit and it will have given off a quantity of steam.

ARRANGEMENT FOR CONCENTRATING JACKET WATER HEAT

The water at this temperature being returned to the jacket through pipe B by the circulating pump, will again be heated to 160 degrees Fahrenheit and the cycle repeated. Instead of circulating 40 pounds of water per brake horsepower per hour, it would be necessary to circulate [illegible] B.t.u. divided by [illegible] degrees temperature change, which would equal [illegible] pounds per brake horsepower-hour. This would, of course, require [illegible] engine but a short calculation will show that [illegible] pipe would be large enough for a [illegible] horsepower gas engine.

I am not able to follow exactly the reasoning in the last paragraph of the editorial [illegible] of pounds of water that could be evaporated by the exhaust gases. Using the figures given, [illegible] B.t.u. per horsepower, [illegible] per cent. of this would be [illegible] B.t.u. According to the tables of steam in Kent's handbook, the total heat of steam at 150 pounds gage pressure is [illegible]. Subtracting from this the temperature of the feed water, [illegible] degrees, as given, leaves [illegible] B.t.u. required per pound of steam. [illegible] B.t.u. divided by [illegible] equals [illegible] pounds per horsepower-hour, instead of [illegible] pounds. Which is the nearer right?

There is one feature which may make up to some extent for the small output which it is said would scarcely justify the complication necessary for its production. The heat produced by the exhaust can be stored in [illegible] reservoirs during seasons of normal load and utilized on the peak load. This would supply overload capacity, in which the gas engine has always been sadly lacking.

A. L. [illegible]

[illegible], Penn.

Faulty Indicator Diagrams

In a recent number, J. [illegible] shows diagrams taken from a high-speed engine and asks for opinions as to the trouble and for a remedy. As he says, the diagrams show a very one-sided adjustment, the crank end doing practically no work, and I suspect the crank pin suffers because of it. The head-end diagram shows that the exhaust valve closes so early the compression is excessive. On the same end the steam port closes late, giving a release pressure of apparently [illegible] pounds. The crank-end steam port barely opens at all, and the small amount of steam which does get through expands down to atmospheric pressure when the valve is reversed and compression begins.

My remedy would be to lengthen the valve stem for a more equal steam distribution. I think it will be found that the eccentric requires moving ahead in the turning direction, until a nearly equal admission line is obtained.

In the same number, M. C. [illegible] shows a set of diagrams from a [illegible] engine which, he says, is [illegible] [illegible] [illegible] [illegible] very small amount of compression, but is it not at the expense of the condenser?

WILLIAM AULD.

Milwaukee, Wis.

A New Method of Firing

I do not approve of a thick bed of coal on the front end of grates with little or no depth of fire on the back end near the bridgewall. The proper method of coking is to keep a good, thick fire on the back of the grates at all times, as well as on the front. In this way, after being pushed back and replaced by a new charge, the fire will be of equal depth all over the furnace. None but an ignorant or lazy fireman would keep coal piled up just inside the furnace door.

One of the first things a fireman should learn is to keep a good thick fire in the back end of the furnace; otherwise, the cold air, meeting little or no resistance, will rush through the thin layer of coal without becoming heated enough to mix with the gases from the front. The bridgewall, instead of being heated hot enough to assist combustion, will retard it by cooling the gases passing over it.

C. E. BASCOM.

Marlboro, Vt.

Criticism of Turbine Installation

The recent article describing a mammoth turbine for Buenos Aires strikes me as a good one on which to base a discussion. First, I would like to call attention to the amount of water the circulating pumps are capable of delivering per hour. Each pump, it is stated, will pump 112 gallons per second; the two pumps will, therefore, pump 224 gallons per second, providing they are both in condition to run at the same time. This is 13,440 gallons per minute, or 806,400 gallons per hour, and assuming 8.3 pounds per gallon (critics, excuse the figure) this will amount in round numbers to 6,693,120 pounds per hour. The turbine at maximum load develops 14,200 horsepower, which is equivalent to 10,593 kilowatts. It is stated that the machine will develop a kilowatt-hour on 13.86 pounds of steam. This will mean about 147,000 pounds of steam, round numbers, to be condensed per hour. Dividing 6,900,000 by 147,000, we get as the circulating water per pound of steam 47 pounds, nearly.

This is the first point I would like to see discussed. The American practice is to allow not less than 60 pounds of condensing water per pound of steam. I think that a larger circulating-pump capacity should have been provided. The temperature of the water the year round must be taken into consideration, the final temperature of the circulating water, and, last but not least, the temperature of the condensed steam. This last point is one I am very much interested in. At what temperature can the condensed steam be maintained with a 28½-inch vacuum?

The second feature in the plant in question is the cooling surface in the condenser. It is 14,000 square feet, and at maximum load of the turbine the ratio is 1 square foot of cooling surface per horsepower. The latest American practice is to have 2 square feet per horsepower for reciprocating engines and 4 square feet per kilowatt for turbines. This may seem to be a rather liberal allowance, yet I have found in my own experience that it is none too much, for several reasons. Trash may stop up a number of tubes between morning and shutting-down time, and it is not always possible to shut down the condenser and clean them out. In summer the circulating-water temperature may get rather warm, or the circulating-pump capacity may decrease. In the case of a turbine, in order to keep the steam consumption down to 13.86 pounds per horsepower per hour, it is necessary to have about 28½ inches of vacuum, and in order to do this there must be sufficient cooling surface. It has been my actual experience that no matter how much water in put through a tube, the element of time has considerable to do with the amount of heat it can absorb. From the foregoing it would seem that there is not enough cooling surface to this particular condenser.

I also notice that this station is making a bid to be classed among the most economical of power stations, by using electric auxiliaries. I fail to see where these so-called modern improvements are making any more than an apparent saving. Suppose the prime mover has a thermal efficiency of 18 per cent. and the electrical end of the auxiliary has a 90 per cent. efficiency, the combined efficiency is 16.2 per cent. This same plant, if served completely by electric auxiliaries, will probably have a feed-water temperature of 100 degrees Fahrenheit, a loss of 11 per cent. in fuel. How much do they gain by the modern auxiliaries? This latter question applies to a good many modern power stations, in part if not altogether.

E. H. LANE.

Kansas City, Mo.

Repairing a Broken Eccentric Rod

Owing to the heating of the steam eccentric, the eccentric rod of a 14 and 26 by 30-inch high-speed Corliss engine broke in three pieces. The first break happened at the rocker-arm brass, where the diameter was less than ¾ of an inch. Coming in violent contact with the concrete floor, it again gave way near the eccentric strap. The oil guard was demolished and a portion of the automatic oiling system was dismantled. It was imperative to have a new rod in place before 4 p.m. the next day, but to get a rod from the maker inside of 18 hours was impossible. It was a case of hustle, therefore, to make a new rod in time for the evening load. Fig. 1 shows the valve gear; at *A* is shown the position of the steam-valve cranks. There is no valve-stem stuffing box, as a ground joint of a special oval pattern makes it unnecessary, as shown.

On this engine the opening in the steam bracket was so small that half a turn of

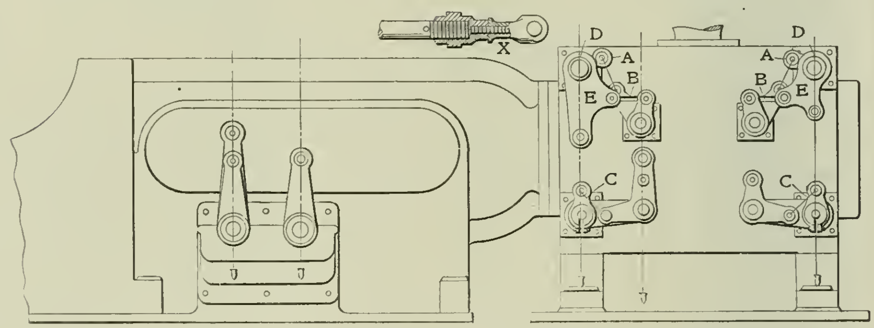


FIG. 1

the eccentric rod one way or the other would cause the valve crank to knock against the edges. Hence, the new eccentric rod had to be the exact length, or we were liable to have another accident in the shape of a broken valve bracket.

With the eccentric rod removed, the striking points of the valve cranks were marked on the box of the rocker arm. The links *B* were then removed and the eccentric rod screwed in for as near its right length as we could determine. The air pump was started and the engine allowed to be turned slowly by the vacuum. The length of the eccentric rod was so adjusted that the mark on the rocker arm traveled slightly inside the marks on the box cover. The links *B* were replaced, the engine brought to speed and load given it, when the job was completed with the aid of the indicator. Some may wonder why the reach rod was not taken out instead of the links *B*. There is only one position of the crank which permits the reach rod on this engine to be taken out, and that position is difficult to stop at. At *X* is shown how the narrow end of the eccentric rod was stiffened and strengthened, by a special nut planned by the superintendent.

At first sight the valve gear looks to be quite complicated, and many would infer that it is difficult to adjust. An inspection of the plumb lines in Fig. 1 shows that the valves are almost as easy to adjust as slide valves. No adjustment is possible on the brass links B of the steam valves and C of the exhaust valves. After adjusting all rods to their proper length, place the engine on the crank-end center, turning the engine in the direction it is desired to run. Then loosen the hub bolts and set screws of the flywheel and revolve the latter on the shaft, until the required lead is obtained at the crank end. On this particular engine the lead is 1/8 inch on the high-pressure side, and 3/16 inch on the low-pressure cylinder. Tighten the hub bolts and set screws on the flywheel, and place the engine on the head-end dead center. The lead on the head-end valve should be practically the same. If it is not, equalize it by means of the steam rod. On the steam-valve bracket washer D, Fig. 1, will be found five marks, the two outer corresponding with the maximum travel of the steam rockers E, the two next with the minimum travel and the middle mark with the central position. These marks should be verified before the steam bonnets are replaced. The maximum travel marks are easily found by rotating the engine.

To find the minimum-travel marks, loosen the tension on the governor springs A, Fig. 2, being careful to count the number of revolutions the springs are turned, and [illegible] the weights W simply against the stops D. Each steam valve should now travel an amount equal to its lap only, i.e., the two marks (the valves are ported) on the circular end of each valve should come line and line with the marks on the valve chamber. This insures that the engine will not run away, should the load be suddenly thrown off. Do not, however, let the valves travel an amount less than their lap, for the governor springs are liable to be overstretched and strained.

When the valve and valve-chamber marks on either side coincide, the mark on each of the rocker arms E will be line and line with one of the minimum-travel marks on each of the two washers, if these marks are correct.

The exhaust valves, when the rocker arms are central, as in Fig. 1, have 3/16 inch lap on the high-pressure side, and 1/4 inch on the low-pressure side. Compression begins when the crosshead is within 3⅓ inches, or 12 per cent., of the end of its stroke. For the benefit of those who might wish to study the action of the governor the layout is plotted in the dotted lines in Fig. 2.

Now place the flywheel in such position that the two [illegible] bolts are downward; loosen and remove them and [illegible] the bolts by a [illegible] and [illegible] replace them. [illegible] with a [illegible] and [illegible]

FIG. 2

a hammer or pegs to set them up; all corrections due to settling will simply take care of that.

Fig. 3 shows the low-pressure governor and the method of changing the receiver pressure. Lengthening the link rod A decreases the travel and consequently raises the receiver pressure. The spring B is connected to the governor weight arm at

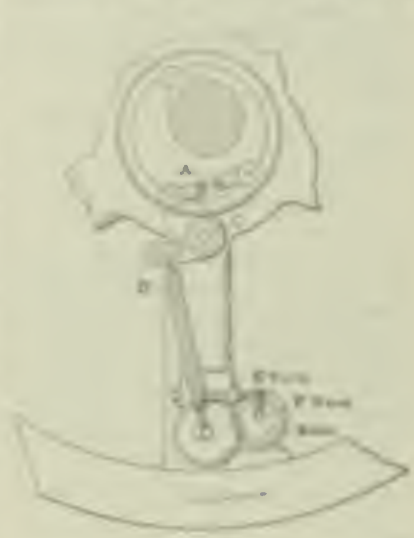


FIG. 3

one end and at the other to the worm gear which is operated by the small motor shown, which is used to make slight changes of speed while synchronizing from the switchboard.

E. O. [illegible]

Framingham, Mass.

Hygrometry

In J. H. Harris' contribution on "Hygrometry," which appeared in a recent number, in the middle of the second column he states: "If moisture is in contact, it in general becomes saturated for that temperature, to precisely the manner that steam becomes saturated in a boiler [illegible]."

I should like to draw attention to the [illegible]. In my opinion when considering "steam" the word "saturation" applies to heat; that is to say, when we state that steam is saturated we intend to convey the idea that it is saturated with heat units. Such being the case, it is [illegible] impossible [illegible] for the steam to [illegible] at all, as any further addition of heat merely [illegible].

Practically, we allow but a certain percentage of moisture being present in saturated steam, and in today's [illegible] we [illegible] the term "dry" or "commercially dry saturated steam" which [illegible] about 2 per cent. by weight of moisture.

W. [illegible]

West Hartlepool, England.

Polish for Brass Steam Pipes

Herewith is a recipe for a polish for brass steam pipes, or other hot-brass work in the engine room, which I have used for years and believe to be the best polish that can be made:

Melt together 1¼ pounds of cake tallow, 2 ounces of spermaceti, 2 ounces of gum camphor and 2½ ounces of beeswax. Then add 8 ounces of raw linseed oil, 10 ounces of coal oil and 2 pounds of tripoli powder.

J. B. Draper.

Kenton, O.

Pump Suction Limit

In a recent issue a correspondent asks why a pump will not lift water a distance nearly equal to the head balancing the atmospheric pressure, say 32 or 33 feet. Leaving out the question of water temperature, for the time being, and assuming that the suction pipe is air-tight, then

A_p = *Total suction limit* =

$$H = \frac{v^2}{2g} + F_p,$$

where

A_p = Atmospheric pressure expressed in feet,

H = Elevation of pump above water level,

v = Velocity of flow in feet in suction pipe,

g = Gravity equals 32.16,

$\frac{v^2}{2g}$ = Velocity head,

F_p = Friction loss in feet, which depends upon the velocity of the water in the suction pipe. This friction factor includes losses in foot valve and elbows.

From this it is seen that the hight to which a pump will lift water by suction can never equal 32 or 33 feet, unless the flow in the suction pipe is extremely slow.

If the temperature of the water is taken into consideration, it still further lowers the lift, as will be seen from an examination of the following table, based on atmospheric pressure at sea level:

Temperature of Water. Deg. Fahr.	Pressure of Vapor in lb. Per Sq. Inch.	Limit of Suction Head, Considering Temperature Only.
70	0.36	32.96 feet.
80	0.50	32.6
90	0.69	32.2
100	0.94	31.4
110	1.26	30.9
120	1.68	29.7
130	2.22	27.3
140	2.87	25.9
150	3.70	24.8
160	4.72	22.5
170	5.98	19.6
180	7.50	16.9
190	9.33	9.9
200	11.52	9.3
210	14.12	1.1

In the foregoing it was assumed that the suction pipe was perfectly air-tight, but as this is hard to secure, due allowance should be made.

John B. Sperry.

Aurora, Ill.

A Homemade Socket Wrench

On taking a turbine pump apart one day, to remove a worn-out impeller, it was found necessary to remove five 1-inch hexagon nuts from the position shown in Fig. 1. A hole in the outside wall was closed by a 2-inch plug, and to reach the nuts a socket wrench was required, and none of suitable size being at hand, it was decided to make one.

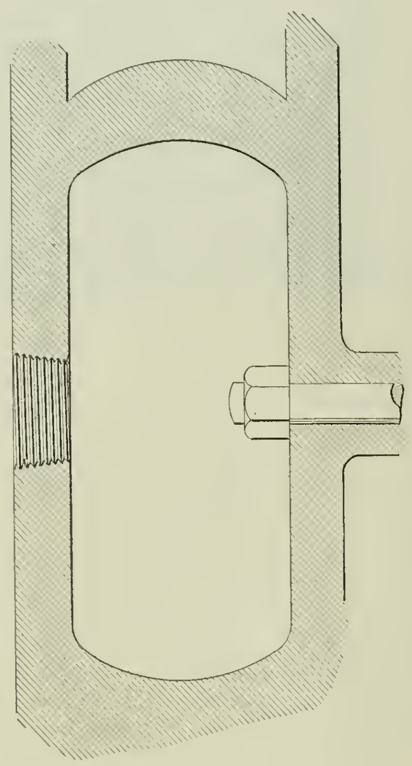


FIG. 1

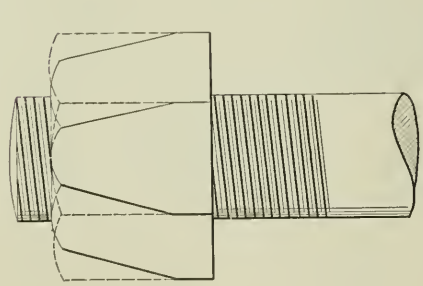


FIG. 2

Picking out a 1-inch bolt and nut from the scrap pile I dressed the nut down to a taper, as shown in Fig. 2, when it was found to just about enter a piece of 1½-inch gas pipe. To heat the end of the pipe and forge it into a hexagon shape to fit the nut was then a simple matter, and it proved an excellent wrench.

In the same manner a 1¼-inch pipe may be made to fit a ¾-inch nut, and 1-inch pipe will answer for a ⅝-inch nut. Socket wrenches of these sizes will always be found handy around a steam plant.

R. Cederblom.

Gary, Ind.

Storage Battery Troubles

In a recent number, J. M. Herwig narrated his troubles with a storage battery which apparently became dead shortly after being charged. The battery has evidently had hard usage, and he will doubtless find that the cells have either short-circuited or accumulated sulphate. Short-circuiting may be caused by sediment accumulating in the bottom of the cell until it reaches the plates. The cells should be cleaned frequently and new electrolyte added to replace that which is lost, to bring the gravity of the solution up to 1.210. If there is any suspicion that there is foreign matter in the solution, new electrolyte should be used.

Care should be taken while cleaning the battery not to allow the negative plates to dry in the least. If they are allowed to dry it will be necessary to charge them again for a period equal to the initial charge.

Sulphating is the most troublesome element to contend with in a storage battery. It is formed when a cell is nearly discharged and is noticeable by the formation of a white coating over the plates. If a cell is discharged and allowed to stand with the electrolyte in place it will sulphate very rapidly. This also causes buckling of the plates, because the formation of sulphate in the active material causes it to expand, forcing the grids out of shape. This sulphate, being a non-conductor, increases the resistance of the plate, and when it is removed carries part of the active material with it. Long-continued charging at a moderate rate will gradually remove all sulphate from the plates.

When the cells are fully charged and in good condition the positive plates should be of a brown or deep red color and the negative plates gray. The battery should never be charged above its maximum charging rate, because it will cause a rapid accumulation of sediment, excessive evaporation of the electrolyte and the life of the battery will be much shortened. A low-reading voltmeter should be used for testing each cell, and a discharge lower than 1.8 volts per cell should not be allowed. The battery should be charged until the voltage shows 2.5, then the charge should be cut to about half and continued until the cells again show 2.5 volts; the battery is then fully charged. As the age of the battery increases the final charging voltage will drop to about 2.4.

The change of temperature affects the final voltage so that it is lowered with an increase of temperature above 70 degrees Fahrenheit and correspondingly increased by a lowering temperature. After the charge is completed and the current is cut off the voltage will drop to about 2.2 volts per cell, and when the discharge is started it will drop to 2 volts.

The temperature of the surrounding air of a storage battery should rise no higher than 80 degrees Fahrenheit and drop no lower than 50 degrees Fahrenheit. If the surrounding temperature is high the wear on the plates is excessive. No harm results from a low temperature except that the capacity of the battery is reduced.

NORMAN S. CAMPBELL.

Detroit, Mich.

If the plates were buckled when received, it would indicate an old battery. Buckled plates would account for the rise in temperature of the electrolyte, and the battery, owing to this condition, has a reduced capacity. The battery in this condition cannot be charged properly, although it will appear to be fully charged and will gas freely, especially if the sulphate forms between the active material and the grid. The active material contracts in the negative plate and closes up the pores; this reduces the active surface, the contact between the active material and the supporting grid is reduced, and when the battery is allowed to discharge too low, and stand in this condition, electrolytic action may take place on the surface of the material next to the grid, which will cause a layer of sulphate to form between the grid and the active material. The expansion of this layer of sulphate crowds the active material farther away from the grid, decreasing the contact and increasing the layer of sulphate, the result is the insulating of the active material.

If the active material in the negative plates has contracted, the separation from the grid can often be noticed. In this case, remove the positive plates and substitute dummy plates, made of thin sheets of lead, about 1/16 inch thick. The positive terminals from the charging leads are connected to the negative plates, the negative leads to the dummy plates. In charging the plates this way the negative plates become positive in effect. By reversing the polarity of the charging current the negative plates are reduced back to sponge lead. This reversing of the direction of the current tends to open the pores and bring the plates back to their normal capacity.

If a layer of sulphate is formed between the active material and the grid, the only way that I am aware of to reduce the sulphate is by burning it off. Charge the battery as rapidly as possible, without raising the temperature above 110 degrees Fahrenheit, and when it gases freely, reduce the charging current to three-fourths or two-thirds of the normal, and continue until the gas bubbles again appear; then again reduce the current to one-half the normal, and continue as before; give the battery a light discharge, and repeat the charging operation. This treatment will have to be performed several times. If the battery has been short-circuited by sediment filling up to the bottom of the plates this charging operation will remedy it. The rate of discharge affects the temperature of the electrolyte, the higher the rate, the higher the temperature. The temperature also affects the capacity of the battery, the higher the temperature the greater the efficiency. It also increases the density. The battery, however, deteriorates rapidly if worked at a temperature above 110 degrees Fahrenheit.

E. G. [illegible]

East Las Vegas, N. M.

Effect of Superheated Steam on Cast Iron Fittings

Referring to the peculiar effect of superheated steam on cast-iron fittings, one example of which was shown in a recent number, a possible explanation of this action may be in the fact that metallic iron at a high temperature [illegible] has the property of decomposing steam, resulting in the formation of magnetic oxide of iron and free hydrogen. The action is very rapid when the iron is clean, but is retarded and becomes sluggish from the coating of oxide formed over the surface of the iron. I do not know that it has ever been determined whether this action ceases entirely if the temperature is reduced below a red heat, but it seems reasonable to assume that the high temperature of the steam would reduce the affinity of the atoms forming the water molecule, and assist the iron to dissociate them. The action could be very slow and still produce marked effects in the time the fitting in question was in service, i.e., three years.

The increase in the size of the fitting can be accounted for by the oxidation of the iron, but if this is found to be confined to a thin coating inside, another explanation would be the occlusion of the hydrogen by the cast iron. The great tenuity of hydrogen gas gives it great penetrative power, many solid metals, among them iron, being readily penetrated by it. When there is an attraction (perhaps a feeble chemical affinity) between hydrogen and the metal, the gas may become largely condensed in the pores of the casting. Whether this action would result in any increase of bulk in the original metal I do not know, but a careful physical and chemical examination of the metal composing the fitting would show what changes in structure and composition had occurred. In view of the great importance of such information it is to be hoped that a careful investigation will be made and the results published.

E. S. [illegible]

Hamilton, O.

Corliss Valve Setting

Following are convenient rules for setting the valves of a Corliss engine: First remove the bonnet covering the ends of the valves. Reference marks will be found on the ends of the valves and seats, giving the positions of the working edges of the valves and ports. Reference marks will also be found on the wristplate and supporting stud. Turn the eccentric around on the shaft, and see whether the wristplate has equal travel on each side of a vertical center line. If it has not, equalize the travel by altering the length of the eccentric rod.

Next place the wristplate in mid-position with the dashpot plungers hooked up. By means of the wristplate rods give the steam valves the proper lap and the exhaust valves a negative lap or opening about as indicated in the following table:

Steam Cylinder, Inches	Steam Lap, Inch	Exhaust Opening, Inch
12	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

To adjust the length of the dashpot rods place the wristplate in one extreme position, as indicated by the reference marks. Adjust the length of the proper rod until the latch catches, with about 1/32 inch to spare, and repeat for the other extreme position. Should it be necessary to disturb the lengths of the wristplate rods, this operation must be attended to a second time.

Next, connect the [illegible] rod to the wristplate. With the engine on the center, set the eccentric 90 degrees plus the small angular advance necessary for the required lead, ahead of the crank, in the direction the engine is to run. If the lead is not the same with the engine on the other center, adjust with the wristplate rod. Then block the governor balls half-way up and see that the reach-rod lever is clamped at right angles to a line and [illegible] the reach rods. Place the engine on one-quarter stroke from the head end, and adjust the reach rod which trips the head-end valve, until the valve is released. Repeat for the crank end. Final adjustment may be made with the engine running slowly.

Drop the governor balls to their lowest position and adjust the safety cams on the knockoff cams so that, with the governor in this position, the valves cannot be opened by the wristplate motion.

F. L. [illegible]

Hyde Park, Mass.

Waste in a Power Plant

After reading C. R. McGahey's letter in a recent number, I do not wonder that the piping leaks, if the two boilers are connected as his illustration shows.

Regarding the size of pipe for a 28x48-inch engine, running at 100 revolutions per minute, it would be, according to the rule most used, as follows:

$$\frac{(28^2 \times 0.7854) \times 800}{6000} = 821;$$

$$\sqrt{\frac{821}{0.7854}} = 10.2,$$

or, say, a 10-inch pipe.

Nothing is said as to the speed of this engine, but it took the place of a 300-horsepower engine, which, at 100 revolutions per minute, would require only a 7½-inch pipe.

I have often seen a 300-horsepower engine with a 7-inch pipe carrying 500 horsepower, with a very small drop in pressure. I should say Mr. McGahey must be carrying, or trying to carry, a great deal more than 300 horsepower. He has an engine that with a mean pressure of 35 pounds and at 100 revolutions per minute, will carry 530 horsepower.

C. L. Johnson.

Mason City, Ia.

Effect of Scale in Boilers

In the December 8 number, F. Hilton Williams has something to say concerning the effect of scale in boilers. Mr. Williams may be glad to know that very complete information on this subject may be obtained in Bulletin 11 of the Engineering Experimental Station of the College of Engineering of the University of Illinois, Urbana, Ill.

This bulletin discusses the heat-transmission loss due to boiler scale and its relation to scale thickness, and covers a large series of experiments conducted by the experimental station under the supervision of Prof. E. C. Smith.

The statement commonly made that 1/16 of an inch means an increase in fuel consumption of from 12 to 15 per cent. is purely theoretical, and is based on the assumption that that thickness of scale covers the entire circumference of the tube, a condition which is seldom encountered in actual practice. On this subject, the bulletin in question states as follows: "Considering the scale of ordinary thickness—say of thickness varying up to ⅛ inch—the loss in heat transmission due to scale may vary in individual cases from insignificant amounts to as much as 10 or 12 per cent., and the loss increases somewhat with the thickness of the scale. Furthermore, the mechanical structure of the scale itself is of as much or more importance than the thickness in producing this loss."

In actual practice, a boiler with clean tubes will generate almost as much steam with a given quantity of fuel as two boilers of exactly the same size with the tubes coated with scale from ¼ to ½ inch thick.

H. E. Gansworth.

Buffalo, N. Y.

Removing the Cause of a Hot Crank Pin

The crank pin of an engine gave considerable trouble from heating. The third day after taking the plant to operate the works were shut down, and the writer thought it a good opportunity to look into the cause. Taking off the strap, the boxes still remained on the pin and it required considerable work to separate them. An examination showed that at some time the pin had worked itself loose, making the hole out of round. The engineer had wedged tin around the pin to hold it tight, after which he screwed up the nut at the back of the crank, assisted by a sledge hammer.

Another cause for the pin heating was that when this pin was originally put in there was a counterbore, requiring a collar on the pin to fit in the counterbore. The other engineer had turned the collar off so as to make the pin that much larger in order to fit in the hole better. This left a large opening in the crank. The inner collar on the brasses was also squared off in order to fit the new length of the pin.

In Fig. 1 is shown how the babbitt worked out and filled in the counterbore on the crank. As a consequence, every two weeks or so the brasses required refilling. This kept the pin hot all the time.

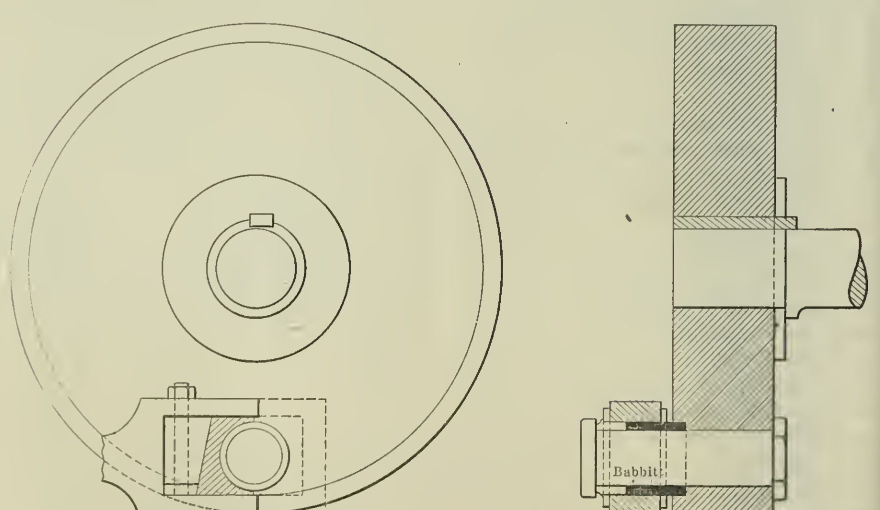


FIG. 1 SIDE AND SECTIONAL VIEWS OF BRASSES AND PIN FIG. 2

I found some ¼-inch copper wire and cut a piece large enough to make a ring to fill in the counterbore on the crank, Fig. 2. Then taking what was left, and putting a half ring in the boxes next to the crank, riveting them to the boxes, prevented the babbitt from working into the counterbore of the crank.

John Tyron.

Lynchburg, Va.

Remedying a Traveling Crane Trouble

Some time ago I had charge of the repair work in a large shop having an old-style crane that did first rate for small work. It was driven from one end, the motor being placed over the cage on the side of the crane.

When we undertook to handle a large casting, the drive end would start ahead of the opposite end and cause the work to sway back and forth, making it dangerous for the men to work on the floor. This ground the flanges off the wheels and sides off the track. As the floor for heavy work was situated directly under the out end, all the lifts were consequently made there. We decided to change the drive to the center, and also to put on a hand brake.

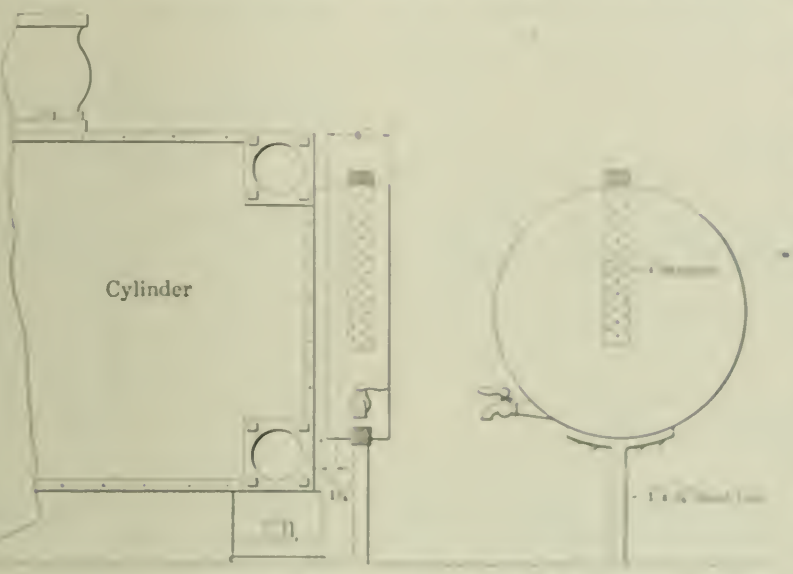
A track ran through the shop, and we had a box car pushed in and ran the crane directly over it. We then built a scaffold on top of the car high enough to work at the job. We took the motor and drive shaft down and laid out the bolt holes for the motor at the center of the crane. We also placed a new hanger to strengthen the drive shaft; also a 15-inch pulley on the shaft over the cage, and a hand brake with a foot lever to work in the cage. When ready, the crane ran a great deal better and without any swing, as both ends started at the same time; and with the brake, the crane could be stopped as quickly as the latest-style crane in the shop. Neither was there a strain on the shaft and gears, nor did the wheels grind and cut on the track.

S. J. Kelley.

Orange, N. J.

Cylinder Oil Tank Arrangement

The accompanying sketch shows a cylinder oil-tank arrangement I recently came across in a plant in St. Paul. It is attached to the engine cylinder as shown. It takes up but little room and does not



ARRANGEMENT OF OIL TANK ON CYLINDER

disfigure the engine to any extent. It is made of galvanized iron and painted to match the color of the cylinder.

E. O. Jeanson.

St. Paul, Minn.

Eccentric Troubles

Recently a friend called my attention to the condition of one of his cross-compound Corliss engines. The eccentrics on the high-pressure side were clattering badly and running very hot, while the eccentrics on the low-pressure side were running smooth and cool. Oil was being fed at the rate of thirty-two drops per minute, the sight feeds delivering oil directly over the center of each steam valve. The receiver gage showed 27 pounds and never "flickered."

There being a hand-regulated cutoff on the low-pressure side governor, and being asked to see what I could do, I tried to change the receiver pressure, but the gage remained the same. We removed the gage and found it to be stuck fast. After repairing it and setting it with the other engine receiver gage, we replaced it and found that the receiver pressure was only 3 pounds. This was immediately changed to divide up the load. After taking a few cards we evened up the load very nicely, which helped the eccentric a great deal, but did not cure it. At the noon hour we took off the eccentric straps and found the eccentrics badly cut and grooved. The question confronting us was how to smooth them up without taking them off, and I decided to file them while in motion.

We made a blank of No. 14 sheet iron and blanked the flange [illegible] on the high-pressure side of the receiver, or, in other words, the high-pressure cylinder into the receiver [illegible] and the valves on the high-pressure cylinder and ran the low-pressure side with the equalizing valve. The engine was run very slowly and after four hours' work the eccentrics were in fine condition and calipered true. In the meantime the straps were scraped and calipered until they became smooth and true. When the engine was assembled we started off and a better running engine cannot be found.

The plant has in it three 30 and 70 by 60-inch cross-compound condensing engines, direct-connected to 500-volt generators, operating at a steam pressure of 175 pounds.

Marion T. Merrell.

St. Louis, Mo.

Automatic Engine Stops

In an engine house where they were having trouble at the throttle the automatic stop was blamed. Upon investigation it was found that the engineer had packed the throttle-valve stem too tight, with the result that when the stop operated it was necessary to use force to open the valve. We overcame this trouble and eliminated all carelessness of engineers by getting metallic packing for the valve stem.

By having the stop directly connected to the main throttle it is operated every time the engine is started or stopped, thus insuring its being in working order.

When a speed limit is used it should be set to operate at [illegible] revolutions in excess of normal speed. The speed limit should also be tested at stated intervals.

[illegible]

[illegible], Penn.

Moving Heavy Machinery

I [illegible] in one of the [illegible] issues [illegible] A. G. Knight's method of moving heavy machinery on rollers or on skids. As he says, the method of moving heavy weight on rollers is old, but holding it up on inclines with pipe tongs and depending with tackle, jack or block is certainly new to me, and I have moved considerable heavy machinery. Suppose one of the men should fail to get a good grip on the pipe roller, and the others fail to hold it, where would the machinery land, and what would become of anyone who happened to stand in its downward course, if there were no tackle or block to stop it?

My advice would be to adopt some extra precaution in case of the possible slippage of the pipe tongs or wrenches.

William S. Luckenbach.

Leavenworth, Kan.

Commutator Troubles

In replying to the request of Edward A. Young in a recent issue, I advise that the brushes be given the correct tension on the commutator. If the tension is too light the brushes will jump and spark; if too heavy they will cut the commutator, which seems to be the trouble with Mr. Young's machine.

In the case of the D.C. [illegible], the heating of the commutator may be due to overload. Such heating is generally accompanied by excessive sparking, which cannot be remedied, except by reducing the load. The trouble may also be due to the improper position of the brushes. The brushes may not be properly spaced around the commutator, [illegible] all brushes should have the same relative position with regard to the [illegible] line.

A broken connection in the commutator leads or an armature coil broken will produce flashing at each revolution and the bars on each side of the one disconnected will be badly burned. The [illegible] wire should be [illegible], or if broken the commutator bars on each side of it should be soldered or bridged together by a temporary repair. As soon as possible a new coil should be put in.

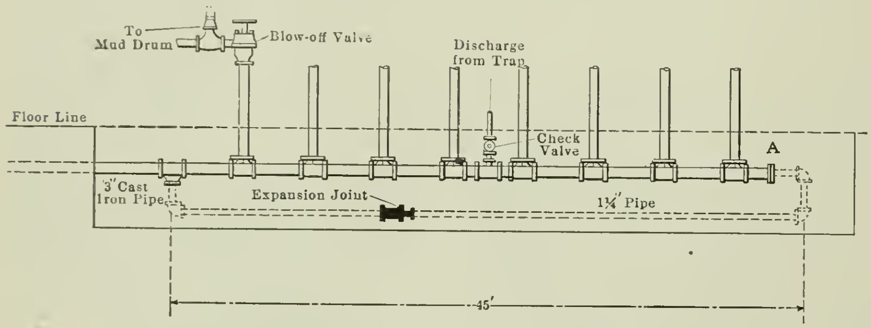
Sparking may also occur in a multipolar machine from the wearing away of the bearings, which produces [illegible] of the armature with respect to the fields and consequently unequal magnetic reluctance at different points. In some cases [illegible] wear amounts to [illegible] a very close consideration to insure true [illegible]. If such is found to be the case, the bearings should be [illegible] up [illegible] [illegible] the armature [illegible] under the pole pieces, thus relieving the bearing strain and probably [illegible] a complete [illegible] of the windings.

[illegible]

[illegible]

Blowoff Pipe Trouble Remedied

By the plan described herewith the writer got rid of at least 90 per cent. of the trouble from a very troublesome blowoff pipe. The full lines in the sketch show the 3-inch cast-iron pipe as first arranged. It was fitted with flange joints and tees to connect to the 2½-inch wrought-iron pipes, two of which connect to each mud-



HOW BLOWOFF-PIPE TROUBLE WAS REMEDIED

drum, there being four boilers. The discharge from two low-pressure steam traps enters about the middle of the pipe. The end *A* was blanked.

For a year this pipe gave all kinds of trouble with broken tees, blown gaskets and, at one time, a split pipe. It was impossible to keep it tight more than two days. After a time, noticing that the breaks nearly all occurred near the closed end, I concluded that our trouble was caused by water hammer, and set out to find a remedy. Taking off the blank at *A*, we piped a 1¼-inch loop, as shown by the dotted lines. This pipe is 45 feet long and an expansion joint was inserted about the middle of its length, to take care of the expansion. This change has almost entirely cured the trouble. We have no more broken fittings, only an occasional gasket has to be replaced and we do not have to touch it for months at a time.

H. W. Ginaven.

Springfield, O.

To Etch Tools

The best way to mark names or initials on metal tools is to etch them. The mark is ineffaceable and easily done, with a little experience.

The first step in the process is to spread a thin layer of soap over the surface intended to be used. Next, with a sharp stick, or scratch awl, cut the name in the layer of soap, exposing the metal. Then drop into the letters enough of the following solution to commence an oxidizing action on the metal exposed: One ounce salt, 2 ounces copper sulphate (bluestone), and 1 quart of vinegar. A few drops will suffice, and a few trials will teach how long to let the solution work before wiping it off with a cloth.

This also makes a good solution for an open-circuit battery, for electric-bell and telephone work. Use copper and zinc terminals.

J. J. O'Brien.

Buffalo, N. Y.

Using Kerosene Oil in Boilers

In a recent issue a correspondent states that he cannot see any real gain in using kerosene oil for removing scale in steam boilers. Some years ago I had charge of a small steam plant in which was installed a second-hand boiler. It was in good condition, only it was badly scaled. After the boiler was set and bricked in I removed the scale with kerosene oil in the following manner:

All loose scale and sediment were removed from the tubes and shell and kerosene oil sprayed over the interior surfaces of the boiler, so that when the boiler was filled the oil would rise and come in contact with the under side of the tubes.

The top manhole was left open, and after filling the boiler to the proper level a slow fire was started and kept up for about ten hours. The boiler was then left to cool off over night and the next morning the water and loose scale were removed. The operation was repeated until most of the scale was taken out.

More kerosene was sprayed over the tubes and shell and the boiler was put in service for a week, meanwhile feeding kerosene with the feed water. Then the boiler was opened up and the loose scale removed.

When kerosene oil is used in a boiler, never place a torch or candle inside, until it has been thoroughly ventilated; better still, use an incandescent lamp.

Care should be exercised when using kerosene for removing old scale in steam boilers to open up the boiler a short time after using the oil, because the scale is liable to drop down on the fire sheets.

H. Jahnke.

Milwaukee, Wis.

An Emergency Piston in an Air Compressor

The accompanying description and illustration are of an emergency piston used in a disabled air compressor. The piston is from the steam cylinder of an 18 and 18¼ by 24-inch straight-line compressor. The original piston was wrecked when the heads of two follower bolts broke off and fell into the clearance space. The spider was split in two and the follower plate was broken.

The air from this compressor is in constant demand, so a temporary piston was constructed as follows:

We sheared out 12 plates of ⅓-inch tank steel in circles 18⅛ inches in diameter and bolted them together, as shown, by eighteen ¾-inch bolts. These were drawn up as tightly as possible and the piston put in a lathe. The taper hole in the hub was bored out to fit the piston rod and the piston turned down to the proper size. Three grooves were turned in the surface, ⅝ inch wide and 9/16 inch deep, and high-pressure spiral packing was forced into the grooves. The bolt heads and nuts projecting through the outside plates were turned off so as to make the piston 7 inches thick, the dimension of the broken piston.

The piston was then put on the rod, fitted into the cylinder and run for four or five days, when the new piston was put in. The temporary piston, when taken out, was in good shape, excepting the packing, which was pretty well used up.

The steam pressure was 160 pounds, with 100 degrees Fahrenheit superheat. The piston was rather heavy, but it did the work and no damage was done to the

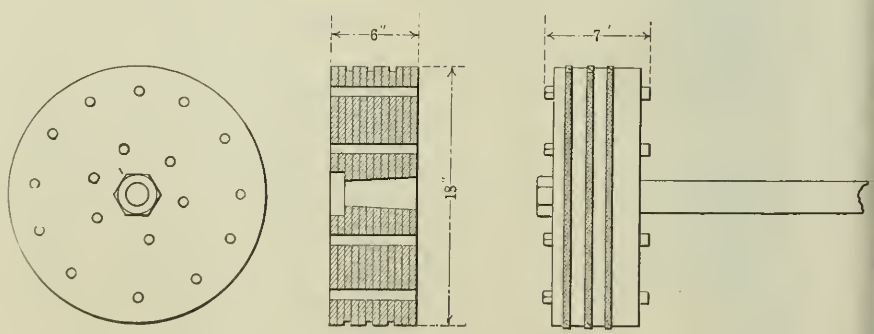


PLATE PISTON FOR AIR COMPRESSOR

cylinder; in fact, the surface was finely polished when taken out.

G. L. Fales.

Copperhill, Tenn.

Grout Foundation

I am operating a plant containing a 15x22-inch double engine furnishing power to a coal-washing plant. Six years ago the engine was set up on a concrete foundation, and later the top of the foundation crumbled under the bed plate to a depth of 4 inches. It became necessary to reline and level the engines, and at the same time rebabbitt the crank-shaft bearings. We began the job Friday night at

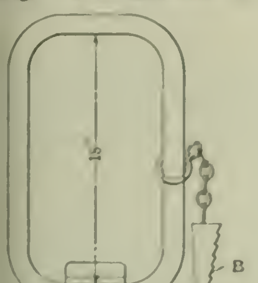
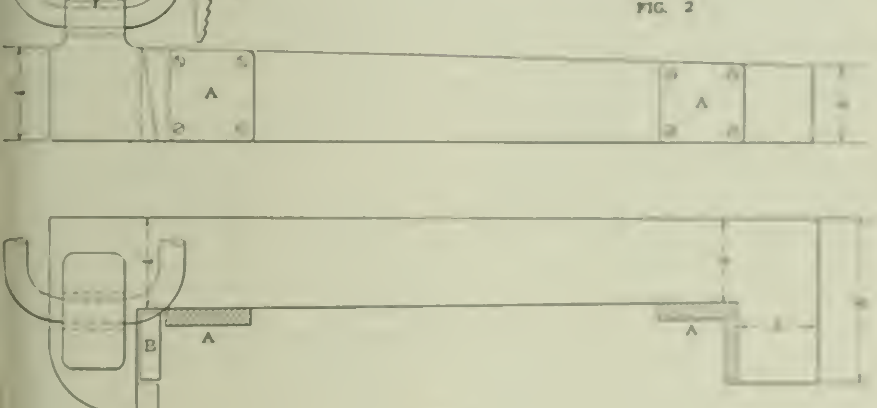



FIG. 1

9 p.m., and had until 6 a.m. Monday morning in which to finish the work.

I used 33⅓ per cent. Vulcanite portland cement and 66⅔ per cent. sand in a grout in a mold 4 inches deep on the foundation, after cutting and cleaning away all loose particles. After allowing 32 hours for the cement to become set we secured the engines with the sixteen 1¼-inch anchor bolts and started up on time Monday morning. After three days we again gave the anchor bolts about one-half turn, and today the engines are in place as solid as a rock.

J. J. Kerr.

Dunbar, Penn.

Scraping Valves and Valve Seats

I desire information regarding scraping and fitting flat valves, of the type commonly known as the "Sweet" valve. Also, the successive steps, tools required, etc., to properly fit these valves.

S. A. Ellman.

Uniontown, Penn.

Engine Turning Device

Following is a description of a [illegible] used to turn the flywheels of a vertical engine. The flywheels are [illegible] feet in diameter, 30 inches face, and weigh [illegible] tons. It was necessary, therefore, to make the hook good and strong. Fig. 1

FIG. 2

FIG. 3

shows side and top views of the rig, the small end of which is 1 inches square, the larger end is 2 inches square. The [illegible] is of 1½-inch iron and 18 inches long. The parts A have leather facings to prevent injuring the paint on the flywheel.

The wedge B, Fig. 3, is [illegible] with [illegible] as shown in Fig. 3,

which slants in the direction of the pull. The wedge is 8 inches long, 2[illegible] inches wide and tapers from 1 inches to ¼ inch. It is shown in position as shown in Fig. 2.

One might suppose the rig would grip the rim of the wheel so tightly that it would stick to the wheel, but such is not the case as it is only necessary to loosen the [illegible] hook, and the wedge will [illegible] loose, thus permitting the rig to slide down on the rim of the wheel ready for a new grip.

[illegible]

Kansas City, Mo.

Nuts and Wrenches

The skilled man [illegible] use a wrench in "any old way," and the other fellow cannot. Did you ever find yourself holding a hot piece of pipe in an awkward position and the other fellow with the monkey wrench in his hurry to secure a threaded union turning the wrench the wrong way, or opening the jaw in setting the wrench to size instead of closing it?

Regarding the standard drop-forged wrenches, why is it that the double-end solid wrench is used so much? The writer has always preferred the single-ended wrench, it being much more convenient.

I notice that a large number of manufacturers are reversing the standard hexagon nut when putting up large steam fittings. I did not take kindly to the change at first, as it looks sloppy, but under the conditions I think it is a good thing to do. In the rush to get work out of the shop there are tons of large gate valves, tees, ells and pipe flanges that are not spot-faced for bolts, which should be done; consequently, the round or chamfered side of the nut adapts itself to the work, rather than the other or finished side.

Charles [illegible].

Hartford, Conn.

Driving Up a Bag in a Boiler

In a recent issue, [illegible] describes an excellent way of driving up a bag in a return-tubular boiler, but the following method can be used where no foundry is handy [illegible] [illegible]

A bag developed and the [illegible] set the boiler out of a [illegible] of steam [illegible]. The [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] The bag was then heated and driven up with a sledge by working around and around the bag, gradually [illegible] the center.

The boiler, which has been inspected several times, has been in use for several years since and is said to be the best boiler in the battery of five.

The plant was not shut down as in the other case, and the boiler was out of use only three days, the expense amounting to the cost of ten gallons of gasolene and a helper for two days.

W. F. Johnson.

Bamberg, S. C.

A Peculiar Lighting Condition

If C. L. Greer, whose letter appeared in a recent issue of the paper, will remove the ground on the negative side of the circuit *C* (see reproduced sketch), he will find that the negative side of circuit *B* is grounded.

I would advise a new extension cord on the lamp used by the boiler washer. Then the lighting system should work properly.

E. B. Austin.

Burlington, N. C.

Concerning C. L. Greer's inquiry, I would say that the following conditions might give rise to his trouble:

Should a dead ground exist at any point on the outside wire of circuit *B*, and a similar ground exist at a point on the outside wire of circuit *C*, the lights on circuit *C* would burn under the conditions he mentioned, namely, with the switch *A* closed on the exciter circuit, switches *B* and *C* closed and the circuit breaker open. The lamps on circuit *C* are then fed as follows: From the positive side of the direct-current machine to the lamps by way of the positive side of switch *C*, through the lamps to the ground, then

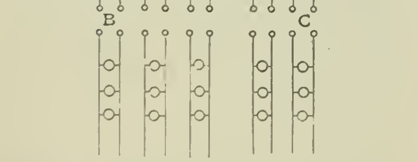


DIAGRAM OF WIRING FOR LIGHTING SYSTEM (REPRODUCED)

from ground on circuit *C* to the ground on circuit *B* and through the negative side of switch *B*, back to the direct-current machine by way of the negative side of switch *A*.

If we put the circuit breaker in it will remain there, the only part it plays is to supply an additional path for the current of the negative side, and the amount of current it will take will be proportional to its resistance and the resistance of the circuit through the grounds. In other words, we have a divided circuit of which one leg includes the circuit breaker and the other leg includes the grounds. If, now, the switch *A* is opened all of the circuit *C* must pass through the circuit breaker; this momentary rush of current may be sufficient to trip the same in the manner spoken of.

Walter G. Mullen.

Gloucester, Mass.

Air Compressor Accident

Quite recently, in one of the largest railroad shops in the middle West there was a serious air-compressor explosion which wrecked the tanks, engine and hundreds of feet of pipe and tore great holes in the walls of the building.

The accident was a progressive one, the first trouble being the explosion of about a hundred feet of underground air pipe in the yards, which so lowered the tank pressure as to cause the engine, which was air-controlled only, to run away and burst the flywheel, which was directly in line with a battery of large boilers. They, however, escaped injury.

The primary cause was undoubtedly oil in the pipes, which became volatilized and fired, either by heat or by electricity, the former being more likely.

There are three lessons to be learned from this accident, of which the most important is that an air-compressor engine should not be controlled by air alone, but should be fitted with an auxiliary governor which will act as soon as the speed rises above a certain point. In this way an accident to the tanks or piping, causing a sudden lowering of the pressure to a dangerous degree, would not cause the engine to race. The lowering of the pressure need not necessarily be caused by an explosion, but the giving way of a pipe, valve or tank from any cause would have the same effect.

The second lesson is one that is being driven home by dozens of accidents all over the country, and that is, *keep an excessive amount of oil out of the system.*

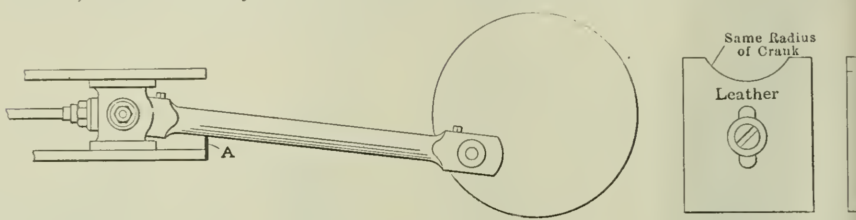
The third and last lesson is one that is seldom needed, but which in this case was disregarded, though fortunately without serious result. It is that no engine should be so set that the bursting of the flywheel would be apt to crush the boilers.

Ethan Viall.

Decatur, Ill.

Preventing a Crank from Throwing Oil

An engineer experienced a great deal of trouble from oil thrown by the crank of a Corliss engine. He tried a number of methods of getting rid of the nuisance, but had not been successful.



OIL GUARD ON GUIDE

The idea of fastening a wiper to a wire, so that it would wipe the surplus oil off as the crank went past the bottom developed. This idea resulted in the application of a wiper, as shown in the illustration. It was cut out of leather and fastened with a screw and washer to the end of the guide. After this wiper was put on and adjusted so that it touched the rod lightly at each revolution, the oil-throwing nuisance completely disappeared.

W. L. Whitmarsh.

Phenix, R. I.

A Lead Brush

Soon after I took charge of the plant I now have, one of the carbon brushes of a two-brush four-pole shunt-wound motor broke in half. As there was not enough left to be of any use, I got some lead and cast a brush. I then filed it up and sandpapered it to fit the commutator surface. I had no trouble for the rest of the shift and the next morning I replaced it with a new carbon brush.

C. R. Moure.

Exeter, South Australia.

Belt Ruined by Oil

The following experience was a costly one for my employer, although he never discovered the cause. A 6-inch belt gave trouble and the office was convinced that a larger belt and pulleys were needed. After the belt was put in place, the superintendent gave me a gallon of neatsfoot oil and told me to soak the belt with it. Although I knew better, I brushed the oil on until the belt was as limber as a rag. Then it began to stretch, and a heavy idler pulley was put up.

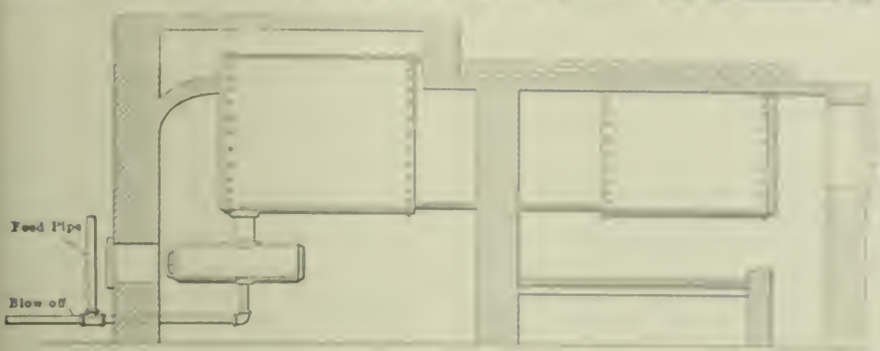
The oil so injured the glued joints that they had to be pegged and riveted repeatedly. Finally the belt parted and wound between the pulley and hanger. It was so badly damaged that a new one was necessary.

Charles Haeusser.

Albany, N. Y.

Boiler Setting

S. Kirlin's improvement on Mr Wheeler's idea of a boiler setting as illustrated in a recent number, appears favorable in many respects, although I should arrange details slightly differently The sootblower door, for instance, could be located



MR. CEDERBLOM'S SUGGESTION FOR BOILER SETTING

to better advantage in the opposite end so the flues could be blown out with instead of against the draft. As it is, the soot will be blown out in the fire room if too much pressure is applied.

Where the blowoff pipe now enters the boiler I would have a good-sized mud drum connected to the boiler by a 6- or 8-inch nipple, and pump the feed water into this drum through the blowoff connection, as shown in the accompanying illustration The arrangement would be safe from burning out, and would hold water at such a high temperature that most of the scale-forming matter in the feed water would be precipitated in the drum, where it can do no harm and is easily removed.

R Cederblom.

Gary, Ind.

Repairing Commutators

The "flashing over" or excessive sparking of a commutator may produce a minute cavity in the commutator insulation, which, from time to time, becomes filled with a conductive material from the brushes, particularly where a lubricant has been used When enough has accumulated in the spot to become a fair conductor, and a current passes through it from bar to bar, the mass becomes incandescent, immediately burns out, and with it a certain amount of commutator insulation.

At intervals the process is repeated Often the original cause of this defect is obscure and beyond prevention by the man in charge This condition, however arising, is always recognized by a reddish-yellow spark forming a momentary ring of fire around or partly around the commutator and always recurring at the same place. The damaged spot becomes worse, and unless attention is given will inevitably end in serious damage to the commutator, and often to the armature coils.

In order to properly examine a commutator in this condition ample light must be provided. Each segment must be thoroughly inspected and the faulty parts marked. When a burned spot is found it must be scraped and cleaned out until absolutely no trace of carbonized material remains. This is by no means an easy task, but the same may be facilitated by the use of a special tool which is conveniently made from a 4 inch piece of hacksaw blade, one end being ground to a point similar to a shaper tool. This end is also made just thin enough to enter between the bars. If this tool is given a sharp, square cutting edge no difficulty will be experienced in scraping the mica insulation clean.

After the cavity is thoroughly cleaned it should be refilled with either silicate of soda, or silicate of soda and powdered glass, plaster of paris, or plaster of paris and shellac. A mixture which the writer has used successfully is silicate of soda with calcium carbonate, more commonly called powdered chalk. They are in the right proportions when mixed to a thick paste. The latter is packed into the cavity and a small surplus left on top to be afterward smoothed down with sandpaper. These materials combine chemically, forming calcium silicate and become very hard in a few hours.

Where a burned [illegible] is deep enough, or where it occurs at the end of the commutator, [illegible] may be cut to [illegible] in the part, the cavity coated with moderately thick shellac and the [illegible] tightly driven in, the projecting edges being trimmed off afterward.

Where a machine [illegible] at one time, [illegible] times, but [illegible] applied to [illegible] will hasten the drying and all the [illegible].

[illegible]

[illegible]

Lamp Wiring Diagram Wanted

Can any of the readers suggest a wiring diagram for throwing, say, three battery lamps from parallel to series and vice versa, using only a standard switch or switches?

E. J. Williams.

Cleveland, O.

Laying Out an Eccentric Keyway

In a recent number, John [illegible] gives a simple method of determining an eccentric keyway which, I believe, is not quite correct, as the angularity of the eccentric rod has not been considered.

Let the circle (see illustration) denote the throw of the eccentric and O R the length of the eccentric rod, which in this instance is six times the throw. The arc A O B would be the path of the eccentric rod through the center of the shaft, and the line O A the position of the eccentric at mid stroke, when the valve is in its central position. Mr. [illegible] takes the vertical line C D for this position, and the keyway would be cut as much as the angle C O A, or about [illegible] degrees.

If this was corrected, the keyway so determined would be right only if the rocker arm or [illegible] [illegible] with the center line of the engine. As it is inclined higher or lower, corrections would have to be made accordingly.

If I had the rod and [illegible] surface plate to place them, I would prefer to lay out the keyway with the [illegible]. There is always some part of the keyway near enough to find its position [illegible].

[illegible]

[illegible], Ind.

[illegible] LAYING OUT AN ECCENTRIC KEYWAY

Low Pressure Turbines and Steam Engines*

Advantages to be Obtained in a Combined Plant; Flexibility of Application a Turbine Characteristic; Efficiency Ratio Possible

BY J. R. BIBBINS

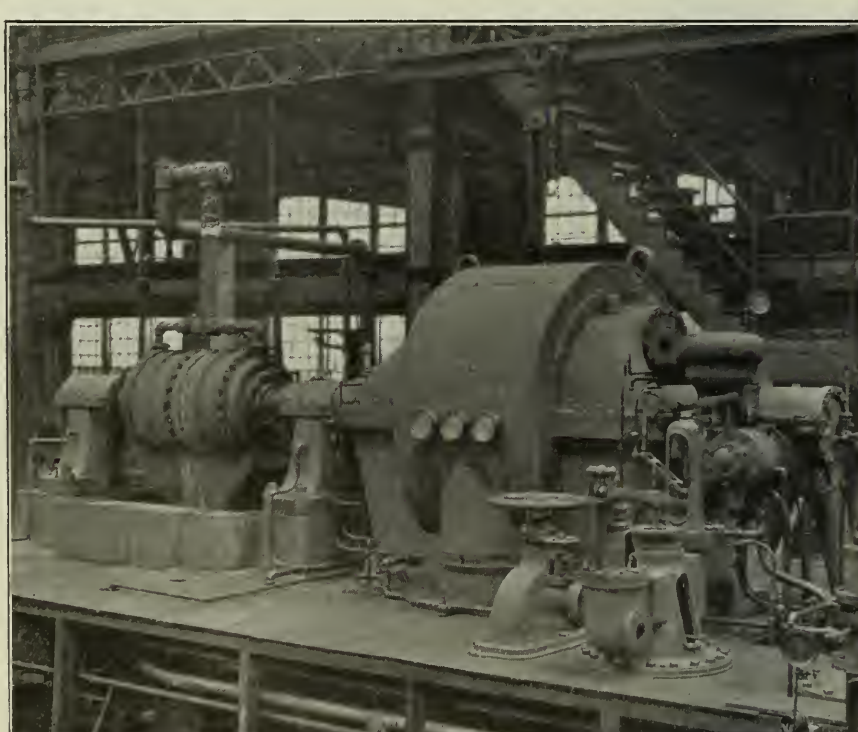
Both the standard types of prime mover, the reciprocating engine and the steam turbine, have distinct fields in which their highest efficiencies are respectively obtainable. The steam engine finds its most efficient territory in the higher pressure ranges above atmosphere, while the steam turbine works to best advantage in the lower stages. This, of course, does not carry the inference that the engine cannot benefit substantially from high vacuum, nor *vice versa,* the turbine from high boiler pressure, for the advantages of each are well known. In the engine, the losses due to condensation and reëvaporation on the cylinder walls during each consecutive cycle are large; in the turbine there is no cyclic change, and therefore no such losses, comparatively speaking, as a fairly constant temperature and pressure obtain at any given point in the expansion range. In the engine the mechanical friction of the enormous sizes of cylinder necessary to accommodate the lower expansion ranges constitutes an effective barrier; in the turbine the lower ranges are obtained with comparative ease and without incurring excessive losses, mechanical or thermal.

A good Corliss engine will give the best efficiency** (72 per cent. at normal load in the case to be discussed later) when operating noncondensing against exhaust pressures of from 15 to 20 pounds absolute. Certainly cylinder ratios of 1 to 2.5 to 3.5 will do so. Similarly, the steam turbine expanding from 15 to 25 pounds absolute down will show a maximum efficiency ratio as high as 73 per cent. for moderate vacuum, and commercial guarantees are today made above 70 per cent., a fact which speaks for itself. Thus, it occurs that the combination engine-turbine plant will show an overall efficiency ratio (65 to 75 per cent. of the ideal cycle) considerably in excess of either an engine or complete-expansion turbine unit running alone, which can hardly do better than 65 per cent. In the case treated later, the Rankine cycle efficiency of the combined unit was found to be 69.3 per cent. at normal load.

The pioneer work (about 1890) of C. A. Parsons, to whom we are all indebted, has brought about so thorough a discussion of the marine problem as to take definite form in the recent decision to equip the two monster transatlantic liners with combined engine and low-pressure turbine plants. Professor Rateau's work in steel mill and mine hoisting has also resulted in the practical application of low-pressure turbines in connection with the steam-regenerative principle, permitting the turbines to operate constantly, using the exhaust steam from engines intermittently operated. His work has been brought to our notice in this country by H. H. Waite, in discussing regenerative turbine application to steel mills.† J. W. Kirkland‡ has introduced the subject of low-pressure turbines in light and power plants. And it is this line of thought that it is desired to enlarge upon in the present paper.

*Paper read before the Canadian Society of Civil Engineers, Montreal, Can., November 26, 1908.

**It is understood that the term efficiency in this case refers to efficiency ratio in per cent. of the Rankine-Clausius cycle, i.e., efficiency in per cent. of available energy in the steam within the range of pressures, not steam consumption.



WESTINGHOUSE DOUBLE-FLOW TURBINE ON TESTING FLOOR

Application

There are two general classes of service in which the low-pressure turbine finds effective field for application:

Class A—Supply of steam intermittent and widely varying in quantity. For example, rolling mills, for blooms, plate, sheet, wire, rail and structural shapes, steam hammers and hoisting engines. All of these involve the regenerative principle, requiring a careful study of the time element in supply and demand, generally resolving into a special problem for each individual installation.

Class B—Nonintermittent supply without regeneration. This class embraces central power stations for lighting, traction or for factory drive, and may be discussed as a general problem of power extension where the widely varying plant conditions may be summarized as follows:

(1) Good engine design; fair operating efficiency. Increase in capacity necessary.

(2) Inefficient engines, condensing or noncondensing, improvement in operating economy or increase in capacity necessary.

(3) Present condensing plant unsuitable or inefficient.

(4) Plant location; where water supply is limited, unsuitable or costly, for example, enforced noncondensing operation.

†American Institute of Electrical Engineers, December, 1907.

‡National Electric Light Association, June, 1908.

(5) High cost of fuel.

Given a reciprocating-engine plant of serviceable construction, along what lines shall needed power extension be made?

(1) By installing more reciprocating units of the same type and operating under the same conditions.

(2) By installing more efficient complete-expansion turbines with suitable auxiliaries.

(3) By utilizing the low-pressure turbine principle to render the present plant more efficient.

Primarily, the problem before us is that of Class B, (1) and (2), *improving the efficiency of a given reciprocating-engine plant*, which may be in the best physical shape, but operating under unsuitable conditions. The importance of this subject will at once be appreciated when we reflect that a plant of noncondensing engines may be changed over to reduce its water rate from 30 or 35 pounds per kilowatt-hour to 15 or 18 pounds per kilowatt hour in comparatively small sizes; in other words, for the same expenditure of coal and water, a net increase in power of from 80 to 100 per cent. may be realized, depending upon the type of equipment. And the resulting cost of power is reduced in the same proportions. In the case later discussed, a minimum water rate of 15.8 pounds per kilowatt-hour (150 pounds dry saturated steam to 28 inches vacuum) is obtainable from an engine giving 28.5 pounds per kilowatt-hour noncondensing, and 20.05 pounds per kilowatt-hour condensing, with an increase in rated capacity of 90 per cent.; maximum, 100 per cent. This is equivalent to 9.9 pounds per indicated horsepower-hour, or an efficiency ratio of 75 per cent. indicated, 66 per cent. brake.

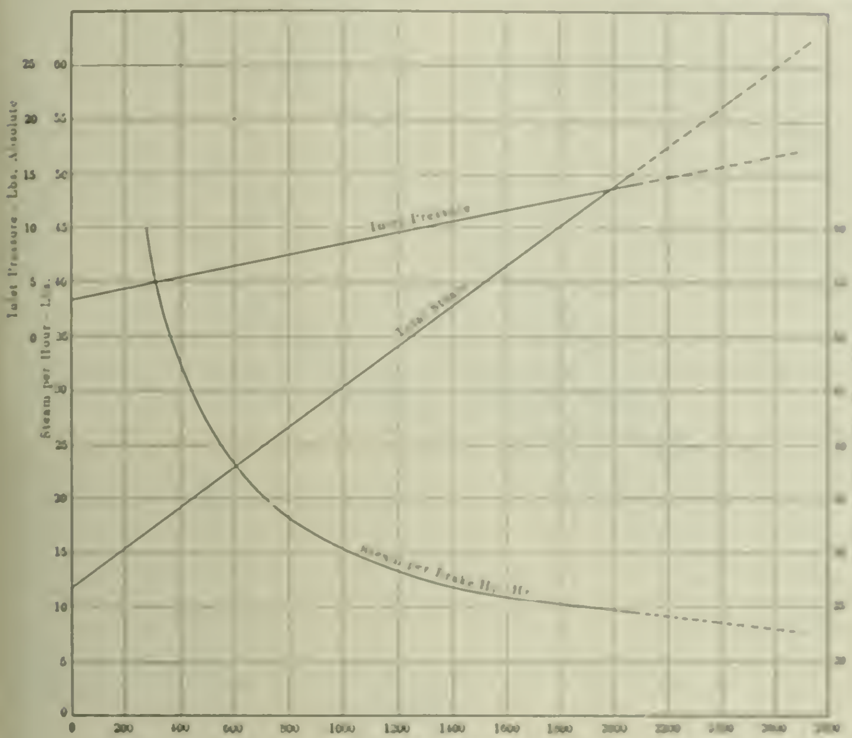


FIG. 1

Turbine Tests

Two series of tests*, Figs. 1 and 2, will serve to illustrate the possibilities of economy and capacity. Fig. 1 represents tests at several different loads and varying inlet pressures, all on approximately dry-saturated steam and 27.5 inches vacuum. Although a few of the original observations were slightly irrational, this was due to the difficulty of maintaining exact vacuum, and when corrected fall well into line. Note that these tests, Fig. 1, were all conducted at inlet pressures below atmosphere, but the characteristic for higher pressures is the same, a straight line, as has been proved by other tests carried as high as 20 pounds absolute. Thus, at 19 pounds inlet pressure, the water rate is approximately 200 pounds per brake horsepower (31.2 pounds per kilowatt-hour) and at 20 pounds inlet pressure, about 21 pounds per brake horsepower (30 pounds per kilowatt-hour).

The effect of higher inlet pressures and varying vacua is well shown by Fig. 2, a series of tests upon the low-pressure section of a 2000-horsepower lighting turbine for the Interborough Rapid Transit Company in 1902. This machine is of the single-flow design, the high-pressure section expanding down to about atmosphere and the low pressure section below. Note that the water lines are virtually straight up to the maximum initial pressure, 30 pounds, and slightly divergent for varying vacua. This range of inlet pressure represents quite closely the actual range of operation in a combined engine-turbine plant. The result of tests on this machine, the first one of the type built for commercial service, shows an efficiency ratio of about 70 per cent. at 15 pounds absolute inlet pressure and 27 inches vacuum. And this may be improved upon if it is considered expedient to design for higher vacuum.

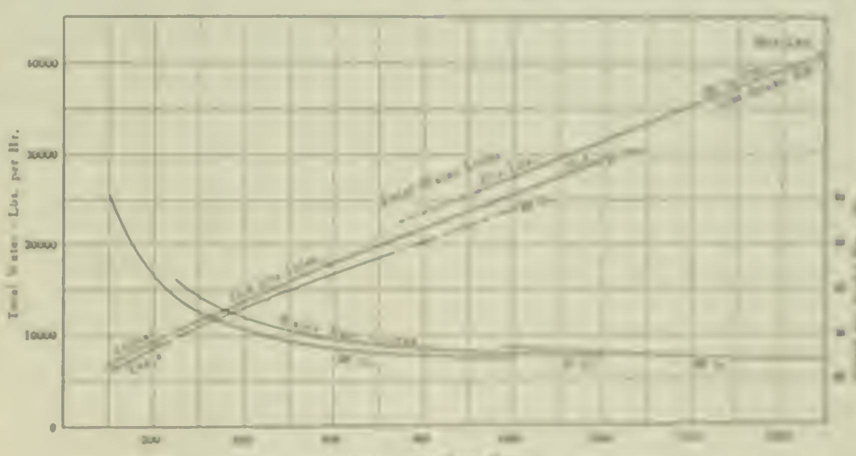


FIG. 2

Characteristics of Low-pressure Turbines

From a thermodynamic standpoint, the low-pressure turbine is the exact counterpart of the complete expansion turbine, and it possesses the same characteristics shown by Fig. 2. As in the high-pressure turbine, the line of total consumption per hour, or water line**, is practically straight, resulting in a constantly decreasing water-rate curve. The power developed by this machine, increased in proportion to the inlet pressure, having the small friction drop throughout the range as at no load. As this type of machine employs no mechanism in the shape of overload or secondary valves, this

*Owing to the author's special familiarity with developments of [illegible], these data refer entirely to results obtained from Westinghouse apparatus.

**Sometimes called the Willans line.

would be expected, and the water-rate curve is necessarily an equilateral hyperbola. The low-pressure turbine may be regarded as the third cylinder of a triple-expansion system, and is equivalent to such cylinder fitted with *fixed cutoff*. In other words, it must have a definite initial pressure to enable it to pass a given weight of steam. This necessitates a careful study of engine-cylinder proportions and valve movements. For it occurs that when direct-connected to an engine, the release pressure in the low-pressure engine cylinder may be well above the initial pressure required by the turbine, or considerably below it, depending upon whether the load is heavy or light. In the first case a large receiver drop would ensue between engine and turbine, and in the second a serious loop in the low-pressure diagram. Therefore, the type of engine, cylinder ratio, the cutoff and the average- and maximum-load demand must be known before any rational decision can be made as to the proper size of turbine to install and the resulting distribution of load predicted. However, should errors be made in the calculations or determinations of the low-pressure turbine characteristics, the same may be easily rectified by a slight change in the angle of the blades, requiring but a very small expenditure.

Engine Characteristics

Assuming a normal design of Corliss compound engine, there are two methods of governing which may come under consideration:

(a) High-pressure cutoff variable; low-pressure fixed.

(b) Parallel cutoff, i.e., both high-pressure and low-pressure variable in the same direction, increasing with the load.

The parallel system is widely employed in Corliss practice to maintain an equalization of work in the two cylinders. It is difficult, however, to avoid loops in the low-pressure cards at light loads (noncondensing), as the low-pressure cylinder expands below the exhaust pressure. In case (a) the low-pressure cutoff is deliberately fixed far enough in advance to eliminate the low-pressure loop in the lower ranges of load anticipated. But this system has the disadvantage of causing a great disparity† in loading cylinders.

A point worth noting is that in lightly loaded plants where large increase is anticipated, the low-pressure loop may be to some degree avoided by omitting a few rows of blades, thus enabling the turbine to pass the same quantity of steam at a lower inlet pressure. Ordinarily two rows will be sufficient and these may be re-replaced later when normal operation is resumed.

†Thus with the low-pressure cutoff fixed at 75 per cent. of the stroke and the high-pressure as short as 15 per cent., the engine would deliver steam to the turbine at 8 pounds absolute and without loop. But on maximum load with high-pressure cutoff at 75 and 25 pounds back pressure, the ratio of work in the two cylinders would be about 2 to 1.

This brief discussion will serve to illustrate the necessity of a careful study of the engine problem. In designing a plant for a given loading factor, say, 75 per cent. average and 150 per cent. maximum rating, the point of rating of the combined unit may be regarded as corresponding to the point where the engine is operating at its best economy, noncondensing, for the combined plant virtually retains the characteristics of the engine equipment.

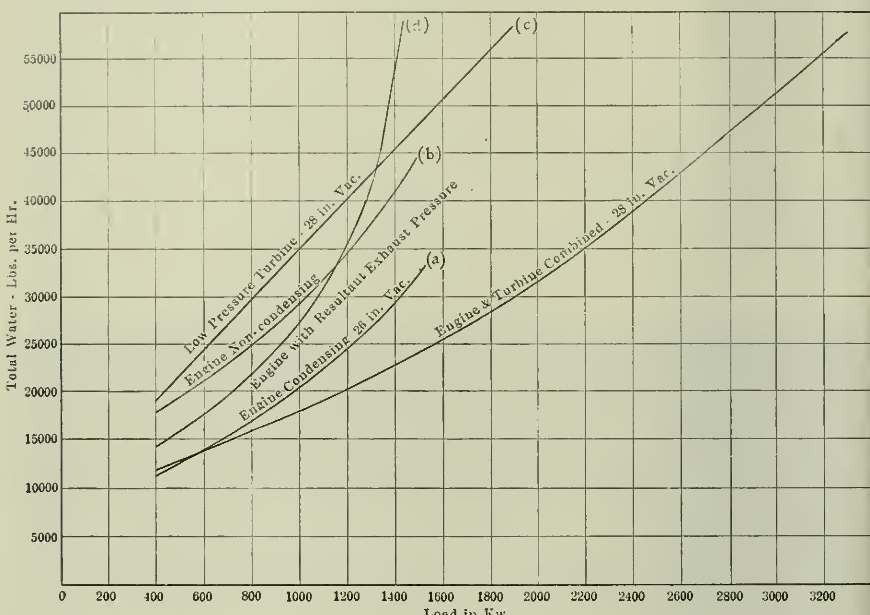


FIG. 3

Combined Plant

The effect of the various factors outlined may be best illustrated from Figs. 3 and 4, which have been prepared to exemplify the principles of design for a 2000-kilowatt installation suited to a 50 per cent. overload, or thereabout. Fig. 3 shows only the water lines, from which are derived the respective water-rate curves, Fig. 4. These water lines cover the following conditions:

(a) Engine alone condensing, 26 inches vacuum.

(b) Engine alone noncondensing, 17 pounds absolute back pressure.

(c) Low-pressure turbine alone, 28 inches vacuum, variable inlet pressure.

(d) Engine noncondensing with variable back pressure, resulting from its connection to the turbine.

(e) Combined engine and turbine system, 28 inches vacuum.

Of the above, (a), (b) and (c) were obtained by actual data. The combined curve (d) must be found graphically from the characteristic curves of engine and turbine, and the final curve (e) by combining (c) and (d). These water lines, Fig. 3, serve to illustrate the difference between the Willans characteristic for turbine (c) and an engine (a) (b) governed by cutoff. One is a straight line, the other a curve. The turbine has no point of lowest water rate other than maximum load; the engine ordinarily does its best at rating or under. It is usual practice to rate an engine at its point of lowest steam consumption. This may be found from the water lines as the point of tangency of a radial line from the origin. Thus, this engine running condensing shows its best economy at about 1000 kilowatts, and noncondensing at about 1200 kilowatts, which is entirely rational. On the other hand, the resultant engine curve (d) shows a best point of economy slightly under 900 kilowatts, due to the influence of the variable back pressure. Therefore, the turbine should be designed to pass just the amount of steam required at a back pressure corresponding approximately to this point of best engine economy, noncondensing. Care must be taken, however, in adapting the turbine to the engine, to avoid any condition that will cause excessive pressures on engine crank pins and bearings.

This point of safe pressures is mentioned because of a tendency permanently to overload the engine in the desire to produce a very low water rate. It should not be considered good practice to operate an engine on pressure much in excess of 50 per cent. of that for which it was designed‡. A recent study of a combined plant that has been widely discussed shows that the engine had been forced to a mean effective pressure of 56 pounds referred to the low-pressure cylinder. In our typical study, Figs. 3 and 4, it has been thought best to take an engine of normal proportions, as found in many lighting and traction plants (cylinder ratio 1 to 3¾) rather than a ratio more suited to efficient noncondensing operation; for example, 1 to 2.5 or 3. There-

‡In average practice, a compound Corliss engine (condensing) would be designed for about 30 pounds mean effective pressure at rating, and should not operate with mean effective pressure much over 45 pounds (referred to low-pressure cylinder).

fore, the results may be considered conservative in this respect. The design is based on, first, an engine rating (best) of about 33 pounds mean effective pressure referred to the low-pressure cylinder, 165 pounds absolute boiler pressure and 17 pounds absolute back pressure, and second, allowing 1 pound drop between machines, a turbine passing the engine room at 16 pounds inlet pressure, 28 inches vacuum. The combined plant, 2000 kilowatts, has an overload capacity of 50 per cent. with some excess margin.

Examining the water-rate curves, Fig. 4, we find that the engine gives an economy of 20.05 pounds per kilowatt-hour condensing, 28.31 pounds per kilowatt-hour noncondensing, for a normal load of 1000 kilowatts in each case; but in combination with the turbine, a maximum water rate of 15.8 pounds per kilowatt-hour.

Curve (c'), Fig. 4, has been derived from (c) for comparison of water rates of combined plant and condensing engine on the *same basis of rating*, i.e., equivalent to curve (c) at half scale. Thus, at rating, the combined plant shows an improvement of 22 per cent. in water rate. At light loads, however (500 kilowatts), the combined plant ceases to be as efficient as the engine running alone condensing. The point of equal economy is, of course, somewhat variable, as it is difficult to locate it accurately with two curves at such an acute angle, but it immediately suggests that in the practical operation of a combined plant, it would be desirable to shut down the low-pressure turbine when the load falls below 30 per cent. rating, for example, and operate the engine alone.

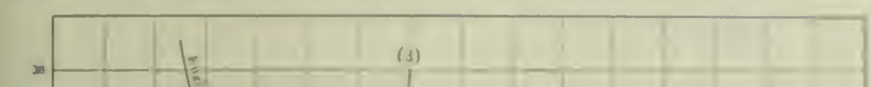


Fig. 4

GOVERNING

For a study of governing the various classes of service may be summarized as follows:

Class A—Turbine electrically locked with engine, that is, serving the same busbars.

(1) Turbine taking all of the engine steam. No governor required. Load on turbine varies with engine load.

(2) Turbine taking part of the engine steam. No governor required. Output remains practically constant with uniform pressure in exhaust mains, due to excess supply of exhaust steam.

In both of these cases atmospheric relief should be provided (if only to enable the engine to operate while the turbine is shut down) and, of course, a hand throttle valve.

Class B—Turbine electrically independent of engine; that is, serving separate bus; for example, lighting only, engines on traction bus.

(3) Turbine taking all or part of engine steam. Governor required in case of intermittent supply.

With momentary deficiencies, occurring only infrequently, a reducing valve need be used for auxiliary live-steam supply, also in case of deficiencies of long duration; but with rapidly fluctuating supply averaging in excess of the demand, a regenerator may become profitable, or its equivalent in electrical storage may be used in direct-current systems.

In all of these cases a safety stop is obviously essential, simply for insurance against possible overspeeding. In Class A (2), for example, should the circuit open with the turbine under load, the safety alone would prevent disaster. The automatic safety stop may operate either a butterfly valve or a positive closing throttle.

GARY INSTALLATION

A typical example of low-pressure turbine application is found in the plant of the United States Coal and Coke Company, at Gary, W. Va. It operates the mining property serving hoists, pumps, blowers, lights, etc. The plant contains two 24 and 44 by 48 Corliss engines, 700 kilowatts, one 1000-kilowatt complete expansion steam turbine and a 1000-kilowatt low-pressure steam turbine, both of the Parsons type. These turbines are served by three cooling-tower units, fan-driven, each 24 feet in diameter and 25 feet high. Two of these units serve the low-pressure turbine and one the high-pressure turbine. The following figures roughly indicate the normal operation of the generating units from readings taken October 7, 1908:

Output of two turbine units	[illegible] kw.
Output of low-pressure turbine	[illegible] kw.
Steam pressure gage	[illegible]
Vacuum, L.P. turbine	[illegible] in.
Temperature of injection	[illegible] deg.
Temperature of air	[illegible] deg.
Cooling in tower	[illegible] deg.

Thus the low-pressure turbine carried nearly half the total load on less than 26 inches vacuum, and would have carried more than 1500 kilowatts on 28 inches vacuum, with better condensing conditions.

AUXILIARIES

Inasmuch as the turbine is so dependent upon auxiliaries, it is pertinent to point out some facts in this regard. If we compare the ideal water rate of a turbine expanding from atmosphere down to various vacua, we shall find that while the ideal machine improves continuously down to the lowest condenser pressures, the actual turbine cannot make as good use of the last inch or two of vacuum as in other parts of the expansion range; in other words, we may expect the highest efficiency in moderate ranges of vacua. This is in strict agreement with high-pressure turbine work, as the author has endeavored to point out many times before. However, assuming that the turbine improves 5 per cent. per inch of vacuum around 27 inches, it is plain that an efficient condenser is very desirable, but with warm circulating water it is not always possible to obtain the vacuum desired. This is due almost always to the inability of the condenser to work with a small enough temperature difference between steam and discharge water. A condenser may be regarded as a heater, and its effectiveness is entirely dependent upon its ability to deliver water heated as nearly as possible to the temperature of the steam. This is of the utmost importance in places where cooling towers are necessary. And at this point may be emphasized the fact that the cooling tower is rapidly becoming less objectionable as a device. This has been brought about by the recent development of more efficient condensing apparatus.

A good surface condenser should operate within 15 degrees difference between the temperature of the steam and discharge water; a good barometric jet within 10 degrees; yet we find that twice this difference is tolerated in modern power plants as supposedly good performance. This is the secret of the poor vacua against which turbine builders are obliged to struggle in designing machines for better conditions.

There are now on the market condensers of the jet type which are able to operate within 2 to 5 degrees of the steam temperature and without unusually bulky or wasteful auxiliaries. This considerably reduces the quantity of cooling water necessary to condense a given amount of steam; in other words, makes possible a higher vacuum with a given temperature of water. For example, assuming a cooling tower able to cool down to the temperature of the air, what vacuum will it be possible to maintain with 75 degrees water? A perfect condenser (with no temperature difference between steam and discharge water) would require about 220 volumes of cooling water for 29 inches vacuum. For 28 inches vacuum it would require 35 volumes. An efficient condenser of the jet type, working within 5 degrees of the steam temperature, can maintain 28 inches with 43 volumes of water. An ordinary jet condenser, working on 10 degrees difference, will require 57 volumes to maintain 28 inches, while the ordinary surface condenser, working for 20 degrees difference, cannot maintain 28 inches except by using an impracticable amount of water, 140 volumes.

The more efficient jet type is thus responsible for reducing the quantity of cooling water to one-third of that required for the average surface type.

In cooling-tower practice, where extra power is required to lift these large volumes, this is evidently of the highest importance, for the increase in auxiliary plant may more than offset the benefits of the increased vacuum. Therefore, the determination of the *most economical vacuum* for a given plant involves a study of the plant economy at various vacua, the power consumption of auxiliaries and the operating and fixed charges against the auxiliary plant. This becomes more and more important as condensing conditions become more unfavorable.

It is important to deliver steam to the turbine as dry as possible, owing to the well known effect of moisture in decreasing the output through friction. The quality of steam from the engines is, of course, indeterminate, but varies between wide limits, averaging 93 to 90 per cent., or less. So that a separator had best be installed in the exhaust main before the turbine. This also serves to remove the water of condensation from a long run of exhaust piping. This necessity suggests the use of a moderate superheat in the engine, sufficient to insure dry steam at the turbine, entirely feasible with the internal type of superheater in common use. This would avoid the resistance through the separator, which may be a serious matter in dealing with large piping and high velocities. The only other alternative is the use of drying coils in the exhaust main. This, however, has proved to be decidedly uneconomical if live steam must be used for this purpose. It could be applied only in cases where some form of waste heat could be used to advantage.

Summary

The most important thoughts presented in the preceding may be summarized as follows:

(1) Low-pressure turbine application is exceedingly flexible, and may work into existing engine plants of good, as well as poor, design to advantage, in conjunction with engines of high- as well as low-expansion ratio.

(2) Regenerative accumulators not always essential in low-pressure turbine work; in fact, average power-plant work does not require their use, resulting in great simplification of plant.

(3) Important to choose proper turbine size so as to permit good economy in engine and maintain exhaust pressures above atmosphere during normal loading, thus preventing air leakage in valves and piping.

(4) During periods of light loads, it may be expedient to run engine condensing, omitting the turbine entirely.

(5) For infrequent or long-continued deficiencies in the steam supply, the turbine may take live steam through a reducing valve to supplement normal supply.

(6) Inherent efficiency of both turbine and combined plant greatest at moderate vacua, 70 to 73 per cent. of the ideal steam cycle.

(7) Condenser problem lies largely in its ability to work on small temperature differences.

(8) Weight and cost of low-pressure turbine unit not far from that of the complete expansion unit. Length of turbine reduced about 30 per cent., unit about 18 per cent.

(9) No governor required if turbine is electrically connected to engine and takes all or part of the steam.

(10) Efficient safety overspeed stop a vital necessity.

Surface Condensers

By Frederick L. Ray

The type of condenser shown in Fig. 1 is practically a salt-water apparatus, as this is the only type that salt water can be used with where it is desired to use the condensation for boiler-feed water; and even with this type it is often impracticable to use the condensation because of leaky tubes allowing the salt water to mix with the water of condensation. If it were possible always to keep the condenser tubes tight, then the surface condenser could be used on the sea coast and salt water used for cooling purposes.

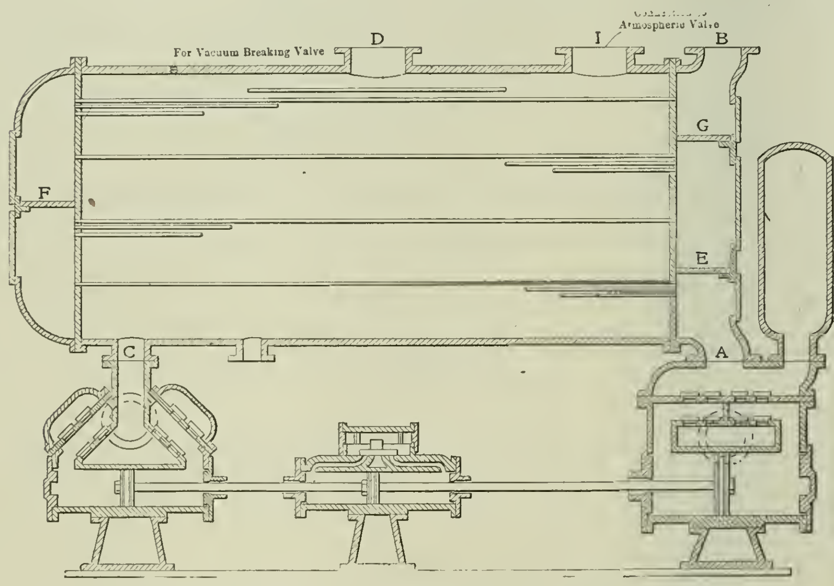


FIG. I. CONDENSER IN WHICH SALT WATER MAY BE USED

Where the circulating water is also used for boiler feed, the surface condenser may be used regardless of leaky tubes. But why go to the extra cost for equipment for such a large cooling surface, circulating and air pumps, where the jet condenser would answer as well and often much better? The surface condenser requires much more attention on the part of the operating engineer, is more complicated and costs much more than the jet condenser.

Care and Operation

As there are many surface condensers in use and more will be installed, regardless of trouble and costly repairs, a few observations on their care and operation are given in the following:

Fig. 1 shows a sectional view of a surface condenser and pumps on one base, in which *A* is the inlet for the circulating water, *B* the discharge for it, and *D* the inlet for exhaust steam which, on entering, strikes a perforated plate, and is distributed over the tubes, thus protecting the tubes from the impact of the steam.

The instant the steam strikes the cold surface of the tubes it is condensed and falls to the bottom of the condensing chamber, from which it flows out at the nozzle *C* to the air pump. The circulating water passes in at *A* and out at *B*, and in its course meets the baffle plate *EFG*, which causes it to pass through the condensers four times. It would appear that this construction would require only one-fourth as much as if the water passed through but once, but this cannot be, as in the repeated passing through the tube, in contact with the steam, it is heated, becomes less efficient and more is required in consequence.

This construction requires that the condenser be somewhat larger, due to the less efficient cooling surface of the tube, but at the same time requires a very much smaller circulating pump. At the left is shown the connection to a vacuum-breaking valve, used to destroy the vacuum before shutting down the air pump, and an automatic atmosphere snifting valve is connected to the outlet *I*. Should the air or the circulating pump break down, or the vacuum be destroyed from any cause while the engine is in operation, this valve will open and relieve the condenser of any excess pressure, and the engine can be run noncondensing.

The tubes of this type of condenser, being quite small, are easily stopped up and considerable trouble may arise from this source, especially when sea water is used, as it always carries more or less seaweed. A strainer of fine mesh is sometimes inserted between the foot valve and the pump, in which case the pump is protected as well as the condenser. This strainer requires cleaning often to insure a proper supply of water.

After a time the steam side of the tubes of a condenser becomes coated with grease carried over with the exhaust steam, and when thickly coated the efficiency of the condenser is greatly impaired, as grease is a nonconductor of heat.

Boiling Out

A process called "boiling out" is effective when animal or vegetable oils are used and is accomplished by fitting the condenser with a soda cock, so that caustic soda can be injected into the steam space upon the grease-covered tubes. The alkali coming in contact with the grease changes it into soap, and in this condition it is easily washed out through the drain cock. This operation is as follows: The steam side of the condenser is filled with water up to and covering the top row of tubes, the alkali is introduced and live steam is let into the condenser, discharging into the water until the water boils. The amount of alkali to be used will need to be determined by experiment, but in any case enough must be used to make the water strongly alkali.

Animal and vegetable oils have been practically superseded by mineral oils for use in the steam cylinder except as they are compounded with mineral oils. Caustic soda has no effect on the grease deposited from mineral oils, therefore the boiling-out process cannot be used. There is no other way but to clean them by hand and to do this the tubes must be removed. It is a difficult and disagreeable task to clean a large surface condenser, as the grease is heavy and sticky, resembling tar. If possible, the grease should be kept out of a condenser and this can be accomplished by installing a grease extractor between the engines and condenser. It should be installed as a matter of economy, making the condenser more efficient and reducing the cost of cleaning and repairs.

Condenser Tubes

Condenser tubes are subjected to great

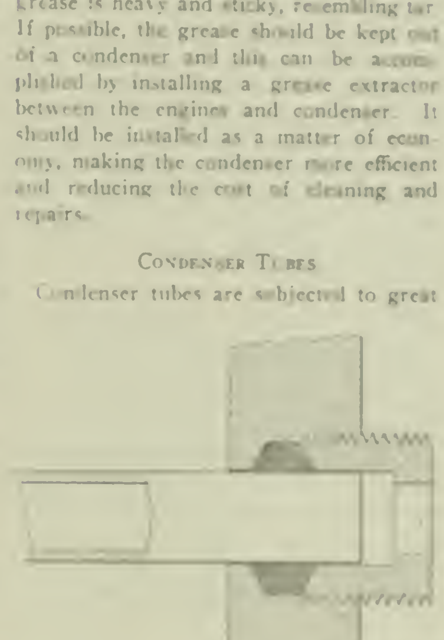


Fig. 2. Special Tube End Construction

extremes of expansion and contraction. In Fig. 2 is shown a method of construction which allows the tube end movement and yet will not allow the tube to crawl out of the packing. This is done by counterboring the screw gland that screws down on the packing which consists of cotton lamp wicking, cotton tape or a rubber ring.

The sources of water leaks in a surface condenser consist of split tubes and defective packing at the tube ends. To test for this leakage, remove the cover plate on the end of the condenser and then by filling the steam space with water, any leaks will be indicated and should be marked for repairs. If temporary repairs must be made, white-pine plugs can be driven into each end of the tube where the tube is split and any packing that is leaking should be replaced with new.

Air leaks will be indicated by a falling vacuum, other conditions being normal, and will be found at the packing on the exhaust-valve stems and piston rods, although it may be in many other places. A lighted candle held to the joint is the best test and where there is a leak the flame will be drawn inwardly. The joints where the tightening of the bolts will not remedy the trouble, the leak may be stopped by plastering over with putty or by driving in hardwood wedges.

When the condensation is returned to the boiler it is very important that the temperature be as high as it is possible to get it, therefore the condenser should be fitted with a thermometer. Under the best conditions it is possible to secure only a certain degree of vacuum, and when more water is circulated than necessary to secure the best vacuum, there is a waste from two directions, i.e., the temperature of feed water is lowered and the circulating pump is using more steam than necessary. Just enough circulating water should be pumped to give the required vacuum, and this will give the highest attainable temperature to the feed water. A reliable thermometer will help the careful engineer to save tons of coal.

Operation of Induced Draft and Suction Producers

By Frank P. [illegible]

It is in the nature of the gas producer, possibly in a wider ratio with reference to plant or unit size than with the steam boiler, that the liability to serious accident increases with the extent of the plant. In the very small producer it may be truly said that there is practically no danger, and no liability to serious destruction of the apparatus from explosions which may occur within its parts. This is not due to any difference whatever in the character or inflammability of the gas, but rather to the relative physical strength of vessels containing gas.

Without exception, we may assume that trained engineers possess a sufficient knowledge, if they only stop and think, to avoid the accumulation of air and gas where the mixture is at all likely to become ignited. The greater the volume of such a mixture, the greater becomes the danger from its ignition and the wreckage it can produce.

There come, sometimes, trying times in the operation of large boiler installations for which no particular person or persons can be held responsible. Invariably an expert boiler attendant is at such times made to face these critical conditions, with readiness to do the right thing at the right moment. So there come, also trying times in the operation of gas-generating apparatus of whatever character and just as with the boiler, the seriousness of the circumstances may be such that a cool head may be the only means of salvation.

Danger of Explosion

The one primary idea to be borne in mind by the operator of any gas-generating apparatus is that whenever and wherever air is admitted into a volume of gas, danger of explosion exists. To illustrate how this point is guarded and feared in the handling of large volumes of richer gases, let me recall an incident of which I was a witness in a large gas works. A single exhauster, direct driven by a steam engine, handled the gas generated by a battery of thirty retort coke ovens of the Solvay type—possibly 130,000 cubic feet per hour. This exhauster delivered a portion of the washed gas back to the burners that heated the system of ovens and through an 8-inch main pipe. The remainder of the gas was delivered into a system of pipes that supplied steel furnaces. On the vacuum side of the exhauster (between it and the ovens) were arranged in series four condensing chambers having a combined volume capacity of probably 7000 cubic feet.

The first warning that something had gone wrong came in the form of an explosion in the 8-inch gas main delivering to the oven burners. The blanked end of this main and a tee at that point were disrupted and blown away. Immediately following this came a series of explosions resembling heavy cannon discharges, occurring at intervals of a few seconds and continuing, it seemed to me, several minutes. The last water seal between the exhauster and the ovens was located near the ovens. Each ignition of the gas burned all that had accumulated since the last explosion back to this seal, and an automatic rapid-fire artillery performance was set up as long as the exhauster continued to deliver an explosive mixture.

Now, you say, why didn't they shut down the exhauster?

With the first report every man sought his post, of course, and the shutting down of the exhauster was the first move the operating engineer would have made, with the permission of the man in charge, but the man in charge had other ideas. There is no doubt that he was doing some rapid-fire thinking, and there were other considerations than the mere stopping of a noise after the one small damage had been done.

The source of trouble would be much more readily located with the exhauster in motion, to say nothing of the serious liability of the combustion to reach backward through broken seals with the lessening of pressures in front and of vacuum behind the exhauster; and, furthermore, depending upon the location of this leakage of air into the system might have been the demolishment of the whole condensing system.

While the shutting down of an exhauster without due warning to everybody concerned meant serious delay and damage to operation, obviously this thing must end somewhere, and the man on whom the burden rested was thinking and acting in sharp blue streaks, though it may take a long time to tell the story. The exhauster was shut down in the end, and no direct cause was located in actual evidence for the derangement, yet there was no mystery about it. Either a seal had been broken admitting air, or one of the operatives had made and corrected an error—taken off and had replaced a cap or plug in one of the many inspection openings.

This incident only serves to show how exciting a situation may become, and how essential to safety and a minimum of property loss is a cool head in the handling of the richer gases, and yet there do not arise any such emergencies that may not be paralleled in frequency and gravity by serious boiler-plant situations. Indeed, in the same plant I can recall that our most frequent and serious anxieties were for our boilers, which were heated by the spent gases from the oven-heating systems. The water supply was not reliable at all times, nor were the dampers controlling or shunting the flue gases, and since the temperatures were high and steam plentiful this became a rather serious combination.

What a Careless Attendant Did

Another incident in producer operation: The attendant had prepared a suction producer for starting up. The producer was of 300 horsepower capacity and the space beneath the grates was of considerable volume, possibly 40 or 50 cubic feet. He had blasted the bed of new fuel to the point of making good producer gas and everything was in prime condition for a prompt start on the engine operator's signal for gas. The two men, working together, understood each other perfectly and all the conditions and liabilities that were involved, but the producer attendant had become a little careless. So, when the signal was given from the engine room, he shut off the blower, threw over the three-way valve and folded his arms, anticipating an immediate start of the engine. After a dozen seconds this start had not been made. Now a dozen seconds at a time like this are sufficient to make a gas-producer operator thoughtful, and the attendant suddenly remembered that his ash doors were all clamped up tightly, and that if just a few more seconds elapsed before the starting of the engine, there would be trouble. Not serious trouble, the producer not destroyed, nobody killed, but probably a door-bar snapped or a producer lining loosened up.

Of course, the first thought would be to open a door *quickly*, but self-preservation being the first law, etc., a cool-headed operator will never attempt to open a door at a time like this. If the engine should start just at the time of laying hold of this door, it may mean, at the worst, a broken arm or leg, and the sensible thing to do is to leave the producer alone and find out what may be wrong at the other end.

The engine man had thought he was all ready to start, but an auxiliary cam would not shift, or a battery switch had been forgotten, or even worse, as a result of which it might be three or four minutes more yet. What then? Go back and open the ash doors and let the producer stand in communication with the engine until ready to start? If the producer is in a room communicating with others where the polluted atmosphere may reach a sensitive constitution, no.

Supposing the producer to be in a fireproof room of only the needed dimensions, let us assume the extreme possibility. This room might become pretty well filled with gas in a few minutes, and when the engine starts up, not only the producer may sustain a shock, but the whole room as well. This last has not occurred, to the writer's knowledge, but a cool head and a careful man will take even such remote contingencies as this into consideration, and act accordingly.

Well, what would be the right thing to do at such a moment, throw back the three-way valve into communication with the purge pipe? Not just yet. *Be sure to open an ash door first; then throw the three-way valve,* because an ignition of the gas below the grates will occur three times out of five under such circumstances, and the one always safe and sure thing to do is to unfasten, or partially open, a base door *just before the blower is stopped.*

And why will these base explosions occur? Why, simply because when the three-way valve is thrown into engine position, the only exit for the gas distilled from the hot fuel is backward, beneath the grate and through the draft conduit. Live fire is resting on the grate bars, and when the engine starts, or the reversal of the three-way valve gives the less active draft by the vent pipe, air is drawn in, partly displacing the gas beneath the grates. When sufficient gas has been displaced by air the remaining mixture ignites from the live fire through which it cannot avoid passing. This contingency is not provided for by the producer builders, because it is not considered sufficiently serious as a danger; nevertheless, a careful attendant will always avoid it.

Flame Arresters Desirable for Test Cocks

In large producers test cocks that are to be lighted, when located anywhere else than on the fuel chambers, should be provided in all cases with gauze flame arresters. In this connection, it is the writer's contention that every operator of a gas producer should have the common judgment, or the training, to enable him to operate his plant right along without resorting to test flames at any point other than on his fuel chamber or vent pipe. This is the one safe means of handling producers without incurring the dangers due to this practice.

When a plant is once put in service and is reasonably free from leakage, the gas left in the vessels at shutting down is better than any new gas which may be made to displace it, so why not start up on it? Here, too, there is one precaution to be taken. New coke fillings in gas scrubbers will absorb considerable volumes of the gas, and if this absorption takes place during a considerable period of layover, even though the engine may have been operated for a short time, and if there is even a small leakage, a considerable volume of air will be drawn in, and there is danger in the application of a test flame. An operator, knowing this, will take no chances, but will blow over a new supply of gas to his engine for the first few times starting up. But he will not need to apply a test flame at the engine. He will have someone to turn his blower for him, if it be a small plant, for these first few starts, and he will know from what he has been told, or from common horse sense, how long will be required to pass this new supply of gas over to the engine. It is evident that the liability to ignition of an explosive mixture is less through the inlet-valve port of an engine normally operating or starting than by the application of a flame to an open jet. The writer has in mind one plant which has been in operation for more than a year. No test flame has ever been applied at the engine; there is no provision for it, and none is sought, the attendant having been instructed to get along without such means.

An incident is recalled of a suction generator of some 200 horsepower capacity under starting blast in which from one poke hole inflammable gas was issuing, while from a poke hole on the opposite side of the fuel bed apparently pure air issued. This is a rare occurrence, of course, but in no way unaccountable. An old bed, after some days' layover, is not as thoroughly cleaned as it should be, because to do so involves the loss of all the fire, and to start a new fire outright takes longer then to blast in the old fire than remains. One side of the bed contains a mass of old clinker which is to be removed as soon as the conditions will permit. It seems quite likely that an improper handling or understanding of this extreme case might cause an explosion.

Finally, a little diligence on the part of the plant operator to acquaint himself with the few simple laws that make for the safety of operation will be worth much, as well as all the talk he can absorb, yet it is unfair to expect him to get all the little details of precaution instilled into his methods by running the liability to danger that so many writers and authorities allow to go undirected in their discussions. He will soon learn, in practice, that in the operation of suction and induced draft producers the admission of a small volume of air into the system between the producer fire and the source of draft is not a serious matter, and no chance or risk at all is sustained. But this volume must be small relative to the volume of gas passing, else serious disturbance, at least, may occur. Herein lies justification for advising the use of a tamping bar with a rod on the bed quite sparingly in the operation of a small suction producer.

A 1-inch opening in the top of the bed chamber of a 100-horsepower producer running with a 4-inch (water) vacuum will do no damage; it will scarcely be appreciable for the length of time required to bar that portion of the fire or inspect the bed. But the same opening into a 10-horsepower producer fuel chamber working at the same rate is almost sufficient to cause an explosion and, if ignited, will at least shut down the engine being supplied.

We are arriving at the intensely practical stage of producer work which demands attention to details, and as time begins to see results we are and have been prone to neglect some of these details that are important.

Improved Pressure Oiling System

By William [illegible]

The improved pressure oiling system herein illustrated and described will be found a very handy equipment in the dynamo plant, office building, hotel or factory engine room. It can be constructed and erected at a very moderate cost and will be found highly economical in the use of oil, as all of the waste oil can be returned, filtered and used again, so long as the oil contains lubricating qualities. In a plant where numerous units are to be oiled and an oil-return and filtering system is not in operation, considerable oil is lost, thus adding to the expense of operation; but where a plant is equipped with a system such as described in this article, the oiling expense should be reduced nearly 50 per cent., not to mention the saving of the labor necessary to do the oiling by hand.

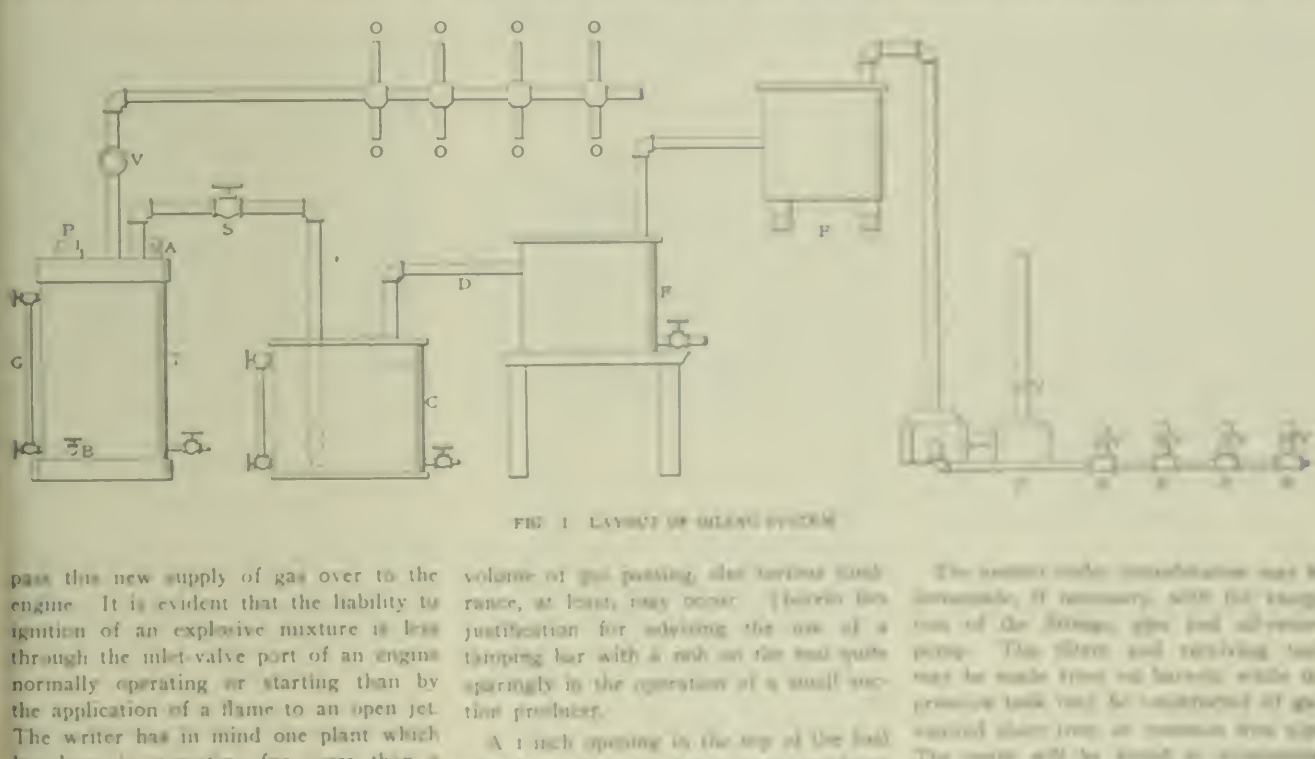


FIG. 1. LAYOUT OF OILING SYSTEM

The system under consideration may be homemade, if necessary, with the exception of the fittings, pipe and oil-return pump. The filters and receiving tank may be made from oil barrels, while the pressure tank may be constructed of galvanized sheet iron or common iron pipe. The outfit will be found so economical, however, that it will be a good investment to have the equipment properly installed and arranged to handle all of the returned oil from the various units.

Fig. 1 illustrates the entire system. The oil-return pump P draws the waste oil from the different units through the oil-return pipes R R R R and then discharges the waste oil into the receiving tank T, where the water is rapidly separated from the oil. The oil will flow from T into the main filter G, then through the pipe D into the receiving tank C, where a pressure pump [illegible]. The oil is taken from the receiving or storage tank F either by a pump or water siphon and discharged into the pressure tank *T*, from whence it is fed to the various units, under a pressure equal to that of the water, if water is used, or, if a pump is used, under any desired pressure which can be maintained on the oil in the tank *T*. The oil flows from *T* through the various outlets shown at *O*, which connect with the oil cups or bearings of the dynamos, engines, or whatever bearing is to be lubricated, the amount of oil flowing into each cup or bearing being controlled by means of a valve placed conveniently over each bearing or cup. In the drawings the location of the valves is indicated by *V*.

The size of pipe to employ in erecting this system will depend on the amount of oil required for each bearing. The main or trunk lines may be any required size from 3/8 inch upward, but the branch

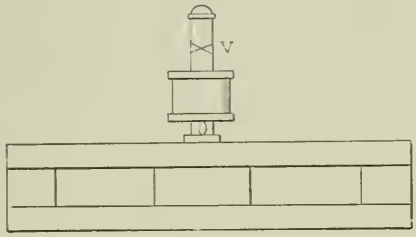


FIG. 2

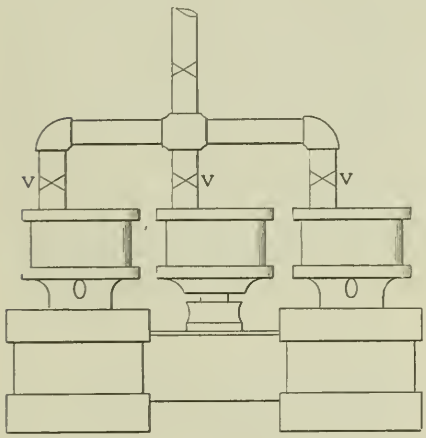


FIG. 3

lines leading into the bearings or cups may be 1/8 inch, and if made of brass will present a neat appearance.

Fig. 2 shows how the pipe carrying oil is attached to the crosshead-slide oil cup, and Fig. 3 is an end view of Fig. 2 and shows plainly the piping for slides and crosshead wipers. Fig. 4 shows oiling connections for main bearings and the crank-pin wiper; Fig. 5 illustrates a sectional view of the "dry" filter, and Fig. 6 is a sectional view of the "wet," or water filter, either of which may be used in this system of oiling. If the pressure on this system is maintained by means of water, the tank *T* should be large enough to contain sufficient oil for a continuous run of, say, from 36 to 60 hours; but if a pump is used to maintain the pressure, the tank *T* need not be so large because the oil supply can be constantly maintained.

The pressure to operate this system will depend in a great measure on the distance it is located from the engine room and the number of bends through which the oil must flow. In actual practice 30 pounds pressure is found sufficient to do the work at this plant, although the system is located more than 50 feet from the engine room.

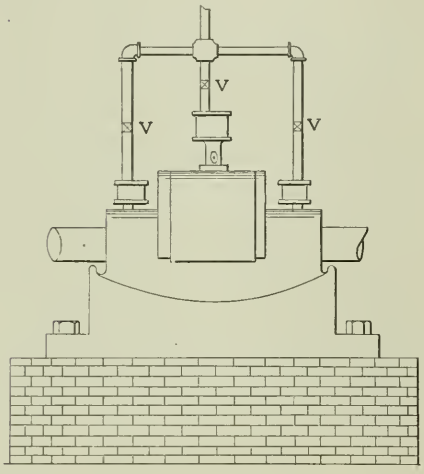


FIG. 4

To operate the system with water, assuming that there is no oil in *T*, fill *T* with water and when water appears at the air vent at *A* shut the water off and close *A*. Open valve *B* and allow the water to run off to the sewer, then open valve *S*, which connects the oil supply in tank *C* with the pressure tank *T*; the oil will be siphoned into *T*, and as the water lowers or runs off, oil will take its place and the amount of oil which has flown into *T* will be indicated by the gage glass *G*. When sufficient oil is in *T*, shut *S* and *B* and open the water valve, and whatever pressure is exerted by the water will be impressed on the lower surface of the oil and tend to force the oil out through the valve *V*. By opening *V*, the oil will flow out through the main line and connections, as indicated at *O*.

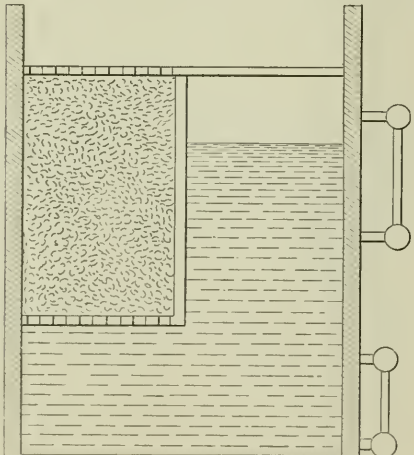


FIG. 5. DRY FILTER

To stop the system from feeding oil shut *V* and the water valve and allow the oil-return pump to run until all of the waste oil is pumped back into *F'*. After shutting down this oiling system it will not be necessary to disturb the setting of the valves located above the oil cups; therefore, on restarting the system adjustment of those valves will not be necessary. By doing this considerable time and labor are saved in starting up. Occasionally the tank *T* should be cleaned out. After allowing all of the oil to flow out of *T*, open the washing-out plug *P* and the valve *B* and allow all of the dirty water and sediment to flow off to the sewer; by playing a strong stream of water through *P* it will facilitate matters considerably.

In fitting up the system it is a good plan to have the oil pipes enter the top of the cups loosely and connected to one side of each cup, as shown in the drawings, as this permits of lifting out the pipes from the cups and of hand oiling, should anything occur to prevent the system from operating. Also, the oil cups may be cleaned or new glasses inserted without having to unscrew the piping.

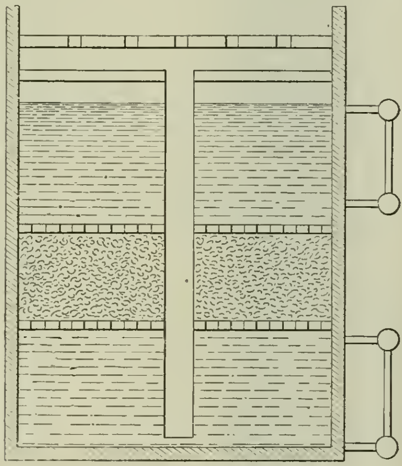


FIG. 6. WET FILTER

Protection of Underground Pipes

C. H. Staten spoke before the Modern Science Club, of Brooklyn, N. Y., Tuesday evening, December 22, on "Insulating and Protecting Underground Steam and Hot Water Pipes." He dwelt at length on the history of the development of central-station heating plants and traced the poor results and failures, which marked the earlier ventures in this direction, to lack of proper protection and insulation.

With a system designed in accord with the best practice of the present time, Mr. Staten said, heating could be done from central stations at a cost not exceeding 30 cents per square foot of radiating surface for seven months.

The Compression Refrigerating System

By F. E. Matthews

What are the general functions of a refrigerating system as a whole and of its different parts? Why does the back pressure rise when the machine is shut down? What is "frosting back"? Is it a waste?

The function of a refrigerating means, whether it be an absorption or a compression refrigerating machine, or simply a bunker full of ice, is to provide a heat-absorbing medium which, after it has absorbed its fill of heat from the products that it is desired to cool in the cold-storage rooms, or other places to be refrigerated (which for simplicity we will hereafter call coolers), may be removed from such coolers so that the heat absorbed may also be removed. After its removal from the "coolers" this medium may either be divested of its heat, after which it may be again returned to the coolers and allowed to absorb more heat, as in the case of ammonia or brine circulated through coolers, or it may be thrown away and a new supply introduced, as in the case of cooling by ice.

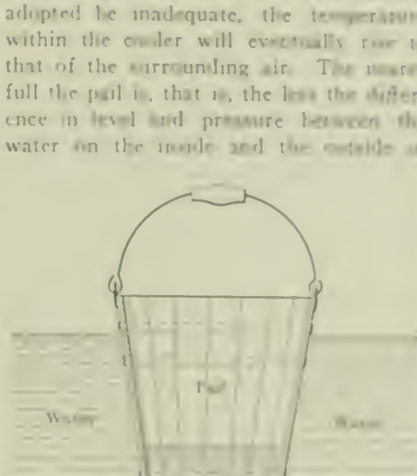
A pound of liquid ammonia in evaporating at 0 degree Fahrenheit has a heat-absorbing capacity of 555.5 British thermal units (B.t.u.) of heat, a B.t.u. being the amount of heat required to raise the temperature of a pound of water 1 degree Fahrenheit. Vapors of ammonia are easily liquefiable, so that in consideration of its high commercial value it becomes economy to use this medium over and over again.

A pound of ice in melting has a heat-absorbing capacity of 144 B.t.u. While the water from the melting ice might readily be frozen again by mechanical means and might accordingly be used over and over again, as is the case with ammonia, its low commercial value when coupled with the fact that it can often be obtained already in the naturally frozen state, to say nothing of such factors as contamination by products in the coolers and transportation to a place where it might be frozen, makes it eminently impracticable even to consider using this medium but once.

An apt though rather old illustration of the action of a refrigerating machine, or in fact any heat absorbing means, is that of the absorption of water by a sponge. The tendency of the sponge to absorb water after one charge has been squeezed out of it is not altogether unlike that of anhydrous ammonia and other liquefiable refrigerating media to absorb heat after the former charge has been squeezed out. The two media, water and heat, may both be considered passive, and simply acting under the influence of the sponge and the refrigerating medium.

A containing vessel, such as a more or less leaky pail, partially sunk in a body of water, as roughly indicated in the accompanying sketch, may be shown to be similar to a cold-storage compartment surrounded by an atmosphere higher in temperature than that within. Since the level of the water in the pail is lower than that on the outside, and since the pail is more or less leaky, a certain amount of water will leak into the pail from the outside. If none of the water is removed or if the process of removal proceeds less rapidly than the infiltration, the pail will eventually fill up to the level of the water on the outside.

Carrying out the comparison in the case of a cooler, the higher temperature on the outside tends to cause an infiltration of heat through the more or less leaky cooler walls. If no steps are taken to remove this heat or if the means adopted be inadequate, the temperature within the cooler will eventually rise to that of the surrounding air. The nearer full the pail is, that is, the less the difference in level and pressure between the water on the inside and the outside of



ILLUSTRATING A COLD-STORAGE PRINCIPLE

the pail, the less will be the water leakage. The warmer the air in the cooler, that is, the less the difference in temperature between the atmosphere on the inside and outside of the cooler the less will be the heat leakage. Furthermore, in the process of "bailing out," the lower the water level in the pail, making it necessary to lift it through a greater distance, the more work will be required. Similarly, the lower the temperature in the cooler the more energy must be expended to expel the heat on account of the increased range of temperature through which it must be raised.

In brief, a compression refrigerating machine consists of the necessary mechanical means of circulating a heat absorbing medium through the cooler and of removing from this medium the heat which it absorbs en route. The heat absorbed in the cooler passes from the atmosphere, products, etc., by virtue of the fact that the refrigerating medium is lower in temperature. This same heat must be similarly removed from the refrigerating medium by introducing a secondary cooling medium materially lower in temperature. Since there is no secondary cooling medium of a lower temperature available than the refrigerating medium, even at the temperature at which it returns from the cooler after having absorbed large quantities of heat, it becomes necessary to raise the temperature of the refrigerating medium enough so that it can be cooled. This is effected in the case of the absorption system by the direct application of heat in the "generator" and in the compression system by the performance of work in a suitable form of "compressor."

Carrying out the comparison of the sponge and the water in the pail, it is evident that the water after being absorbed by the sponge must be raised to a higher level before it can be made to flow away to the surrounding water at the higher level.

More specifically, a compression refrigerating system consists of a set of pipes, or other containing vessel, in the cooler in which the refrigerating medium absorbs heat at a low temperature from the products to be refrigerated and a second set of pipes, or other containing vessel, outside of the cooler in which the refrigerating medium gives up its heat to a secondary cooling medium, such as water or air at a comparatively high temperature, and a compressor for raising the temperature of the refrigerating medium sufficiently to enable it to give up its heat to the secondary cooling medium.

In the operation of such a system almost any gaseous working medium might be employed. In practice, however, the list is limited to only such gases as are capable of being liquefied under ordinary natural temperatures and not too high mechanically produced pressures. Judging from the relative number of commercial installations employing the different media one may assume that under the average conditions anhydrous ammonia comes more nearly to fulfilling all of the requirements of an ideal working medium than any other. This medium will be considered throughout the remainder of this article.

The pipes located in the cooler, through the walls of which the ammonia absorbs heat from the objects to be refrigerated are commonly called "expansion" coils and those located outside the cooler through the walls of which the ammonia gives up its heat, condenser coils. The ammonia, previously liquefied in the condenser under a pressure of from [illegible] to [illegible] pounds, according to the temperature of the cooling water, is conveyed from it to the "receiver," which consists of an approximately cylindrical containing vessel which acts as a storage tank in which the [illegible] is collected and stored until it passes, as required, into the expansion coils. The flow of this high-pressure liquid into the expansion coils is regulated by "expansion" valves, which are virtually nothing more than [illegible] mechanical devices for accurately varying the opening through which the liquid ammonia must pass on its way to the expansion coils. As stated, the word "expansion" has been erroneously applied to these coils and valves because of the idea, likewise erroneous, that the liquid ammonia vaporizes or "expands" immediately the pressure is relieved, as it passes the regulating valve and enters the cooling coils. As a matter of fact, before it is possible for a pound of ammonia to change from the liquid to the gaseous state it must be supplied with about 555.5 B.t.u. of heat.* If this amount of heat were absorbed at the expansion valve, which its immediate vaporization assumes, there would be no further heat-absorbing capacity in the ammonia, and its introduction into the "expansion" coils would be useless.

In the expansion coils the liquid ammonia, which has the peculiar property of boiling at a very low temperature, 28.5 degrees below Fahrenheit zero under atmospheric pressure, absorbs heat from the surrounding atmosphere, boils and vaporizes in much the same way as water, absorbs heat from the hot furnace gases, boils and vaporizes in the similarly constructed pipe coils of an ordinary water-tube boiler.

Having evaporated to a dry gas, the ammonia vapor leaves the expansion coils and enters a "return" header which conveys it back to the suction side of the compressor. This return line is usually fitted with a "scale trap" constructed quite similarly to some of the more simple types of steam separator. The function of this trap is to prevent any scale from the inside of the pipes, or other foreign substances, from entering and damaging the compressor.

It often happens that the expansion valves are not properly adjusted, or that the expansion coils are so arranged that, like poorly designed boilers, there is an abnormal entrainment and considerable liquid ammonia is carried back with the returning vapor. In this case the scale separator may act as a veritable separator and temporarily interrupt the passage of the entrained liquid ammonia to the machine. On account of the difficulty of returning any liquid so trapped to the expansion coils the scale traps are of little value as separators except as means of keeping occasional large volumes of liquid from returning to the compressor. Once having become filled with liquid ammonia they remain in this condition for some time. Since in order to evaporate, the ammonia must have heat, and since the temperature of the boiling ammonia corresponding to the back pressure usually carried in refrigerating and ice-making work is sufficiently low to produce ice on the outside of the traps, piping, etc., these parts soon become heavily insulated with ice which further materially reduces the amount of heat that can be absorbed, and the entrained liquid enters the compressor with considerable capacity for absorbing heat. If this amount is abnormal it may cause the compressor to pound for the same obvious reason that a steam engine pounds when it receives a quantity of entrained water in the steam. When quantities of liquid ammonia sufficient to cause the compressor to pound enter the compressor cylinder, it is usually evidenced by the abnormal cooling effect on the compressor walls, or more noticeably that of the piston rods which, through their contraction, as well as that of the packing and stuffing boxes, may even allow the ammonia to leak by the packing. The evaporation of this entrained liquid ammonia in the compressor cylinder, or that introduced directly into the cylinder through an expansion valve designed for that purpose, refrigerates the gas as well as the compressor parts and tends to prevent superheating of the gas during compression. The evaporation of the liquid ammonia remaining in the expansion coils when the compressor is shut down causes the rise in back pressure usually so noticeable a few hours after the plant has been shut down.

The condition of the ammonia vapor as regards saturation or supersaturation may best be arrived at through thermometers inserted in mercury wells in the return and discharge lines near the compressor. Tables of "properties of saturated ammonia" indicate at a glance the temperatures at which the vapors should return to the machine under different conditions of back pressure and assumed saturation.

If the last trace of the liquid ammonia is evaporated before the vapors reach the compressor, and the return pipes are uninsulated, there is likely to be considerable superheating, i.e., the temperature of the vapor entering the compressor is likely to be several degrees higher than that shown by the tables to correspond to the back pressure carried. This condition results in a considerable loss of efficiency and should not be allowed to continue.

While difference in opinion regarding the amount of unevaporated liquid the return ammonia gas should contain in order to give maximum efficiency has given rise to two distinct systems, viz., the "wet" and the "dry" compression, a discussion of the relative merits of the two systems would be too far-reaching to warrant its introduction here. The best general rule regarding the wet or dry operation of compressors is to follow the instructions of the respective builders as closely as possible.

In the absence of more accurate means, such as thermometers, for determining the temperature of the returning ammonia gas, the "frost line" has been forced into service to give at least some slight indication of such temperatures. The simple formation of frost on the outside of a pipe containing cold ammonia gas, or, in fact, any other cold medium, indicates nothing more nor less than that the heat from the outside atmosphere is absorbed with sufficient rapidity to reduce the temperature of the pipe and nearby air to at least 32 degrees Fahrenheit, under which condition atmospheric moisture is, first, precipitated, just as rain or dew is formed when moisture-ladened air becomes cooled by heat radiation to air at a lower temperature or contact with other colder objects and, second, is frozen, just as dew is frozen to form frost when its temperature is reduced to 32 degrees Fahrenheit.

Since the formation of frost on an ammonia pipe is influenced by the room temperature, it cannot be an ideal means of judging temperature. Where considerable entrained liquid ammonia is present to evaporate and absorb heat rapidly, the general appearance of the frost formed, or the way one's wet finger sticks to the pipe, may give some slight indication of the action taking place inside. Where low temperatures are carried the return gas may be so far below 32 degrees Fahrenheit that the same rise in temperature that would ordinarily completely change the appearance of the return line if it took place at a higher temperature would not affect the frosted line at all, as far as outward appearances are concerned.

It may be generally asserted that it costs an expenditure of energy to remove heat from any substance at any temperature to another substance at a higher temperature. If, then, a certain amount of the heat in the returning ammonia gas has its origin in the engine room, where its absorption is manifested by frost in the return line to the compressor, it is evident that the frosting of the line costs energy to drive the compressor and that this energy costs coal, labor and, finally, money. The return lines to compressors should be effectively insulated to reduce this loss. Nothing is more erroneous than the argument that because the returning gas has passed the rooms that it is sent out to cool, there will be no loss by heat absorption through exposed, uncovered cold pipes. The actual cost of producing a B.t.u. of refrigeration can be computed for any refrigerating plant by simply dividing the total operating cost of that plant by the number of B.t.u. of refrigeration produced. The useless expenditure

*In practice not all of the 555.5 B.t.u. of heat-absorbing capacity, or *negative* heat of a pound of anhydrous ammonia available at 0 degrees Fahrenheit can be utilized for useful cooling work. This on account of the cooling work which must first be expended on the ammonia itself in order to reduce its temperature from that of the condenser to that of the cooler. This may be illustrated by a similar process in which water is the medium in question.

The amount of heat that must be abstracted from one pound of water at 32 degrees Fahrenheit, in order to freeze it, is 144 B.t.u. On this basis a ton of ice would represent 288,000 B.t.u. of negative heat. In practice the expenditure of this amount of cooling will not freeze a ton of water because it must first be cooled from its natural temperature or, in crystal-ice systems, from the temperature of the distilling tank down to 32 degrees Fahrenheit. This involves a further expenditure of 1 B.t.u. pound per degree Fahrenheit cooled through.

of a single unit of refrigeration is just as prodigal as the throwing away of an equivalent amount of money. The fact that this and similar losses are allowed to continue in some of the largest refrigerating and ice-making plants in the country is poor excuse for their existence in others.

Catechism of Electricity

888. *How should the motor be wired in circuit?*

In accordance with the diagram of connections accompanying the machine, or if such a diagram is not furnished, in accordance with the general arrangement shown respectively in Figs. 276, 277 and 278 for shunt-, series- and compound-wound motors.

889. *For which direction of rotation is a motor usually arranged when leaving the factory?*

Unless otherwise specified, motors are usually tested and connected for a left-hand direction of rotation; that is, when facing the machine at the commutator end the top of the armature will turn toward the left. An arrow indicating the proper direction of rotation is generally painted on the machine at the commutator end.

890. *What preliminaries should be observed before starting up a motor for the first time?*

Slowly turn the armature over a few times by hand to make sure that it does not rub or bind, and is perfectly free to revolve. See that the machine throughout is free from dirt or foreign matter, and is properly lined up so that the belt runs in the middle of the pulley. Check up the connections of the motor and its starting rheostat with the wiring diagram for this particular case. Fill the bearings with high-grade dynamo oil until the oil gages show that the proper amount of oil has been introduced. Make sure that the

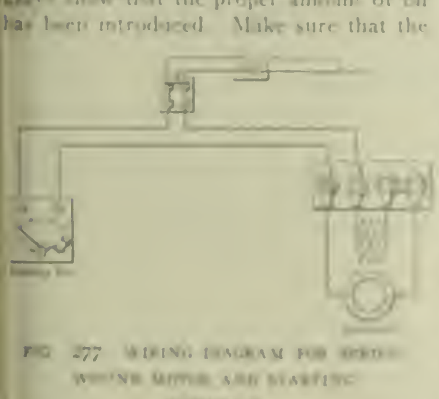


FIG. 277. WIRING DIAGRAM FOR SERIES-WOUND MOTOR AND STARTING RHEOSTAT

oil rings are properly carrying the oil over the bearing surfaces when the armature is turned.

The brushes should be given the proper pressure on the commutator, about 2 pounds per square inch of contact surface. The following table will be found useful in determining the approximate pressure of the brushes on the commutator for various sizes of brushes:

For brushes 1 inch or less wide, about 1 pound.
For brushes 1¼ inches wide, about [illegible] pounds.
For brushes 1½ inches wide, about 1½ pounds.
For brushes 1¾ inches wide, about [illegible] pounds.
For brushes 2 inches and over, [illegible] pounds.

891. *How should the pressure of the brushes on the commutator be determined?*

Use an ordinary spring-balance scale *b*, Fig. 278, placing the hook so as to raise the brush *e* perpendicularly to the commutator *a*, and then read on the scale the

FIG. 276. WIRING DIAGRAM FOR SHUNT-WOUND MOTOR AND STARTING RHEOSTAT

pull in pounds necessary just to lift the brush from the surface of the commutator. If the tension is too great, loosen the thumb screw *s* in the brush holder *c*, which will loosen the spring that presses the brush in position, and if it is too slight, tighten the thumb screw. It is necessary to have the pressure of all the brushes exactly the same.

892. *What directions should be followed in securing the proper position of the brushes on the commutator?*

Motors vary considerably in regard to the position in which their brushes must be placed for the best results. In bipolar motors or motors arranged for rotation in either direction, the position of the brushes should be midway between the pole pieces.

In multipolar machines, a punch mark is generally placed on the rocker arm and two punch marks on the bearing case. If the motor runs with a left-hand rotation, the punch mark on the rocker should be over the right-hand punch mark on the bearing case, and with a right-hand rotation over the left-hand punch mark. Reversible motors have only one punch mark on the bearing, the brushes being set centrally, and these motors should run equally well in either direction. A change in the direction of rotation of a motor from right-hand to left-hand rotation is effected by interchanging the main leads and shifting the rocker arm in clockwise direction until the punch mark on the rocker is over the right-hand punch mark on the bearing case.

893. *If there are no punch marks, how should the brushes be placed?*

The brushes should be placed midway between the centers of the pole faces, allowing for a certain lag previously explained to be necessary, which varies from ¼ inch to an inch or more, depending upon the size of the motor.

In bipolar machines there are always two studs or sets of brushes and these must be placed exactly 180 degrees apart. In multipolar machines there are usually as many sets of brushes as there are pole pieces. By a certain connection of the armature winding the number of sets of brushes may be reduced to two and these in a four-pole motor should be set 90 degrees apart, in a six-pole motor 60 degrees apart, in an eight-pole motor 45 degrees apart, in a ten-pole motor 36 degrees apart, and in a twelve-pole motor 30 degrees apart.

894. *How should the motor be started for the first time?*

Throw off the belt, close the circuit breaker, if there is one, and then close the main switch, having first made sure that the starting rheostat handle is in the "off" position; then start the motor by moving the rheostat handle to the first contact, hold it there a moment and slowly pass to each succeeding contact until all resistance is cut out. Give the motor time to speed up before passing from one contact to another.

Allow the motor to run without load for a time to make sure that it is in proper working order. If the machine operates at a speed higher than that on the nameplate or does not appear to be working properly, turn off the current by opening the main switch. Do not continue to run the motor without locating and remedying the trouble.

When the armature has attained full speed see that the oil rings revolve properly and that they supply the journals with oil, as otherwise the bearings will run hot. Feel all joints and connections. If any one is warmer than the others, the connection is imperfect and should be tightened.

Care should be taken that the shunt-field circuit of a motor is not opened.

FIG. 278. WIRING DIAGRAM FOR COMPOUND-WOUND MOTOR AND STARTING RHEOSTAT

If this should happen during the operation of the motor the armature will tend to run away, if lightly loaded, and burn up, if heavily loaded. If the shunt-field circuit is opened while carrying current and the motor is not operating, there is danger of the field coils being punctured. If it becomes necessary to break the field circuit it should be done slowly, allowing the arc formed to die out gradually.

Gas Engine Compression and Efficiency

A Simple Explanation of How and Why the Degree of Compression Affects the Theoretical Efficiency and the Operating Economy

BY PAUL C. PERCY

The statement that the efficiency of a gas or oil engine is increased by increasing the compression pressure of the engine is familiar to all readers who are interested in the subject. The explanation of the statement is probably not so familiar. Put concisely, it is that increasing the compression increases the temperature range of the cycle, and the thermal efficiency depends on the operating temperature range in any form of heat engine.

Just here it may be worth while to remind the reader that a gas engine, like other heat engines, yields several kinds of efficiency, namely, the theoretical cyclic efficiency, the thermodynamic efficiency, thermo-brake efficiency and the mechanical efficiency.

The theoretical cyclic efficiency is the proportion of the heat in the combustible mixture that is available for doing work as it passes through the cylinder. For example, if the charge contains 1000 heat units and 400 of these are discharged in the exhaust gases, the available heat is 1000 — 400 = 600 B.t.u. and the cyclic efficiency is

$$\frac{600}{1000} = 0.6,$$

or 60 per cent.

The thermodynamic efficiency is the proportion of the heat in the gas that is actually utilized in doing work. For example, if the charge contained 1000 heat units and the work per cycle done by the expanding gases on the piston were 233,400 foot-pounds, this would mean that

$$233,400 \div 778 = 300$$

heat units had been utilized in doing work, and the thermodynamic efficiency would be

$$\frac{300}{1000} = 0.3,$$

or 30 per cent. If it were possible to operate an engine without losing heat through the cylinder walls and piston, and if complete combustion of the gas were obtained, all of the heat in the gas except that discharged in the exhaust gases would be turned into work and the thermodynamic efficiency would be equal to the cyclic efficiency.

The thermo-brake efficiency is the proportion of heat that is turned into useful work outside the engine and the mechanical efficiency is the ratio of the useful work to the total work done on the piston. For example, if the charge contains 1000 heat units, if the work done on the piston per cycle is 233,400 foot-pounds and if the outside work done by the engine in driving machinery, shafting, etc., is 186,720 foot-pounds per cycle, the thermo-brake efficiency will be

$$\frac{186,729 \div 778}{1000} = 0.24$$

or 24 per cent. and the mechanical efficiency will be

$$\frac{186,720}{233,400} = 0.8,$$

or 80 per cent.

These efficiencies are clearly related to each other, and if one is increased or decreased it will affect one or more of the others. Increasing the cyclic efficiency will increase the thermodynamic efficiency within certain limits, which are different for different engines and different operating conditions. Increasing the thermodynamic efficiency will increase the brake efficiency provided it does not decrease the mechanical efficiency too much by enhancing the friction of the working parts. Increasing the mechanical efficiency will increase the brake efficiency provided the thermodynamic efficiency is not decreased correspondingly, and so on. Now it is the theoretical cyclic efficiency which is directly affected by the compression pressure, and increasing the compression would increase this efficiency indefinitely, as shown by the following analysis:

In the theoretical cycle, in which it is assumed that no heat is lost through the cylinder walls and piston, and that combustion is instantaneous and complete, the temperature rise due to combustion is equal to the heat units in one pound of the cylinder contents divided by the specific heat of the cylinder contents. Now, assume that the cylinder contents weigh one pound, that the admission temperature is T_a degrees, that the compression temperature is T_c degrees, that the explosion temperature is T_x degrees and that the temperature of the exhaust gases is T_e degrees, absolute. The rise of temperature due to combustion will be equal to the heat in the gas (H) divided by the specific heat (C_v) of the cylinder contents at constant volume, thus:

$$T_x - T_c = \frac{H}{C_v}.$$

Consequently, the total heat required to produce a given temperature rise $(T_x - T_c)$ will be equal to

$$H = C_v(T_x - T_c).$$

The heat in the exhaust gases is equal to the quantity that would have been required to raise their temperature from that of admission, T_a, to that at which they escape, T_e; this is equal to

$$h = C_v(T_e - T_a).$$

The theoretical cyclic efficiency is equal to

$$\frac{H-h}{H} \text{ or } 1 - \frac{h}{H},$$

and substituting the foregoing equivalents for H and h gives

$$1 - \frac{C_v(T_e - T_a)}{C_v(T_x - T_c)}$$

as the cyclic efficiency expressed in temperatures. The specific heat symbols cancel out, leaving

$$1 - \frac{T_e - T_a}{T_x - T_c} = \textit{cyclic efficiency}.$$

Since both compression and expansion are assumed to be adiabatic in the theoretical cycle, the ratio of explosion temperature to exhaust temperature is the same as the ratio of compression temperature to admission temperature, thus:

$$\frac{T_x}{T_e} = \frac{T_c}{T_a}.$$

Consequently,

$$\frac{T_e - T_a}{T_x - T_c} = \frac{T_a}{T_c},$$

and the formula for theoretical cyclic efficiency may be reduced to

$$1 - \frac{T_a}{T_c} = \textit{cyclic efficiency}.$$

The higher the compression pressure, the higher will be the compression temperature and the smaller will be the fraction

$$\frac{T_a}{T_c};$$

consequently, the higher will be the cyclic efficiency. Take, for example, two engines taking in equal quantities of gas per cycle and at the same temperature, say 700 degrees absolute. Suppose one compresses the cylinder contents from 14 pounds to 61 pounds absolute pressure per square inch; the temperature of compression will be 983 degrees absolute. Now suppose the temperature rise due to combustion were 1966 degrees; then the explosion temperature would be 1966 + 983 = 2949 degrees absolute. The *theoretical* exhaust temperature would bear the same relation to the explosion temperature that the compression temperature bears to the admission temperature; consequently the theoretical exhaust temperature would be

$$\frac{2949}{983} \times 700 = 2100$$

degrees absolute. The theoretical cyclic efficiency would be

$$1 - \frac{2100 - 700}{2949 - 983} = 0.1879,$$

or 18.79 per cent. The shorter formula gives the same result, thus:

$$1 - \frac{700}{983} = 0.1879.$$

Now suppose the other engine compressed the cylinder contents to 182 pounds absolute pressure per square inch. The compression temperature would be 1457 degrees absolute, and the theoretical cyclic efficiency would be

$$1 - \frac{700}{1457} = 0.48,$$

or 48 per cent, as compared with 18.79 per cent for the first engine.

Effect on Operating Efficiencies

It does not follow that increasing the compression will always increase the thermodynamic and thermo-brake efficiencies, however. It will do so up to a certain point, but beyond that point any further increase in compression will produce a decrease in operating fuel economy. The point at which this change occurs differs in different engines, and it is not usually the same for both indicated and brake efficiencies. During compression some heat is lost through the cylinder walls and piston, and the higher the compression the greater will be the heat loss. Moreover, higher compression means higher explosion temperature and that increases the heat loss through the walls during combustion and expansion. The loss of heat due to these several causes increases more rapidly than the thermodynamic or indicated efficiency increases; consequently, there is a point at which increasing the compression any further will cause more heat loss than the increase in cyclic efficiency will offset, and the net result will be a decrease in thermodynamic efficiency. Assume, for example, that an engine using natural gas and compressing to 130 pounds absolute shows a thermodynamic efficiency of 30 per cent. The heat taken in per indicated horsepower-hour will be 8483 B.t.u. Now suppose that increasing the compression to 140 pounds would increase the efficiency to 32 per cent if there were no additional heat losses, but that in fact the heat losses were increased 700 B.t.u. The net result would be that the engine would take in [illegible] B.t.u. per indicated horsepower-hour and the thermodynamic efficiency would be reduced from 30 to [illegible] per cent instead of being increased to 32 per cent.

Increasing the compression increases the pressures on the crankpin and main-shaft bearings and thereby increases the friction and decreases the mechanical efficiency, which tends to offset any increase in indicated efficiency. There are consequently two critical compression pressures, one beyond which the indicated or thermodynamic efficiency begins to decrease by reason of the preponderance of the increase in heat losses and one beyond which the brake efficiency begins to fall off by reason of greater loss due to added friction than gain in indicated efficiency. Usually the latter is lower than the former, though it is possible for the two to coincide.

Influence of Burnt Gases

There is another factor which undoubtedly affects the relation between compression and operating efficiency, although it does not come into the question of theoretical cyclic efficiency. That is the influence of the spent gases in the "clearance" upon the combustion of the fresh charge. It is quite customary to assume that after the expulsion stroke is completed the combustion space or "clearance" remains filled with burnt gases and that the succeeding suction stroke draws in a volume of fresh mixture equal, at the most, to the piston displacement. Except where special means are provided for scavenging, there is no reason to question the accuracy of this assumption. At any rate, it is doubtless true that these conditions are obtained in a large majority of four-stroke gas engines. In such cases, therefore, it is also true that increased compression tends to increased economy by reason of the smaller proportion of dead gases in the cylinder contents at the time of combustion. For example, if the compression ratio of an engine were three, that is, if the cylinder contents were compressed to one-third the volume which they occupied before compression began, the volume of the combustion space would be one-half as great as the volume swept out by the piston, consequently one-third of the cylinder contents would be dead gases and two-thirds fresh mixture. With a compression ratio of six, only one-sixth of the cylinder contents would be dead gases. Consequently, the rise of temperature in the latter case would be one and a quarter times the rise of temperature in the former case, and the area of the theoretical indicator diagram would, therefore, be considerably larger, although the quantity of fuel used would be the same in both cases. Assume, for instance, that the piston displacement in each case is such as to take in a cubic foot of fresh mixture, containing 100 B.t.u.; then the weight is 0.08 pound and the specific heat at constant volume is 0.25. With the compression ratio of three, the total weight of the cylinder contents, including the gases in the combustion space, would be 0.12 pound. The theoretical rise of temperature due to combustion, therefore, would be

$$\frac{100}{0.12 \times 0.25} = 3333$$

degrees Fahrenheit.

With the compression ratio of six, the total weight in the cylinder would be 0.096 pound, and the heat units the same as before. The theoretical rise of temperature, therefore, would be

$$\frac{100}{0.096 \times 0.25} = 4167$$

degrees. Assuming equal combustion efficiency for the two cases, and putting it at 30 per cent, the actual rise of temperature would be [illegible] degrees with low compression and [illegible] with high compression.

With the lower compression ratio the compression temperature would be about [illegible] degrees absolute and the pressure about [illegible] pounds. With the higher ratio, the compression temperature would be about [illegible] degrees and the pressure about [illegible] pounds. Since the relation between compression and explosion pressures is the same as that between compression and explosion temperatures, the following temperatures and pressures would be obtained:

Compression ratio	[illegible]	[illegible]
Compression pressure	[illegible]	[illegible]
Compression temperature	[illegible]	[illegible]
Explosion temperature	[illegible]	[illegible]
Explosion pressure	[illegible]	[illegible]
Release temperature	[illegible]	[illegible]
Release pressure	[illegible]	[illegible]
Mean effective pressure	[illegible]	[illegible]

The figures for temperatures and pressures are based on an initial temperature of 700 degrees absolute, initial pressure of [illegible] pounds absolute, and on [illegible] as the exponent of the compression and expansion curves. In practice, the engine with the higher compression would show better combustion efficiency because of the more intimate commingling of the molecules of gas and air and the lesser radiating surface of the combustion space, although the latter might be neutralized by the greater average temperature during combustion. However, the figures [illegible] clearly and roughly the general effect of high compression upon fuel economy. They also indicate the effect of temperature range during expansion, on which the theoretical cyclic efficiency is based; the figures would not agree exactly with those relating to cyclic efficiency because in this case the influence of the spent gases upon the explosion temperature and pressure is taken into consideration.

POWER AND THE ENGINEER

DEVOTED TO THE GENERATION AND TRANSMISSION OF POWER

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Unreasonable Specifications

It is all right, of course, for the purchaser of machinery to make rigid specifications covering the performance and durability of that machinery. It by no means follows, however, that it is fair for the buyer to specify details of design which affect the performance and durability of the machine unless he is willing to shoulder the entire responsibility. If we expected to buy a gas engine, steam engine or any other power-plant equipment, we should be quite content to dictate the maximum continuous ability under stated conditions, the economy at stated loads, the limits of speed variation and the degree of builder's responsibility for breakages or failures within a reasonable period of time. We certainly should not expect or desire to dictate the method of regulation to be employed on a gas engine, for example, the material of which the cylinders should be made, or any other such vital features, and then expect any reputable builder to assume the responsibility for the results. And if we were building gas engines we should try to content ourselves with what orders we could get from people who are willing to accept satisfactory results without trying to dictate the methods of obtaining them.

Necessity for Good Work on Suction Piping

In a condensing system the large volume of cooling water used necessitates the use of large and, frequently, long suction pipes, which are almost always placed underground. Owing to the fact that flanged cast-iron pipe, or wrought-iron pipe with threaded or flanged ends, is in large sizes more expensive than cast-iron pipe with bell-and-spigot ends, and that the expense of laying is much less in the case of the bell-and-spigot pipe, this form is most frequently chosen.

To secure tight joints in this kind of pipe requires the conscientious exercise of rare skill. Lead joints, so-called, under pressure are easily inspected and leaks readily detected, but when under "suction" inspection is difficult and uncertain. Moisture to the slightest extent on the outside of a joint is evidence of leakage and may be attended to; but the leakage of air to the inside of the pipe is not so readily seen and may be quite large before it is suspected. When suspicion is confirmed it is still difficult, in some cases nearly impossible, to locate the leak. This is particularly the case when leaks are numerous and small. Where surface condensers are used, air-adulterated circulating water causes no serious trouble or impairment of condenser efficiency. It means only a slightly higher rate of speed for the circulating pump. But with the jet and barometric systems air leakage into the injection water means a reduction in vacuum that cannot be met by accelerated pump action or wider opening of the injection valve, for a vacuum can be vitiated by a surplus of water as well as by air.

All natural water carries in solution more or less air; an amount at times equal to five per cent. of its volume. This dissolved air is at once released under the influence of the vacuum in the condenser, and when to this is added the volume of free air which comes along with the cooling water where a leaky suction obtains, the difference between the vacuum due to the temperature and the actual vacuum is marked. It frequently happens that in a jet or a barometric condenser, where a vacuum of 26½ inches is expected, only 23 or 24 inches are realized, and as an increase of cooling water does not help matters, the condenser is charged with being inefficient or too small for the work; while, as a matter of fact, the real cause of failure is the excessive amount of air which leaks into the system through poorly made joints.

Where dry-vacuum pumps are installed with barometric condensers, a high vacuum is maintained by the extra work done by the air pump, and the real effect of the surplus air entering through the joints is felt only in the extra work put on the air pump, which falls short of its calculated efficiency.

Too much care cannot be exercised in the making of joints in the pipe supplying jet or barometric condensers with water, and no grade of skill in pipe laying, particularly in the making of the joints, whether screwed, flanged or bell-and-spigot, is too high to be employed.

Effect of Superheated Steam on Valves and Fittings

Steam-piping systems, which may be termed the arteries of the power plant, in the last twenty years have received practically as much attention as any part of the power-generating installation. The adoption of the standard thread and the manufacturers' standard for flanges, the almost universal acceptance of a fixed set of dimensions for fittings and valves for 100-pound pressures, and the use of standard pipe up to the 12-inch size, with bent pipe for flexibility, have made low-pressure piping an easy problem susceptible of a very satisfactory solution. With the "Van Stone," or rolled lap, and welded flanges, the 200-pound standard valves and fittings and the corrugated gaskets, both copper and steel, the high-pressure piping problem is practically solved.

Now a new Richmond has entered the field and with the increasing use of superheated steam the problem has had to be taken up anew, this time not with the idea of heavier, stronger and better work, but with the necessity of finding a material better suited to the changed conditions of pressure and temperature.

The standard valve and fitting material, cast iron, has suffered in many cases a marked and continuous deterioration under the action of superheated steam. We have already illustrated this action in the columns of POWER and the reports of failures of valves and fittings are still coming in. Numerous explanations of this action have been offered, but are not satisfying.

To obviate this trouble manufacturers are offering valves and fittings of various qualities of cast steel which, up to the present writing, have presented no serious failures. These steel fittings have been in service approximately three years, and while it cannot be maintained that the problem is solved, at least a very satisfactory result has been obtained. At the outset the cost of this material was very high, but the increasing demand has led more manufacturers to embark in the steel-casting business and it will be only a short time before steel valves and fittings may be obtained at reasonable advance above the price of the cheaper material.

It must be added, however, that a number of manufacturers are endeavoring to discover the cause of the deterioration of cast iron by superheated steam, so far without success.

Through Bracing

A large class of engineers, who have made a study of steam boiler construction, and particularly those who have been brought up under marine-boiler influence, are predisposed to advocate the through form of bracing wherever this type can be put in. It appears that the chief advantage of this form lies in the fact that the strain produced by the pressure on the supported surface causes a direct tensile stress in the brace, while in the crowfoot form the angularity of the brace detracts from its effective holding power. It must be admitted that when considered as an abstract mechanical problem the above statement is correct, but it is doubtful if this is true under many conditions met in boiler practice. That this supposed increased value has considerable weight is evidenced in the new Massachusetts rules which allow twelve and five-tenths per cent. stress on the through form of brace above that allowed on the crowfoot form when both are of weldless-steel construction and over one and one-quarter inches in diameter, this increased allowance being reduced to six and six-tenths per cent. when the braces are one and one-quarter inches in diameter or less.

Notwithstanding the established prestige of the through form of bracing, it would appear that there are often reasons why the solid crowfoot form could be substituted for it to advantage. First, in the matter of effectiveness, through braces are often subjected to strains far in excess of those due to direct pressure loads. This is particularly true where braces are used in the steam space and where they are very long and of small diameter. In such cases the braces are often subject to serious vibration due to synchronism between the period of the brace and that of the varying pressure on the boiler heads and to the impingement of water thrown up by the liberation of steam. That the stresses caused by this vibration are severe is indicated by the fact that they are often found to be stretched after considerable use and sometimes broken near the point of connection to the heads.

When through braces are pinned to one head it is often found that the connections have been strained to such an extent that the brace is too loose to be effective. It is not practicable to space through braces closely enough together properly to distribute the load, and it is therefore necessary to stiffen the heads with angles, or channels, which add to the difficulty of making a tight connection at the brace ends. Through bracing interferes with the proper cleaning of the interior surfaces, which in most cases is a serious defect.

On account of the inadvisability of riveting the blade of a crowfoot brace to the interior of the shell immediately above the fire, in return-tubular boilers the through brace below the tubes is practically indispensable. It appears that if the assumed superior strength of the through brace is not a reality, and other considerations render the crowfoot form more advisable, it should not be discriminated against.

Clean Feed Water

Of all requirements for efficient operation in the boiler room, clean water is by no means the least. Much attention is given in the modern plant to the selection of coal adapted to the particular design of grate in use and to the specific conditions of draft existing. The coal question is, of course, important and is worthy of all the consideration it receives; still there are other factors equally important and demanding the same careful attention to detail. One of these factors is the removal of sand, leaves and other débris from the suction water of a plant. The importance of such a step is generally recognized, but is not always given careful attention. Inoperative valves, deterioration in packing and bushings, worn cylinders and boilers overloaded with sludge tell the tale and bring home to the engineer the results of such neglect in a way not to be forgotten.

Oftentimes but little provision is made of removing suspended matter from river or pond water, when water is to be used in the condenser, and even when used for boiler feed nothing is done in the way of purification until the water reaches the boiler room. It is always a good plan to strain the water at the suction inlet and, when the size of the plant will warrant the expenditure, a filter bed of sand and gravel is preferable. Screens are usually cheaper but, if properly installed, should prove more or less effective. They should be constructed and arranged so that they may be easily raised for cleaning. In raising a screen for this purpose a certain amount of debris will drop off and pass on to the next screen, so that it is better to have at least three screens in action, or even four would not be extravagant, but would allow the operator the privilege of cleaning or repairing a screen at his leisure.

Ordinarily screens are much too small for the service demanded of them. It does not take long to choke up the mesh and almost entirely shut off the supply of water. The finer the screen the sooner will this condition be reached, therefore the more need for a screen of large area. In a certain plant a screen of 1-inch mesh and 1/4-inch wire was used, and with a ratio of suction area to screen area of 1 to 13, or 1 to 7, when compared to the openings in the screen, fairly satisfactory results were obtained. Better results would have been secured with a larger screen, and at that the ratios given are considerably larger than found in common practice. After passing through the screens the water should flow to a well or basin of sufficient area to allow the small particles of dirt to settle, and in addition a screen of fine mesh over each suction pipe is advisable.

On first sight such precautions in protecting the suction inlet might appear unnecessary, but it is perfectly apparent that whatever purification is effected externally will not be necessary within the plant. Smaller expenditures for purifying apparatus in the boiler room, deterioration at a less rapid rate and the saving of considerable trouble and annoyance in the operation of the plant will result.

The management of a power station recently experienced considerable trouble from the breaking of boiler-tube cap bolts on the water-tube boilers. The bolts looked all right, but every time a boiler was cooled down and brought up to steam again a number of the bolts would break off short. The trouble became so serious that several bolts were sent to Arthur D. Little of Boston, an expert chemist, for analysis. He discovered that the bolts were made of overheated steel instead of the best quality of wrought iron, for which the company had paid and supposed it was obtaining.

Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

The Lazier Vertical Gas Engine

The accompanying engravings illustrate the latest type of vertical gas engine built by the Lazier Gas Engine Company, of Buffalo, N. Y. The engine works on the four-stroke cycle and is of the single-acting two-cylinder type, as indicated in Fig. 1, which shows an engine built for belt driving. Both of the valves work in cages set into the cylinder head, as indicated in Fig. 2, which is a vertical section of one side of the engine with the valve-actuating mechanism omitted. The valves are operated by short rocker arms and the usual cam shaft; but the latter is located along the tops of the cylinders instead of lower down on the frame, which is the more common custom. This arrangement, which is illustrated on a larger scale in Fig. 3, eliminates long push rods with the attendant disadvantages of that construction. The cam shaft is driven through spiral gears by the vertical governor shaft, the location of which is shown in Fig. 1. From the ends of the cam shaft the igniters are actuated by means of eccentrics and short push rods.

The cam shaft carries in addition to the regular operating cams a set of compression-relief cams which, when shifted into the position for starting the engine, hold the exhaust valves open during a part of the suction stroke and thereby reduce the compression; after the engine has "picked up," the compression-relief cams are thrown out of action and the engine operates with normal compression. The handle for shifting the relief cams into and out of action is shown in Fig. 3 near the left-hand end of the trough in which the cam shaft is located.

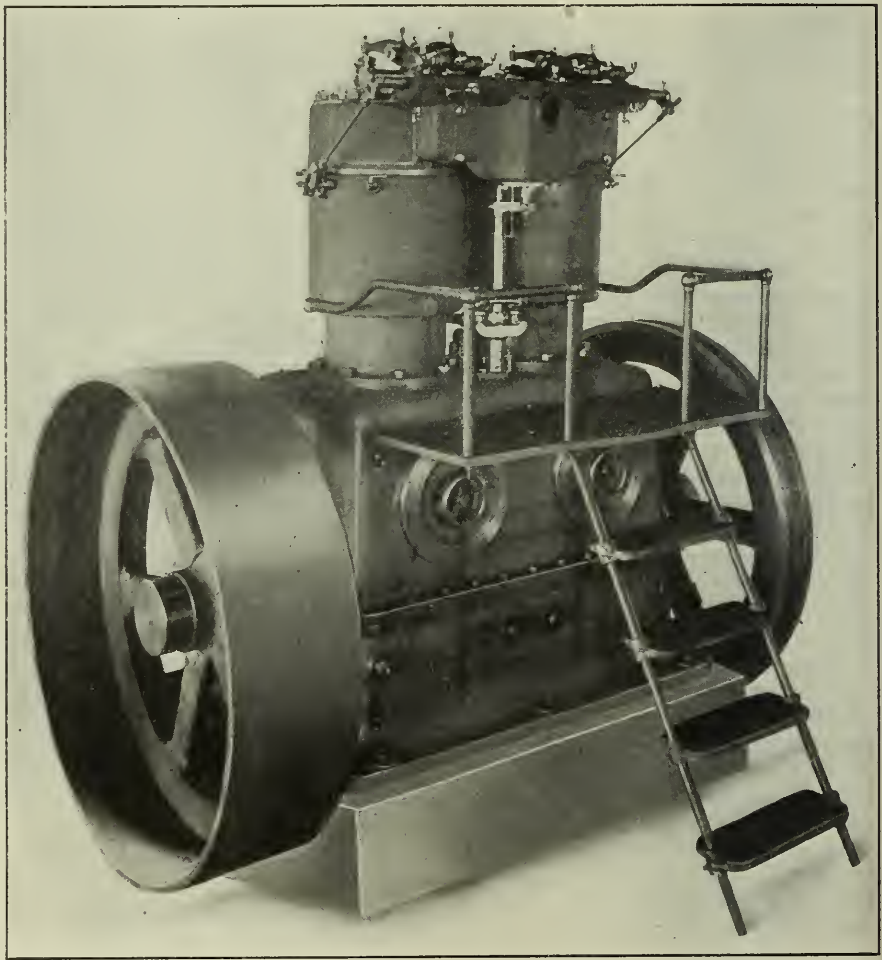


FIG. 1. LAZIER GAS ENGINE

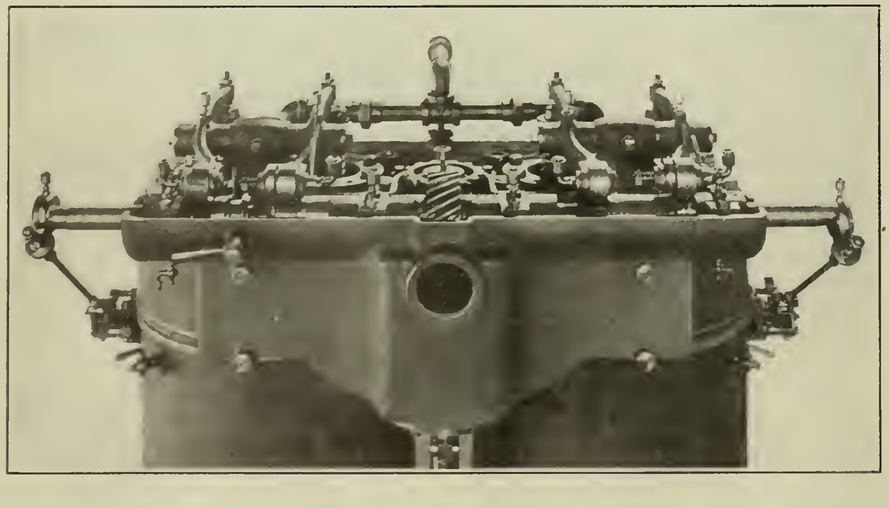


FIG. 3. LAZIER CAM SHAFT AND VALVE GEAR

The igniters are of the make-and-break variety; the construction of the operating mechanism is shown by Fig. 4. The tripping finger or trigger is pivoted near the end of the rocker arm and its upper end is provided with a 45-degree extension which engages with a tripping roller immediately above it and is thereby pressed over to the right until the lifting block is carried beyond the end of the actuating lever; then the spring snaps the lever and the movable electrode back to the idle position, separating the electrodes and making the spark between their contact points. The short finger with a right-angle lug at its end and located immediately below the actuating lever is mounted on the stem of the movable electrode; this finger and the actuating lever are acted on by a single spring which tends to draw their ends together. When the lever is lifted by the trigger, the spring forces the electrode finger up with it until the movable electrode comes in contact with the stationary one and its motion is stopped; when the lifting block is pulled out from under the actuating lever by the tripping roller, the spring snaps the actuating lever downward against the electrode finger, giving a quick-break effect at the electrode contacts.

through the ports into the intake manifold, being agitated by passing through the narrow openings and the mixture thereby improved. The circular grid valve is connected rigidly to the linkage controlled by the governor, and the stem of the disk valve is adjustable up and down in the hub or sleeve of the grid valve. By this means the relative positions of the two valves, and thereby the proportion of gas to air in the mixture, is variable to suit the fuel being used.

The use of the disk valve further provides automatic means for varying the quality of the mixture as the load varies.

shops. It may be pointed out, however, that the cranks, which are located in the same plane, are counterbalanced by weights attached to the backs of the cheeks, thus eliminating the tendency to lateral vibration which exists when counterbalancing weights are used in the flywheel. The vertical countershaft, on which the governor is mounted, is driven through spiral gears, as shown in Fig. 4. Lubrication of the internal parts is effected by the splash method. The rocker arms are lubricated by small grease cups and the cam shaft revolves in an oil trough, which lubricates the cams and gears, but the shaft bear-

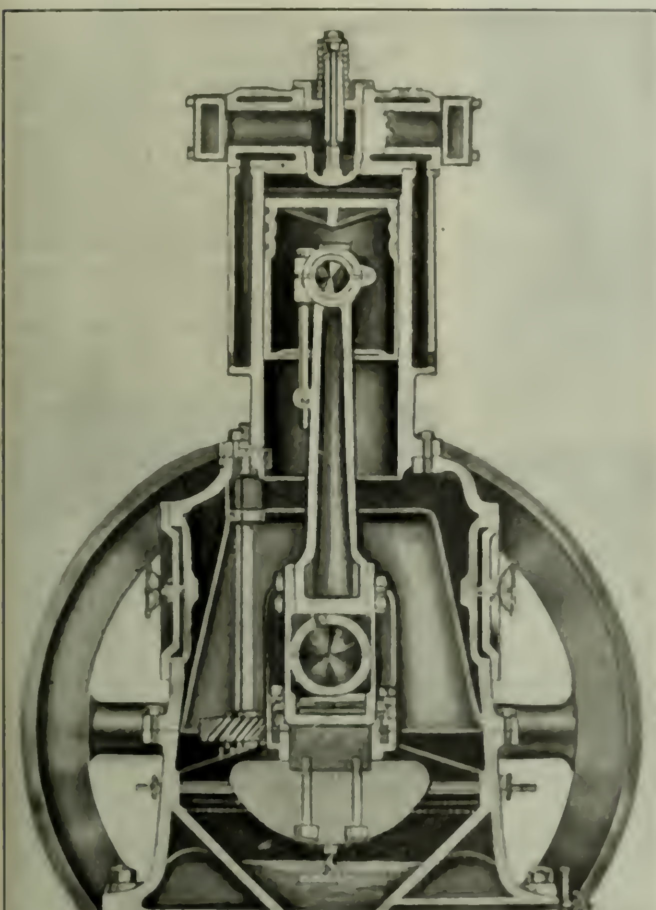


FIG. 2. SECTIONAL ELEVATION OF ONE CYLINDER AND CORRESPONDING PARTS

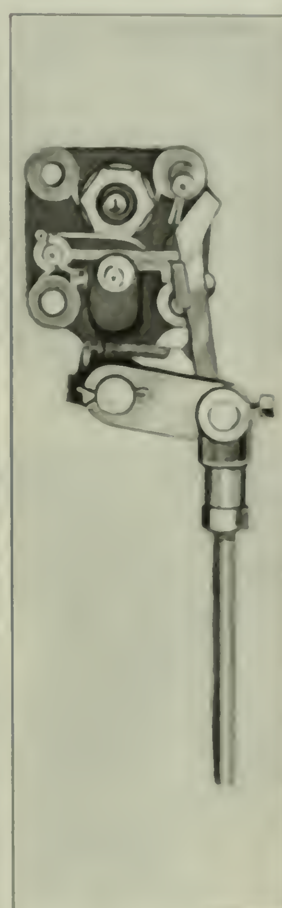


FIG. 3. [illegible]

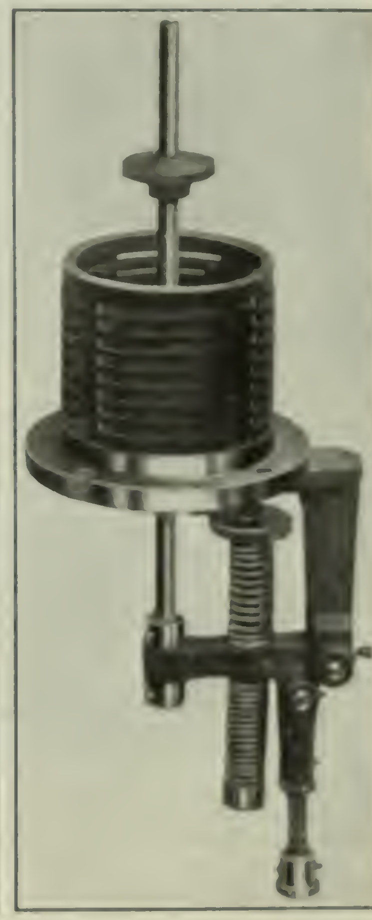


FIG. 5. [illegible] AND SPEED-REGULATING CAGE

The speed is regulated by means of a combination throttling and mixing valve controlled by the governor; this is shown in Fig. 5. The circular cage with ports through its wall is stationary and located in a chamber opening into the intake manifold. The air enters this cage freely at the top and gas enters it through a port controlled by the disk valve shown midway of the upper valve stem. Mounted on a sleeve on the valve stem is a circular grid valve inside the cage, and its position is varied vertically by the governor to cover more or less of the port openings in the wall of the cage. The air and gas are mixed inside the valve and pass

With full load the ports in the wall of the mixing-valve cage will be wide open and the gas port will be opened by the maximum amount proper for the fuel being used. When the load decreases the ports in the mixing-valve cage are partly closed by the governor and the disk valve also partially closes the gas port, thereby impoverishing the mixture slightly and keeping the compression higher than it would be if regulation were effected solely by throttling the mixture.

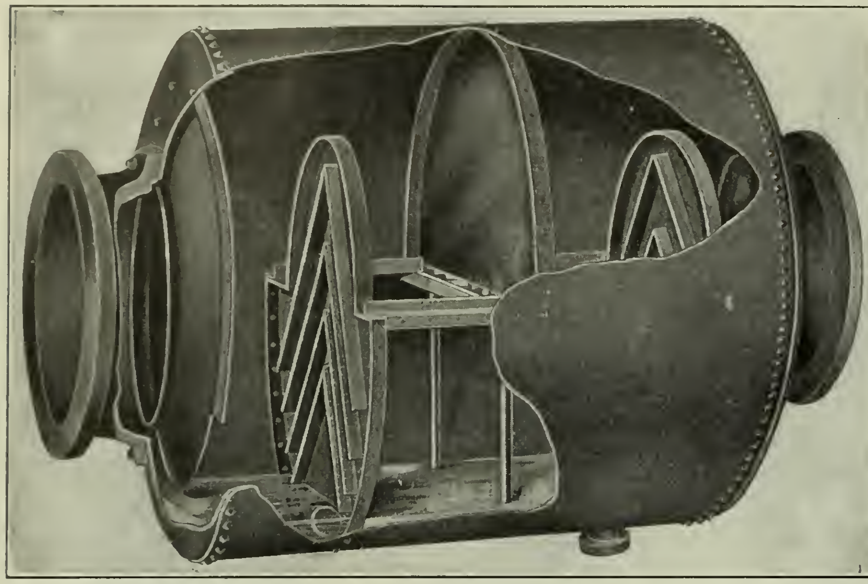
Fig. 2 shows the mechanical construction of the cylinders, pistons, connecting rods and crank case so clearly as to render unnecessary a detailed description of

ings are provided with individual cups as shown in Fig. 3. The crank shaft is a one-piece forging of open-hearth steel with pins somewhat larger in diameter than the main journals. The crank case is split horizontally in line with the center of the crank shaft, to facilitate the removal of the latter if it should ever become necessary. The flywheel is of the split-hub type, but not divided at the rim.

These engines are built in sizes ranging from [illegible] horsepower using natural gas, and from [illegible] horsepower using producer gas. [illegible]

Hoppes Horizontal Oil Eliminator

The Hoppes eliminator is especially designed for use in exhaust pipes of large size, for either vacuum or high-pressure service. The shell of the machine is made of flange steel, the heads and interior construction being of the same material, but the flanges for the pipe connections are of cast iron. The exhaust enters at the left-hand side and passes out at the right. As the oil and water for the most part follow the surface of the pipe, the inlet nozzle is made taper, and an intercepting plate, as shown in the illustration, is used to deflect the entrainment from a straight course into the eliminator, and direct it to the bottom of the shell.



HOPPES HORIZONTAL OIL ELIMINATOR

After the steam enters the shell, it strikes a baffle plate, the face of which is provided with a number of angle-iron strips which catch and hold the oil or water and carry it to the bottom of the shell. The exhaust steam, after passing over this baffle plate, is turned downward by another plate across the upper half of the shell, this plate being provided with an intercepting trough at its lower edge, which is kept partly filled with water, the excess water and oil being carried to the bottom by the drain pipes shown.

After passing the second baffle plate, the steam is prevented from flowing directly out of the outlet by another plate similar to the first one, and the oil and water are prevented from following the surface and escaping through the outlet by a short inwardly projecting nozzle. A small amount of water is always held in the bottom of the shell, as it has been found that this aids in catching and retaining the oil. The intercepting troughs partly filled with water stop the oil from creeping by.

This eliminator is manufactured by the Hoppes Manufacturing Company, Springfield, O.

Westinghouse Special Circuit Breaker

The accompanying engraving illustrates a special application of the standard Type CC circuit-breaker of the Westinghouse Electric and Manufacturing Company. This arrangement was devised in order to meet the requirement for a double-pole circuit-breaker which could be opened either by hand or by a magnet controlled from a distance, and which would also open automatically in the event of an increase in current beyond the maximum allowed in the circuit; the construction had to be also such that when the circuit-breaker was opened from a distance, it could be held open from that point regardless of efforts to close it by means of the resetting handle. The circuit-breaker was to protect a large motor, and the remote-control switch to open it and hold it open was located at the machine driven by the motor, under the control of the machine operator.

The circuit-breaker consists of two single-pole mechanisms, each having an automatic overload tripping coil, a handle located between the two mechanisms and arranged to close and open the two circuit-breakers, and a solenoid (shown beneath the handle) for opening the circuit-breakers in response to the closing of the switch at the machine. The mechanism in the middle is exactly the same as each of the tripping mechanisms of the circuit-breakers, and when it is tripped, by either the solenoid or the handle, it trips both of the circuit mechanisms; similarly, when

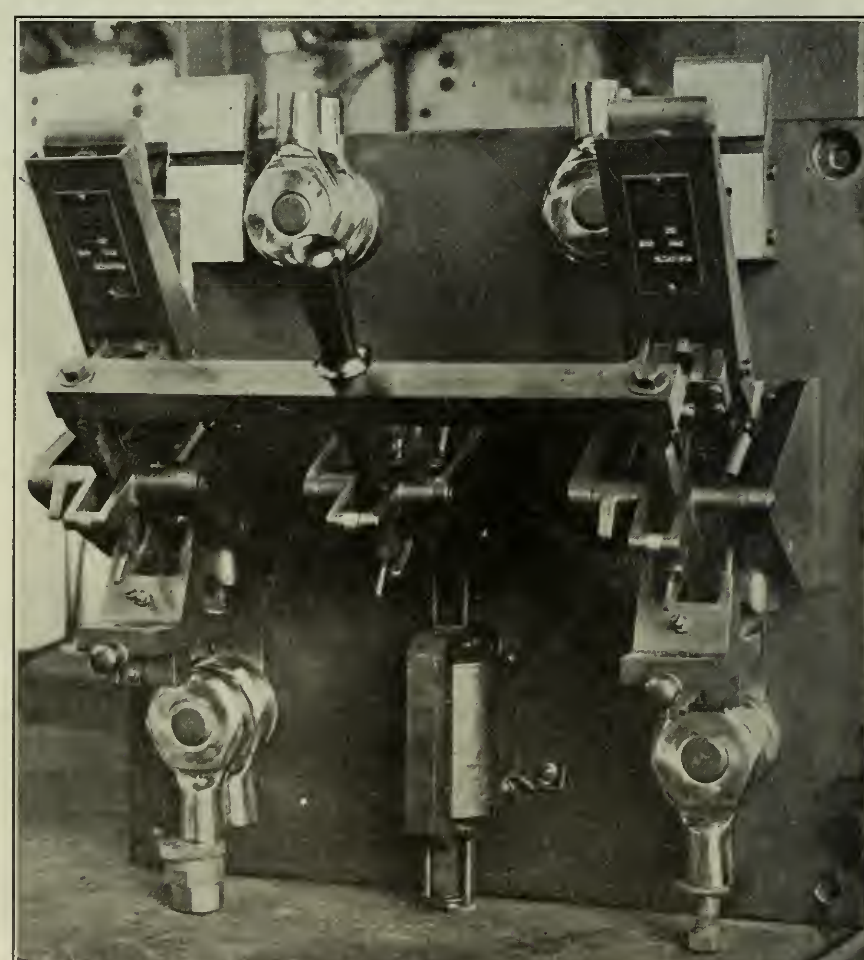


FIG. 1. SPECIAL APPLICATION OF THE WESTINGHOUSE TYPE CC CIRCUIT-BREAKER

either of the two circuit-breaker coils trips its own mechanism, that trips the other circuit latch and the middle latch. When the mechanisms are tripped by the

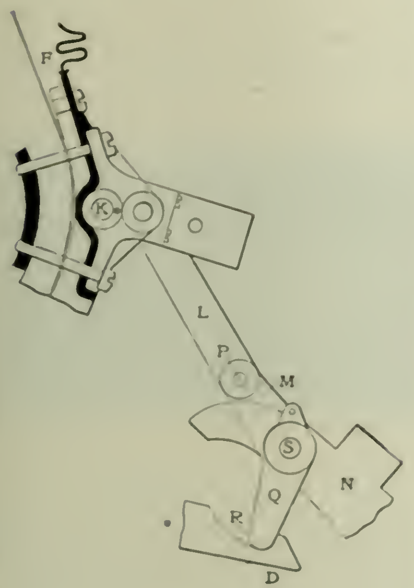


FIG. 2

FIG. 3

remote-control solenoid, the handle is caught by a latch which holds it in the open position as long as the solenoid remains excited. When the remote-control switch is open, the latch releases the handle, which may then be operated in the usual way.

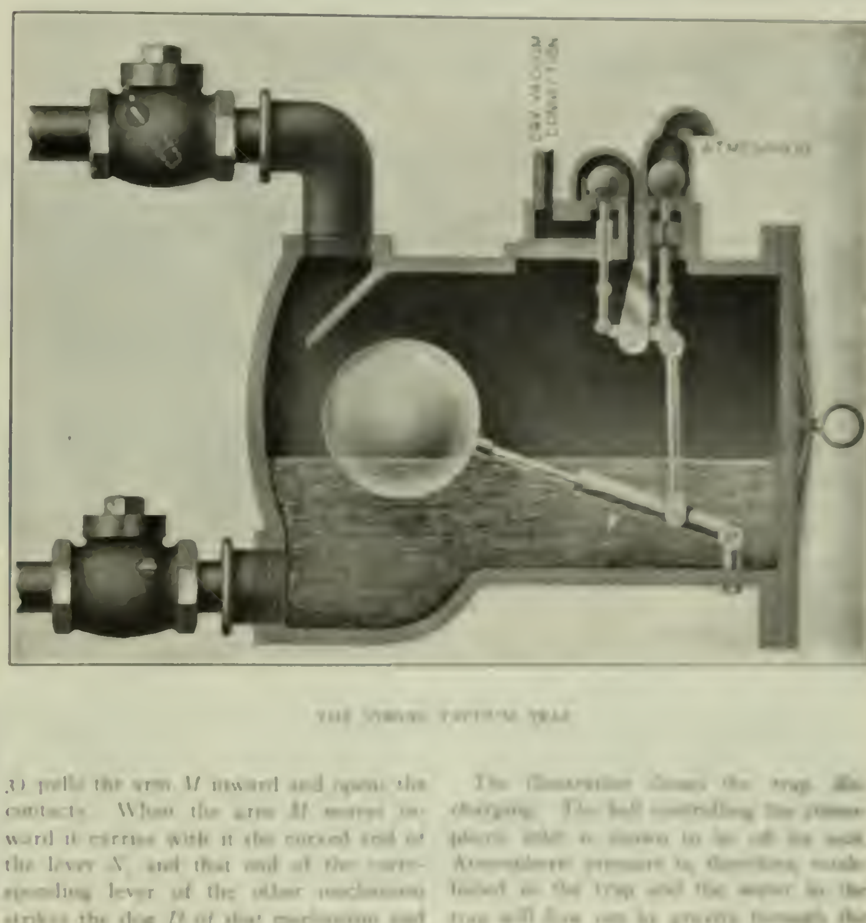
The arrangement of one of the circuit-breaker mechanisms is shown by Figs. 2 and 3. The lever N is one of the three which are bolted to the handle bar. It is mounted freely on the spindle S, on which the twin bell-crank M Q is also swiveled. The end M of the crank is attached by a pin P to the end of the link L which opens and closes the contacts. The end Q of the bell-crank carries a roller R which engages with a latch or dog D, the end of which is drawn upward by a spring and may be thrown downward by the trip (not shown). Figs. 2 and 3 show the mechanism in its closed position. If the overload coil, through its trip, throws the dog D down, releasing the bell-crank arm Q, a pair of heavy springs (see Fig. 3) pulls the arm M inward and opens the contacts. When the arm M moves inward it carries with it the curved end of the lever N, and that end of the corresponding lever of the other mechanism strikes the dog D of that mechanism and throws the contacts open. Raising the handle as shown in Fig. 1 moves both of the levers N and trips both dogs D simultaneously; the solenoid, when energized, raises the handle, with exactly the same result, of course.

When the circuit-breakers are open the curved end of the lever N on each one is down (the handle being up). When the handle is thrown down, the curved end presses the fulcrum R of each breaker forward, pushing up each link L and closing the contacts.

The Strong Vacuum Trap

The Strong vacuum trap consists of a large circular body, 18 inches outside diameter and about 30 inches long, with an inlet and outlet of any size desired from 1½ inches down. A ball float operates a lever which, in turn, operates two ground brass balls, one controlling the atmospheric pressure and the other controlling the vacuum pressure.

The valve seats are screwed into the valve chamber and are made of Government bronze. The valves are readily accessible as shown by the accompanying sectional illustration of the trap. It is not likely that dirt will get between the ball and the ball seat, as they are several inches above the water line and almost the length of the trap away from the inlet.



THE STRONG VACUUM TRAP

The illustration shows the trap discharging. The ball controlling the atmospheric inlet is shown to be off its seat. Atmospheric pressure is, therefore, established in the trap and the water in the trap will flow out by gravity through the swing check valve.

The valve rod operating the vacuum ball is shown to be in contact with the ball. The atmospheric conditions in the trap is transmitted through the inlet port into the cap covering the vacuum ball. The vacuum ball is, therefore, held on its seat by a pressure equal to the difference in pressure between the atmospheric and absolute vacuum it being created, multiplied by the area of the ball seat; this pressure with a 26-inch vacuum is [illegible] pounds.

As the water flows out of the trap, the tendency of the ball float is to drop with the water line. It cannot do so, however, because the vacuum rod is in contact with the vacuum ball and cannot lift it, as it is held on its seat by the pressure mentioned. The water continues to flow out of the trap, dropping away from the ball float until the weight of the ball float and its leverage are sufficient to lift the vacuum ball. When this occurs the ball float drops to the new water line. The vacuum ball is lifted off its seat about ½ inch and the rod operating the atmospheric ball drops the same distance, permitting the atmospheric ball to seat.

The trap is thus closed to the atmosphere and open to the vacuum through the dry-vacuum pipe. In three or four seconds the same vacuum will be established in the trap as is maintained in the vacuum system being drained. Water will then drop by gravity from the system into the trap.

The ball float will rise with the water line until the vacuum ball is about ⅛ of an inch off its seat, and the rod operating the atmospheric ball comes in contact with that ball. The same conditions now exist with the atmospheric ball as existed with the vacuum ball. The atmosphere on one side of the ball and the vacuum on the under side present a total pressure of 20 pounds holding this ball on the seat.

The ball float cannot lift the atmospheric valve under these conditions. The vacuum valve thus remains open and the water continues to flow into the trap, flooding the ball float, which cannot rise with the rising water line. When the ball float is flooded to such extent that its increased buoyancy and its leverage are greater than the pressure holding the ball valve on the seat, it will then raise the ball. The atmospheric ball is thus raised about ½ inch from its seat and permits the vacuum ball to drop to its seat.

The instant the ball is lifted from its seat the pressure of 20 pounds disappears, as the ball is then in equilibrium, the only pressure left being the weight of the ball, about ¾ of a pound. A variation of 6 inches in the water line is thus obtained, giving a capacity of 8 gallons per discharge. Three discharges per minute are possible, giving a capacity of 24 gallons per minute. This trap is manufactured by the Strong, Carlisle & Hammond Company, 336 to 344 Frankfort avenue, S. W., Cleveland, Ohio.

"Roto" Tube Cleaner

Following is a description of a new air- or steam-driven tube cleaner, the general construction of which is shown in Fig. 1, in position in a straight 4-inch water tube containing a heavy deposit of hard scale. The power is developed in a 2-inch cylinder 1½ inches long, containing a slotted piston and a single sliding blade. The cylinder bore is formed in the shape of a heart, the edges of the sliding blade exactly fitting it in every position during the revolution of the eccentric piston.

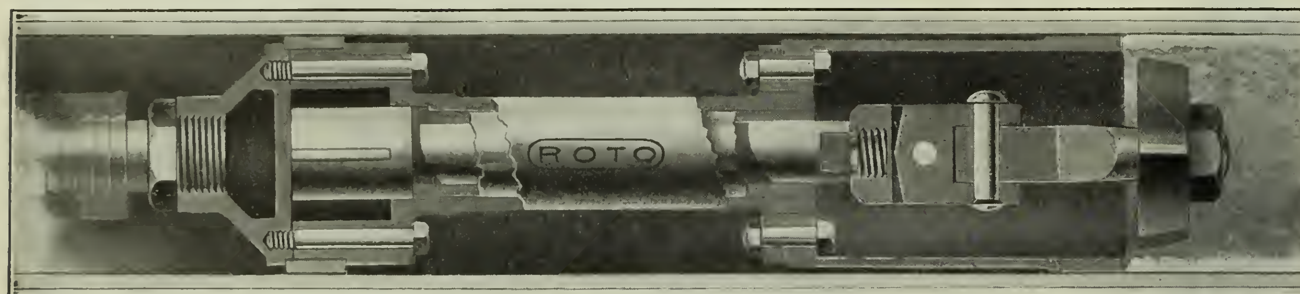


FIG. 1. SHOWING GENERAL CONSTRUCTION OF "ROTO" TUBE CLEANER

The piston shoulder is floated on a thin film of filtered oil, saturated with air or steam. Oil put in at the ball valve soaks into lampwicking in the oil receiver, and a very small jet of compressed air or steam admitted on top of the lampwick passes through it and conducts the oil under the piston shoulder, which it lifts a very little against the thrust of the air pressure and the weight of the tools and escapes in a thin film, thus forming practically a frictionless thrust bearing or step.

The single blade balances itself and admits of large eccentricity and piston displacement, being designed to allow the motor to run perfectly cool at very high speed. The motor is self-starting in all positions and has no spring or air pressure to force the blade against the cylinder walls.

This cleaner uses a hardened-steel sizing shield, carried by the motor and extending to a point close behind the cleaning tool which is thereby held in position to strike and remove the scale, and automatically to move on through the tube. With the sizing shield close behind the tool there is little likelihood that the operator will leave the cleaner in one position long enough possibly to damage the tube. It is not necessary to reduce its external diameter to pass through some one bad tube in the boiler, and so sacrifice thoroughness in cleaning the other tubes, as extra sizing shields are supplied, and these are quickly exchanged to fit the tubes being cleaned.

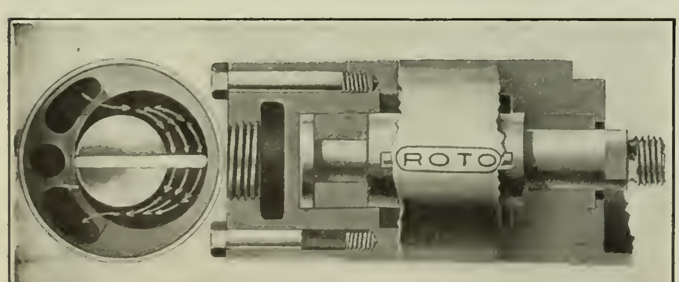


FIG. 2. DOUBLE-BEARING CLEANER

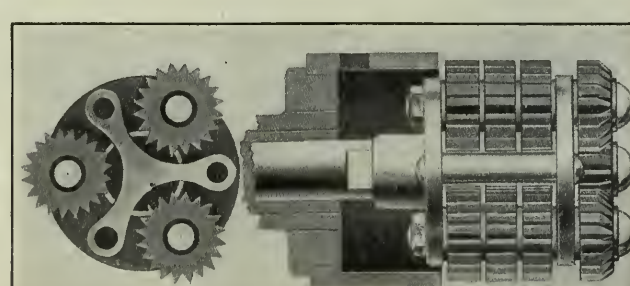


FIG. 3. MULTIPLE-EFFECT POLISHING HEAD

Where scale is very heavy, it may be first roughed out with a small sizing shield following a suitable tool, then with a larger shield. The tubes may be finished and polished by the same cleaner equipped with a larger shield and a finishing or polishing head suitable to the purpose. In short, the new cleaner with assorted shields is equivalent to several cleaners of different sizes. The cleaning should be done with the largest shield that will pass through the tubes when cleaned, so as to remove all the scale without cutting, grinding or bruising the already cleaned tube surfaces.

The cutters are formed of tempered high-speed tool steel. Where very heavy scale is encountered, a sharp pointed drill nut is substituted for the hexagon nut shown in Fig. 1. Several types of head, suitable for all purposes and including drill heads, cone-cutter heads and arm heads, are furnished.

Fig. 2 shows a view of a double-bearing cleaner made in small size for locomotive tubes, etc., the cross-sectional view showing the general construction of the air-driven motor. Fig. 3 shows two views of the "Roto" multiple-effect polishing head.

This apparatus is manufactured by the Roto Company, 62 Market street, Hartford, Conn.

The "Erieco" Engine Valve

The valve herewith described is especially adapted to single-cylinder high-speed engines of the automatic cutoff type, and has been used for the past three years in the "Erieco" engine, built by the Erie Manufacturing and Supply Company, Erie, Penn.

It is a balanced valve of the flat slide type, riding in a pressure plate. It is claimed that it takes up its own wear, and remains steam tight at all ranges of steam pressure. It is made in two pieces, having interlocking projections its entire width. The interlocking projections, having surfaces in opposite directions, are said to be held in steam-tight contact, owing to the difference in the exposed areas of the end of each half of the valve. By referring to Figs. 2 and 3 it will be seen that there are three projections at each end of both parts of the valve, forming five sides. Three of the sides at each end are surfaced to a steam-tight contact; to accomplish this the other two surfaces must spread.

As the valve wears it is held in contact with the pressure plate and seat, owing to the steam being admitted between the two halves of the valve. Steam is admitted between the halves of the valve through its ports, the location of which is such that the proper pressure is said to be maintained at all positions of the valve. The same principle of different areas is applied to the top and bottom of the valve.

It is claimed that the valve is kept steam-tight by the pressure under which it is operating, whether boiler pressure, compression, decreasing pressure due to expansion, atmospheric, or back pressure, and that this valve does away with the expense of frequent scraping by the engineer to keep it tight, and the trouble of shutdowns occasioned by that work. This valve is used on all "Erieco" engines.

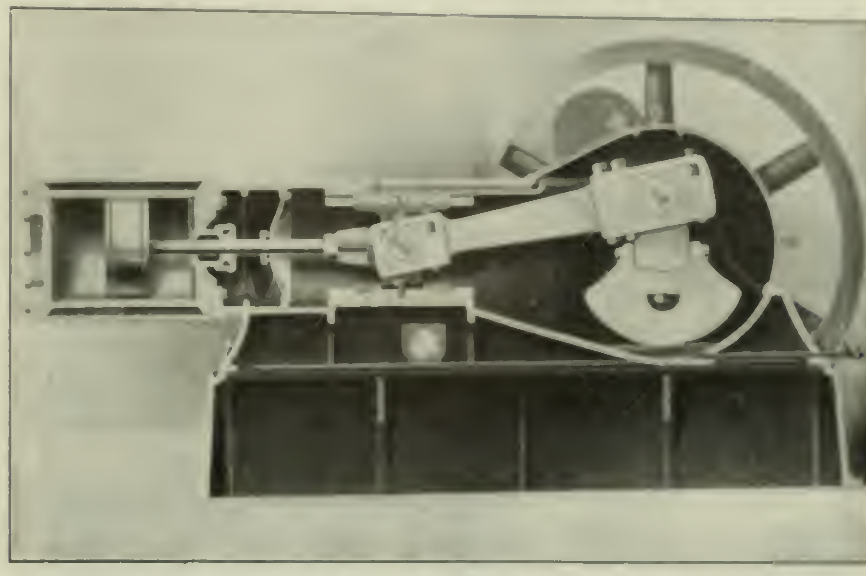


FIG. 1. SECTIONAL VIEW OF "ERIECO" ENGINE

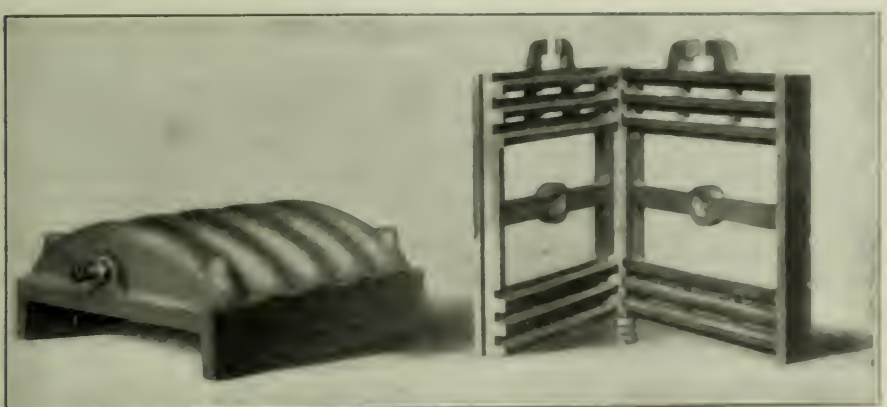


FIG. 2. PRESSURE PLATE AND HALVES OF VALVE

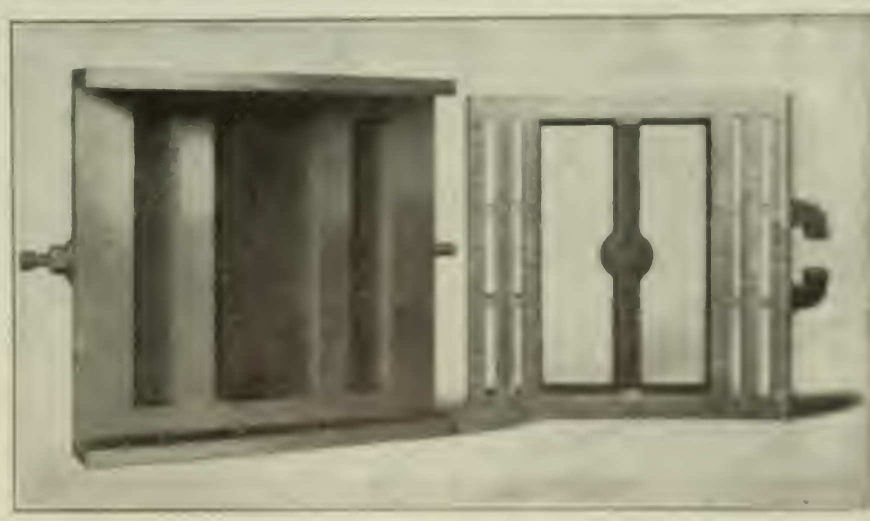


FIG. 3. PRESSURE PLATE AND VALVE

The Orvis Furnace

In the accompanying illustrations is shown the Orvis furnace, which was designed by [illegible] Orvis, of the Orvis Economy Furnace Company, 27 Park row, New York City. The furnace consists of two principal features, an arrangement of air piping and one steam jet to produce an induced draft, and an independent arrangement of piping to circulate the water in the boiler. The latter arrangement is said to stop the formation of scale, and after the system has been installed for a short time cause the old scale to drop off. The illustrations show the furnace adapted to an ordinary tubular boiler.

Differing from usual practice, the blowing device has been placed near the bridgewall instead of at the front of the furnace, or underneath the grate, and the air blast in passing through the contracted space or throat between the top of the bridgewall and the shell, induces a draft and brings the mixture of air and steam in contact with all the gases from the fire. The draft arrangement consists of the pipes *A* and *B*, the former being an air pipe as far down as the elbow, and the latter a small steam pipe, ending in a small jet introduced at the elbow of the air pipe. A small jet of steam issuing from the steam pipe causes a vacuum in the larger pipe, and in drawing the air from the boiler room through the hood *C*, fills the horizontal length of pipe with a mixture of air and steam. This mixture escapes with considerable velocity through a number of blasts in thin sheets toward the rear of the boiler, and in passing through the contracted area indicated in the drawing, increases the draft and consequently the evaporation and horsepower of the boiler.

With the device designed by Mr. Orvis embodying the vacuum principle the amount of steam required is very small, and some idea of the quantity will be obtained when it is stated that a 1-inch pipe will supply sufficient steam to operate thirty-two 100-horsepower boilers.

From a test recently made by Albert A. Cary, at a prominent plant in Newark, N. J., equipped with the Orvis system, it was reported that the blower could increase the steaming capacity of the boiler about 25 per cent., so that a considerable gain would be effected in the horsepower developed and the amount of steam produced per hour, which in a plant with a number of boilers would mean that the capacity could be increased sufficiently to avoid the installation of a new boiler.

Another claim for the device is that it will prevent smoke. From the construction shown in the illustration, it is apparent that the gases formed from combustion must pass rapidly in a thin sheet under the straight arch or baffle wall over a bed of incandescent fuel, which consumes the larger part of the smoke. The gases must then pass upwardly through a narrow passage and above the bridgewall, where they come in contact with a mixture of superheated steam and heated air in the proper proportions, causing the remaining particles of carbon to ignite and burn and in this way prevent any smoke from reaching the stack. The device then has apparently four advantages: To increase the draft, evaporate more water, remove scale and consume the smoke. It should, therefore, be of use in an overloaded boiler room, or where enough draft is not available.

The other feature of special prominence was the circulating tubes shown at *D* in the illustrations. Water is taken from the rear of the boiler, as shown, and caused to flow across the furnace in 4-inch charcoal-iron tubes, which are expanded into suitable headers bricked into the side walls, and from here it is returned into the front end of the boiler. The two connections to the boiler are on the same level, are below the water line and still far enough from the bottom to avoid the sludge and whatever impurities may have settled to this location. To produce the circulation, the tubes across the furnace are tilted slightly, so that the heated water will have a tendency to flow in one direction, and that toward the front of the boiler. By this means a rapid circulation is set up in the boiler and scale formation is prevented.

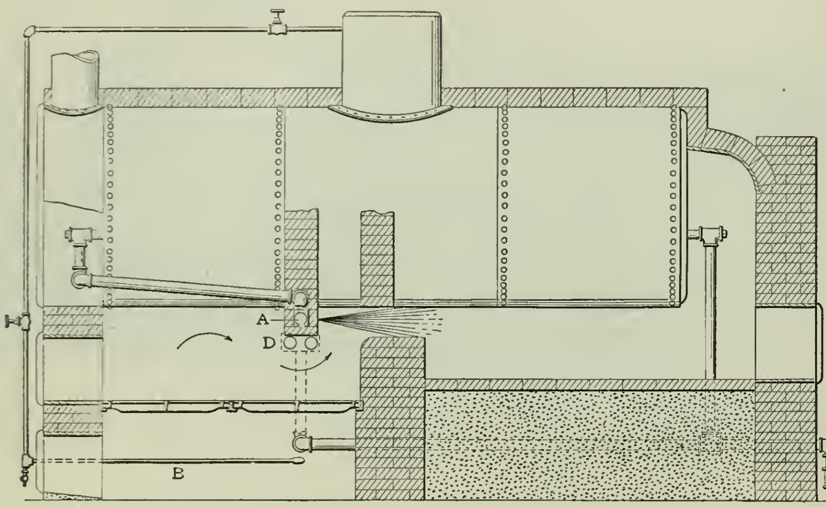


FIG. 1. ORVIS FURNACE ADAPTED TO RETURN-TUBULAR BOILER

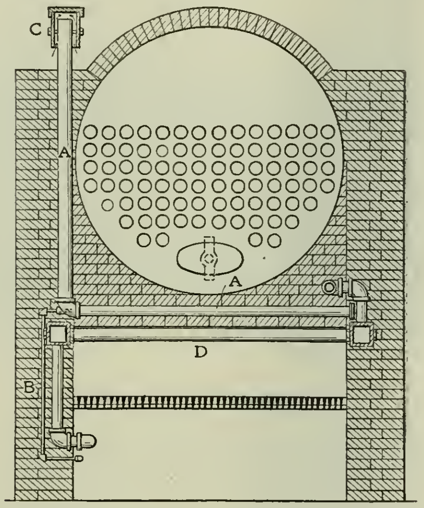


FIG. 2. PIPING ARRANGEMENT IN SETTING

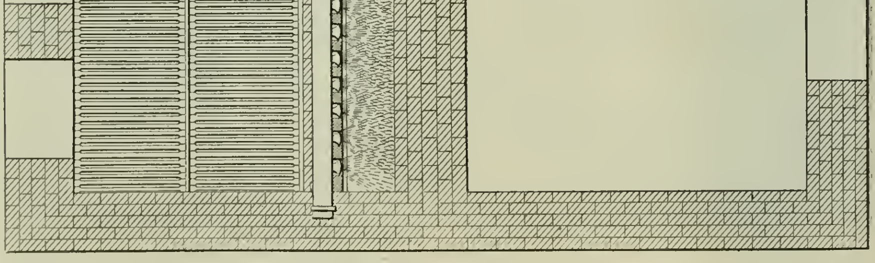


FIG. 3. SECTIONAL PLAN OF BOILER SETTING

Inquiries

Questions are not answered unless they are of general interest and are accompanied by the name and address of the inquirer.

What Is Meant by Centennial Rating

Will you please explain what is meant by a boiler horsepower centennial rating?

C. D.

The centennial rule, so called, declared a boiler horsepower to be the evaporation of 30 pounds of water at 100 degrees temperature into steam at 70 pounds pressure in one hour. It is a measure of the rate of work and is equivalent to the evaporation of $34\frac{1}{2}$ pounds of water from a temperature of 212 degrees into steam at atmospheric pressure.

Comparative Heating Value of Wood

What is the heating value of wood as compared with good soft coal?

D. B.

Two and one-quarter pounds of dry wood contains about the same number of heat units as a pound of average bituminous coal. It is necessary that the wood be thoroughly dry. It seems to make little difference what kind of wood is used, as, pound for pound, poplar is as good as hickory or oak. Some experiments have shown the heat value of perfectly dry wood to be 0.4 that of carbon.

Concrete for Engine Foundation

I wish to build an engine foundation of concrete. What proportions of cement, sand and broken stone shall I use?

C. D. M.

One part, by measure, of good hydraulic cement to three parts of coarse, sharp sand and six parts of clean, broken stone that will pass through a screen of $1\frac{1}{2}$-inch mesh. Spread a batch of stone about 6 inches thick on a floor of plank and wet thoroughly. Mix a stiff mortar with the sand and cement and spread it evenly over the stone. Then, with shovels, turn until thoroughly mixed, wheel or carry it to the form and tamp, particularly around the outside next to the form, to prevent the formation of holes. If it is necessary to let the work stand unfinished over night, the top should be left as rough as possible and well wet before putting on fresh material.

Vacuum in Condensers

In my plant I have a jet condenser which until recently would show only 24 inches vacuum. Another engine was bought with a surface condenser, and the suction pipe which supplied the jet condenser was extended to furnish water for the other. When both condensers are running I get 27 inches vacuum in the jet condenser, but when it is running alone I get only 24 inches. Can you explain this?

F. C. A.

The suction pipe leading to the condensers leaks. When the jet condenser is running alone all the air which is drawn in through the leaks goes to the condensing chamber and expanding there reduces the vacuum. When the surface condenser is running the air is carried past the outlet to the first condenser which gets "solid" water, and a vacuum, due to the temperature of the condenser, is obtained. In order to get good results with a jet condenser it is necessary that the suction pipe be absolutely air-tight. Any air entering the condenser with the injection water produces the same results that come from air leaking through stuffing boxes or exhaust pipe joints. It expands in the condenser and reduces the vacuum.

Flywheel Energy

Is the energy stored in a flywheel during one portion of the revolution given back again without any loss during the rest of the revolution, assuming constant speed and eliminating friction?

G. F. D.

The energy given to the flywheel in the earlier portion of the stroke is delivered to the shaft during the later portion of the stroke when the mean pressure is lower, and this without any other loss than that of friction. You cannot assume the constant speed because the ability of the flywheel to receive and to give back energy lies in an allowable speed variation. The wheel is speeded up under the high initial pressure and slows down as it gives up the energy thus required later in the stroke. The energy necessary to get up a given velocity is

$$E = \frac{W V^2}{64.32},$$

from which it is easy to figure the amount of energy which a flywheel of a given weight with a given variation in velocity will distribute.

Cause of Pound in Ammonia Compressor

What causes an ammonia compressor to pound when it is started up after having been shut down for a few days?

E. W.

We are inclined to think that a pound in the compressor cylinder occurring under such conditions would be due to entrained liquid returning to the compressor with the return gas. If the piston rods are found to get very cold, the discharge pipe being unusually cool and the stuffing box shows a tendency to leak, this is undoubtedly the correct explanation. This liquid may either leak by the expansion valves into the cooler while the machine is shut down, or it may have been pocketed somewhere while the machine was in operation, in which latter case the low temperature of the insulation or possibly ice surrounding the part of the piping forming the pocket might have allowed it to collect faster than it could evaporate.

When the machine is shut down a portion of this residual ammonia will evaporate and increase the pressure on the condenser sufficiently to prevent its evaporation even at a higher temperature of the surrounding insulation, or after the ice has melted off, as the case may be. When the machine is again put in operation and the back pressure is quickly reduced, the comparatively high temperature liquid will begin to boil rapidly, and, as in the case of a boiler that is being "crowded," a certain amount of liquid is bound to pass off with the vapor. If parts of the piping can be found that frost or become abnormally cold, it will give support to this theory.

While it is a far less probable explanation, the contraction of parts of certain types of ammonia piston will sometimes allow of sufficient motion to produce a sound. This is usually where the pressure of the compressed gas is allowed to enter the piston and distend a "bull ring."

It is barely possible that the crank-end clearance is so small that the contraction of the piston rod allows the piston to strike the back head until the rod gets warmed up. This can be proved by taking the clearance and by inserting a piece of solder wire behind the piston just before the crank passes the back center.

A Deserving Cause

We are advised that a fund is being raised in England by subscription to provide for the invalid wife and young children of the late H. H. Thwaite, who in 1894 conceived and proved that blast-furnace gas can be used in gas engines. He was no business man and he got nothing out of it. He spent all his own fortune on it and died, a broken-hearted man, in the spring of 1908.

The widow set to work at once to provide for her two young children, but was attacked with a recurrence of a sickness for which she underwent an operation three years ago. Her case is now believed to be hopeless.

Friends of Mr. Thwaite got Andrew Carnegie interested to the extent that he has agreed to subscribe £100 ($500), provided a like sum be obtained from others.

The committee in charge of raising this fund consists of the following: H. A. [illegible] and T. E. [illegible], of *The Electrical Review*, London; Professor Arnold, of Sheffield; R. K. Gray, of the India-rubber and Telegraph Construction Company, Silvertown, London; W. M. Mordey, president of the Institution of Electrical Engineers, London; Harold Jones, *Iron and Coal Trades Review*, London; Sir William H. Preece, 8 Queen Anne's Gate, S. W., London.

The secretary of the committee, to whom contributions may be sent, is W. H. Booth, 3 Queen Anne's Gate, Westminster, London. Mr. Booth is well known to Power readers.

Obituary

Kenton Chickering, vice-president of the Oil Well Supply Company, of Pittsburg, died at Oil City, Penn., December 8. He was vice-president of the company from its formation, prior to which he was for thirty-nine years connected with Eaton & Cole and the Eaton, Cole & Burnham Company.

The first annual dinner of the superintendents and foremen of the Kinkora Works of the John A. Roebling's Sons' plant was celebrated at Roebling, N. J., on the evening of Wednesday, December 23. Assembled at the tables, where an appetizing dinner was served, were nearly fifty gentlemen bent on having a good time, and they had it. Appropriate favors were distributed. T. A. Major was the toastmaster. It is the intention to repeat this social occasion each year.

The annual smoker of Brooklyn Association No. 8, N. A. S. E., was held at its meeting rooms, 315 Washington street, Brooklyn, on Saturady evening, December 19. An enjoyable entertainment was furnished by the "bunch," assisted by Henry Elder, Carl Cronlin and Charles C. Drant. During the evening addresses were made by James Westberg, R. O. Smith, Thomas Cole and Timothy Healey. Frank Martin made a genial toastmaster. Refreshments of all kinds were constantly on tap.

Business Items

A handsome wall calendar for 1909, printed to represent burnt leather, is being distributed by the Wilpaco Packing Company, 109 Liberty street, New York.

The York Manufacturing Company, York, Penn., manufacturer of ice-making and refrigerating machinery, has closed 28 recent orders aggregating 1377 tons of refrigeration.

C. P. Bassett, of Charlotte, Mich., maker of the McNaughton sectional grates, has received a letter from W. P. Engel, president of the Peoples Gas and Electric Company, Defiance, Ohio, in which he says: "I acknowledge the com. Your boiler grates are far superior to any grate I have used. We have been using two full sets, under two 350-horsepower Heine boilers for two years and three months. The repairs have cost but $1.80 for the sectional grates. There has not been a warp or a sag in the bars, and the increase in draft is fully 25 per cent. We consider that we are saving 40 per cent. in repairs and 20 per cent. in fuel."

The Foos Gas Engine Company, Springfield, Ohio, is furnishing a producer-gas plant complete to the Standard Optical Company, for its new lens-grinding department, at Geneva, N. Y. The engine will be a 100-horsepower three-cylinder Foos vertical from which power will be transmitted by rope drive. The producer will use Pennsylvania anthracite and is so arranged that a portion of the gas will be drawn off and used for annealing furnaces. The plant will be very complete and will contribute materially to the economical operation of the factory. The Foos factory at Springfield has been working overtime for several months in the endeavor to keep up with orders.

The Buckeye Boiler Skimmer Company, South End, Toledo, Ohio, manufacturer of the Buckeye boiler skimmer for removing impurities from the water in boilers, has received a letter from Kelsey & Freeman, of Toledo, Ohio, in which they say: "We have had your automatic skimmers in use now about six months and have given them a pretty thorough test. We formerly cleaned one boiler each week and even at that had difficulty in pulling load on account of foaming. Now the old scale is dropping off and the water in boilers is considerably more free from settlement, thus requiring less attention and giving much better results. Your skimmers have done already what you guaranteed them to do and are worth their cost to us twice over since we installed them. To anyone using water as bad as Maumee river water we cannot recommend them too highly."

New Equipment

A new power plant is being erected for the Oconee River Mills, Milledgeville, Ga.

The Shelby (N. C.) Cotton Mill is building an addition. Electric power will be used.

The city of Clearwater, Fla., has voted to issue $25,000 bonds for water works.

The Beeville (Texas) Water and Light Company will rebuild water and light plant.

Wm. E. Everheart, Maryville, Mo., will establish an ice and cold-storage plant to cost $25,000.

Independent Ice Company, Nashville, Tenn., will erect a new factory building, boiler and engine rooms.

Morris & Co., Chicago, Ill., has had plans prepared for a cold-storage plant, which will cost over $700.000.

The Atlanta (Ga.) Power Company, recently organized, proposes to establish electric-power plant.

The Bellefonte (Penn.) Electric Company is having plans prepared for dam, concrete power house, etc.

The city of Hooker, Okla., voted $20,000 bonds for construction of electric-light plant and water works.

Help Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

AN ENGINEER in each town to sell the best rocking grate for steam boilers. Write Martin Grate Co., 281 Dearborn St., Chicago.

WANTED—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. Address "M. M. Co.," POWER.

AGENTS to sell one of the best known and widely advertised shaking grates on the market. Exclusive territory granted to anyone who can make good. Liberal commission. Perfection Grate Co., Box 1081, Springfield, Mass.

Situations Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

YOUNG MECHANICAL ENGINEER, three years' experience as salesman, would like to connect with engineering house or contracting engineers. Box 82, POWER.

SALESMAN—Mechanical engineer, college graduate, 28 years old, five years' experience with large steel plant, desires salaried position as salesman handling power specialties. Preferably Pittsburg or Cleveland district. Address "F. J.," POWER.

CHIEF ENGINEER, 17 years' experience on engines, dynamos, plumbing, wiring, sewage disposal, telephones, etc. Am at present in good position, having effected saving of about 1000 tons per year. Best references; change of locality desired. Address "H." Box 80, POWER.

ENGAGEMENT DESIRED to install small, or medium-sized steam, electric or hydro-electric plant, or as chief engineer mining company in South or West preferred. Am graduate electrical engineer, experienced in mining and milling work. Can give references. At liberty February 1. Box 81, POWER.

POSITION WANTED as chief engineer; experienced with all kinds of engines, steam turbines, a.c. and d.c. generators, motors and switchboards, boilers and pumps. I can get results and furnish the references; have been seventeen years in the mechanical and engineering business. Box 9, POWER.

POSITION WANTED by a thoroughly competent and practical engineer. Long experience in erecting, installing and operating steam, water and electric power plants; capable of taking full charge of any plant. Am now holding good position under first class Massachusetts license, but desire a change. Best of references on application. Box 77, POWER.

Miscellaneous

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

DRAFTSMEN—Put in a requisition for my parallel device, $2.50. F. G. Hobart, Beloit, Wis.

WANTED—Left hand, second hand Corliss engine in first class condition to develop 100 to 150 horsepower. Box 79, POWER.

IF YOU DESIRE to learn the latest improvements in steam boilers, correspond with the Detroit Water Tube Boiler Co., Detroit.

WOULD BUY ARTICLE in machine line to manufacture. If you have inventions, write, giving full descriptions. If patented give numbers. Box 78, POWER.

ENGINES AND BOILERS, ¼ to 2 h.p., engine castings in sets. Models and general machine work. Sipp Electric and Machine Co., Paterson, N. J. Catalog 4c.

PATENTS—H. W. T. Jenner, patent attorney and mechanical expert, 608 F St., Washington, D. C. I make an investigation and report if patent can be had, and exact cost.

PATENTS secured promptly in the United States and foreign countries. Pamphlet of instructions sent free upon request. C. L. Parker, Ex-examiner, U. S. Patent Office, McGill Bldg., Washington, D. C.

ENGINEERS AND FIREMEN—Send 10 cents in stamps for a 40-page pamphlet containing a list of questions asked by an examining board of engineers. Stromberg Publishing Co., 2703 Cass Avenue, St. Louis, Mo.

THE ANNUAL MEETING of the stockholders of the Hill Publishing Company, for the election of directors for the ensuing year and for the transaction of such other business as may properly come before the meeting, will be held at the office of the company, in the Hallenbeck Building, 497-505 Pearl St., Borough of Manhattan, New York City, N. Y., on Tuesday, January 26, 1909, at 12 o'clock noon. Dated, New York City, December 9, 1908. Robert McKean, Secretary.

For Sale

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

150 HORSE-POWER tandem compound Corliss engine, in good order; 16-ft. wheel; 24-in. face. F. W. Iredell, 11 Broadway, New York.

CHANCE TO GET A TRACK SCALE CHEAP. Fairbanks, Morse & Co., No. 4369, T. R. B. scale with dead rail, style 12, never been used. Morgan & Wright, Detroit.

FOR SALE—20x48 Wheelock engine and two 72″x18′ high pressure tubular boilers in good condition cheap. Address "Engineer," Box 2, Station A, Cincinnati, Ohio.

PLANIMETERS FOR SALE—Get the mean pressure of any diagram with the simplest and best planimeter in a minute's time. Send $1 to Peter Eyermann, Consulting Engineer, Du Bois, Pa., for the planimeter and instructions.

FOR SALE—20″x42″ improved Greene engine. Wheel 32″x14′. Used seven years. Also 24″x48″ improved Greene engine. Wheel 42″x16′. Used eight years. Both engines in first class shape. Can be seen running. The Capewell Horse Nail Co., Hartford, Conn.

New Power Plant of Carnegie Institute

Designed for Appearances as well as Efficiencies, with Extensive Heating and Ventilating Systems and Unusual Metering Facilities

BY THOMAS WILSON

In looking over Pittsburg, strangers never fail to visit the far-famed Carnegie Institute. This is an immense structure occupying a ground plan of about 440x660 feet, with a total floor space of over 15 acres and representing an expenditure of $6,000,000. The building is located in Schenley park in the midst of the residential district of Pittsburg and originally consisted of the Carnegie Library building and Music Hall. In 1900 a large sum of money donated by Andrew Carnegie made it possible to make extended additions to the library and educational institute and to add museums, art galleries and a large hall of architecture and sculpture. Architecturally the building has been given every attention. It is of stone construction with an imposing exterior, and within the design and decoration are highly artistic. For the greater part it is three stories in hight, the bookstack section alone having eleven floors, and is well lighted from an unusual number of large windows. Alden & Harlow, of Pittsburg, were the architects, and Charles R. Cunningham is superintendent of the building.

With the large extensions to the institute it was necessary greatly to increase the capacity of the mechanical plant, and for reasons of economy and convenience of operation it was decided to install a plant entirely new and of sufficient capacity to serve the entire building. Every effort was made to secure the best equipment on the market, to give it the best arrangement possible from an artistic as well as an economical standpoint, and above all to make the plant as attractive as any department in the building. From the photographic illustrations it is apparent that the efforts of Mr. Cunningham were not in vain.

FIG. 1. THE BOILER INSTALLATION

A building of such immense proportions required a large plant, involving the generation of electric current for light and power, heating and ventilation, refrigeration, elevator service, vacuum cleaning and the compression of air. Machinery for these various services was located in the basement of the Institute, but to have a boiler room with its dirt and smoke in such close proximity to the main (very) and important exhibits in the building, was not looked upon with favor. Fortunately a deep ravine nearby offered a favorable site, and when erected but very little of the boiler plant was visible from the institute. Furthermore, one of the conditions was to design a plant which would not produce smoke, and the difficulty of connecting the two departments of the plant with steam and water piping was rendered unobjectionable by cutting a tunnel 500 feet long through solid rock to the central portion of the basement. In all 2400 horsepower of boilers have been installed and in generating equipment 2200 horsepower for supplying with current 30,000 incandescent lamps and over 500 horsepower in motors. The exhaust from these units must heat nearly 14,000,000 cubic feet of interior volume, and a large amount of live steam is required for the various pumps, ammonia compressor and other machines.

Boiler House

Part way up the ravine and about 60 feet below the grade of the institute, a level plot was blasted out of the solid rock to afford a site for the boiler house, which is a brick and steel structure 65x150 feet in plan and 58 feet from the floor to the eaves, bounded by a concrete floor and roof. The entire upper portion is given over to continuous coal bunkers of concrete, holding 8000 tons of coal, and an ash pocket with a capacity of 1000 tons. The tunnel, which is 7½ feet wide by 12 feet high, is 32 feet above the boiler-house floor, and is connected by a stairway with an extensive system of iron grating giving access to the top of the boilers and piping. From this grating stairways lead to the boiler-room floor and to the coal bunkers above. The stack is on the institute side, rising 195 feet above the boiler-room floor. It was built of radial brick by the Alphons Custodis Chimney Construction Company and has an interior diameter at the base of 9 feet.

Eight 300-horsepower Babcock & Wilcox water-tube boilers are installed and are set in four batteries of two each. The settings are spaced 6 feet apart and have been placed to allow a firing floor of 24 feet in front and a distance of 11 feet from the rear of the settings to the wall. The boilers are of the standard heavy-pressure type with two steam drums 42 inches in diameter and 23 feet long, a 12-inch cast-iron mud drum and 144 four-inch tubes 18 feet in length. The tops of the steam drums are covered with 2-inch magnesia blocks which are supported on a wire netting to allow a 2-inch air space between them and the boiler. Each boiler contains 3051 square feet of heating surface, carries a working pressure of 150 pounds and is equipped with an 8-inch delivery nozzle, two 4-inch nickel-seated safety valves set for 160 pounds and a Williams feed-water regulator and gage column.

A grate area of 52 square feet in a Greene chain-grate stoker is provided in each boiler. A water back which can be run close to the fuel bed or raised to allow clinkers to pass is in place at the rear, and with an arch a little longer than usual almost perfect combustion is obtained. Only on rare occasions is smoke visible from the top of the stack and then only a light haze, due to starting up one of the boilers or a similar reason. The stokers are eccentric-driven from a shaft beneath the floor, and this in turn is belted to two Westinghouse Junior 7-horsepower engines, one being held as a reserve. At the rear of the boilers a breeching, 37x60 inches, carries the gases toward the stack, discharging into a rectangular flue at the center 7 feet wide by 10½ feet high, the breeching increasing in size to meet these dimensions as it proceeds toward the stack. The boiler connections are 37x49 inches, and each is fitted with a balanced damper. In the flue or main connection to the stack is a set of double vertical dampers. These are mounted on ball step bearings below the casing, and are controlled by a Kieley "Climax" damper regulator.

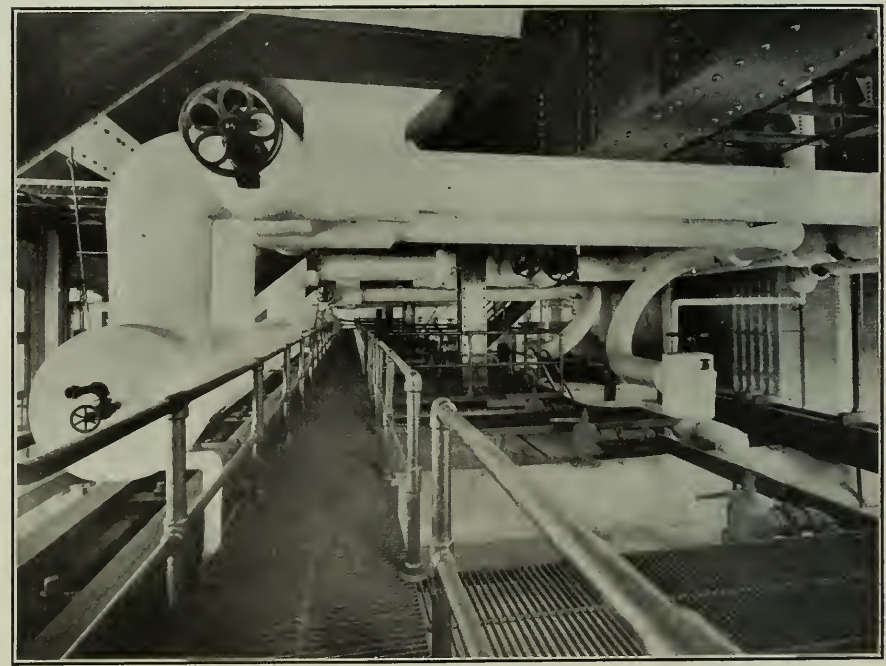


FIG. 2. PIPING AND WALKWAYS ABOVE THE BOILERS

Coal and Ash Handling

As previously stated coal is stored in bunkers of 8000 tons capacity. These are four in number and extend the entire width of the building with a 40-degree slope toward the center. Concrete walls on 30-foot centers divide the bunkers, and at the end an ash pocket of the same width and 15 feet long is located directly over the spur track carrying the coal into the boiler house. From each bunker there are two delivery spouts, one to each boiler, terminating in cutoff gates directly above a runway carrying two weighing hoppers, each of 1000 pounds capacity. These are mounted on four-wheel trucks which can be moved to any one of the eight boilers by a gear operated from the floor and the contents weighed before entering the stoker. The weighing-lever mechanisms, of Howe make, are suspended to within a convenient distance from the floor and are inclosed in "banjo" covers. Usually the scales are set at 700 pounds and coal is allowed to run into the weighing hopper until this weight is lifted. In this way the coal never overflows the hopper and a convenient amount is obtained to fill the stoker hopper.

In the ravine a spur from the Baltimore & Ohio Railroad delivers the coal to the plant, the track extending into the building and allowing the coal to be dumped directly from hopper-bottom cars into a receiving hopper below, which holds an entire carload.

Before being dumped the coal is weighed, a section of track 42 feet in length and the scale beams being suspended from steelwork above. Slack is the fuel usually burned, and in this case it is taken directly from the hopper by a McCaslin conveyer of the overlapping gravity-bucket type, which encircles the entire boiler room, running directly under the ashpits and up into a monitor above the coal bunkers, where a trip set at the desired location empties the buckets as they pass. The conveyer is driven by a 20-horsepower General Electric inclosed motor, which is located at one end of the monitor. The starting box is placed near the motor, so that it is necessary to start the machine at this point, as it is always well to look things over before setting the conveyer in operation. There is a second switch, however, in the basement near the crusher controlling the motor circuit, and this may be opened at any time to stop the conveyer. If the coal is of lump size it is first passed through a McCaslin single-roll crusher, driven by a 30-horsepower General Electric inclosed motor. This machine, by means of gearing and a winch is also called into service to pull the cars from the spur into the boiler house.

From the chain grates ashes drop into steel-plate hoppers immediately below and thence through undercut gates into the buckets to be conveyed to the ash bunker above. As this is directly over the track the ashes are run into the empty cars and from these dumped through the trestlework into the ravine. It is the intention in the near future to give the ashes free passage to the ravine by means of a spout connection to the bunker, as in storing the ashes to any depth they have merged into a solid mass, causing much difficulty in their removal. With the spout arrangement there would be no need for storage, and as the demand for ash filling is great, there would be no accumulation in the ravine. With the present arrangement it is an easy matter to weigh the ashes on the car scales.

Path of the Feed Water

Most of the water for boiler feeding comes from the returns of the heating system and whatever is lacking is made up from the city mains. The condensation is collected in two Webster "Star" vacuum open feed-water heaters of 1000 horsepower capacity each. From these the water is conveyed in an 8-inch line through the tunnel to the boiler house, dropping vertically to the basement and first connecting to a Wainwright surface condenser, with bypass connections, and thence to a special air chamber and continuing to the pumps through 6-inch branches.

Steam from the pumps in the boiler house and the stoker engines is passed through the Wainwright condenser and utilized to increase the temperature of the feed water. The condenser is 4 feet in length, 18 inches in diameter and contains thirty-six 1½-inch corrugated-copper tubes 36 inches long. It is built to withstand a working pressure of 125 pounds. The air chamber is a 12-inch pipe, 10 feet high, in which the water enters at the bottom and is taken off 3½ feet above. The top is capped with a blank flange, and the 6½ feet above the outlet is the air chamber.

The two pumps are of the Wilson-Snyder outside-packed plunger pattern, 8x12x8x18 inches, and both suction and discharges are cross-connected, so that the pumps may be readily interchanged. From the pumps the water next passes to a Cumming reheater and purifier and then to a Cumming filter and thence through a Worthington meter to be measured. There are two sets of Cumming filter and reheater, each of 1200 horsepower capacity, and by the use of live steam at boiler pressure the outfits are capable of raising the feed water to 310 degrees Fahrenheit, at the same time removing most of the scale-forming ingredients contained in the water. The reheaters are steel tanks 42 inches in diameter, 12 feet long and containing 800 feet of 1¼-inch copper tubing, while the filters are 15 inches in diameter by 8½ feet high. The reheaters were built to withstand a pressure of 160 pounds, but at the present writing are out of commission on account of leaks and grave doubts are expressed by the management as to the advisability of using live steam to secure that additional 100 degrees in the feed water. Consequently the reheaters are bypassed and the water turned to the boilers through a common 5-inch copper main running under the boiler room floor. From the main a 3-inch brass pipe carries the water to each boiler, passing on its way up through a graduating valve and a combination check and stop valve at the boiler connection.

Two blowoff connections are made to each boiler, each 2½ inches in diameter and connecting at opposite ends of the mud drum. All the connections lead into a common 4-inch main leading to a receiving tank 4 feet in diameter by 12 feet long at the rear of the basement. This tank receives the dirty drain as well as the boiler waste, and is provided with [illegible]

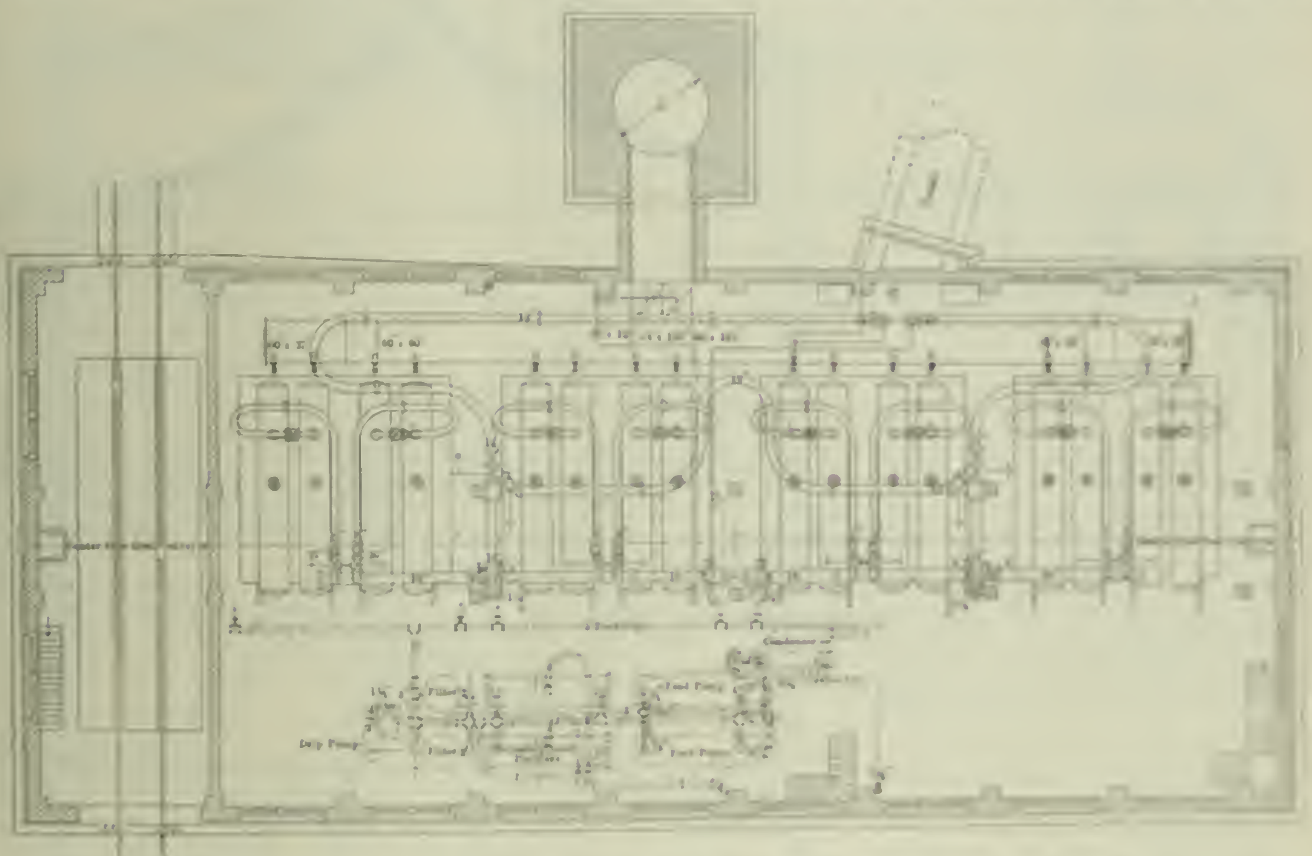


FIG. 3. PLAN OF STEAM PIPING IN BOILER HOUSE AND FEED-WATER APPARATUS OF BASEMENT

feet of 2-inch brass piping to cool the water before discharging it to the sewer. The overflow to the sewer is at a point 8 inches from the top of the tank, which is always nearly full of water and will tend to cool additional water as it is received. A 4-inch connection leading to an exhaust head above the roof allows the steam and vapor to escape.

Boiler Piping

Owing to the size of the plant and the distance between the boiler and engine rooms, an elaborate system of piping has been arranged to carry the steam from one department to the other. The arrangement of this piping is shown in the plan views, Figs. 3 and 7. Primarily the system consists of a large main header in the boiler room, which is connected to a large distributing header in the engine-room basement by two 12-inch mains running through the tunnel and measuring nearly 600 feet in length. The main header in the boiler room is 16 inches in diameter, 93 feet long, and near the front edge of the boilers is carried on roller supports. Leaders 8 inches in diameter connect the boilers to the header, and to provide for expansion these are turned in long radius bends, as shown in Fig. 3. Each leader is provided with a Chapman nonreturn stop and check valve. At the center the main header is sectionalized by a stop valve, and to each half are connected four boilers and one of the 12-inch delivery lines. The supply lines are cross-connected, so that either set of four boilers may supply either line, and at the center of this connection expansion is provided for by the U-bend shown in the drawing.

Each of the supply lines is equipped with motor-operated valves, and these may be controlled from five different places on the engine-room side of the tunnel. Three of these points are in the engine room, one in the engineer's office and one in the pump room. At each control point is a panel carrying three push buttons and three colored miniature lamps; one button starts the motor to open the valve, another button stops the motor, and a third button starts the motor in the opposite direction to close the valve. A red light in connection with the first button shows the valve opening, a white light shows that the motor is running, and the blue light shows the valve closed. After a few trials it is an easy matter to tell the approximate position of the valve, and the control panels are often tried out to show that they are in working order. There is also provision to close the valves by hand in the boiler room. With this arrangement the valves may be readily closed at either end and much trouble averted if a supply line should accidentally burst in the tunnel. The Chapman Valve Manufacturing Company designed this equipment.

The auxiliary header shown in Fig. 4 is 6 inches in diameter and was designed to supply all steam required in the boiler house. It has connections to the

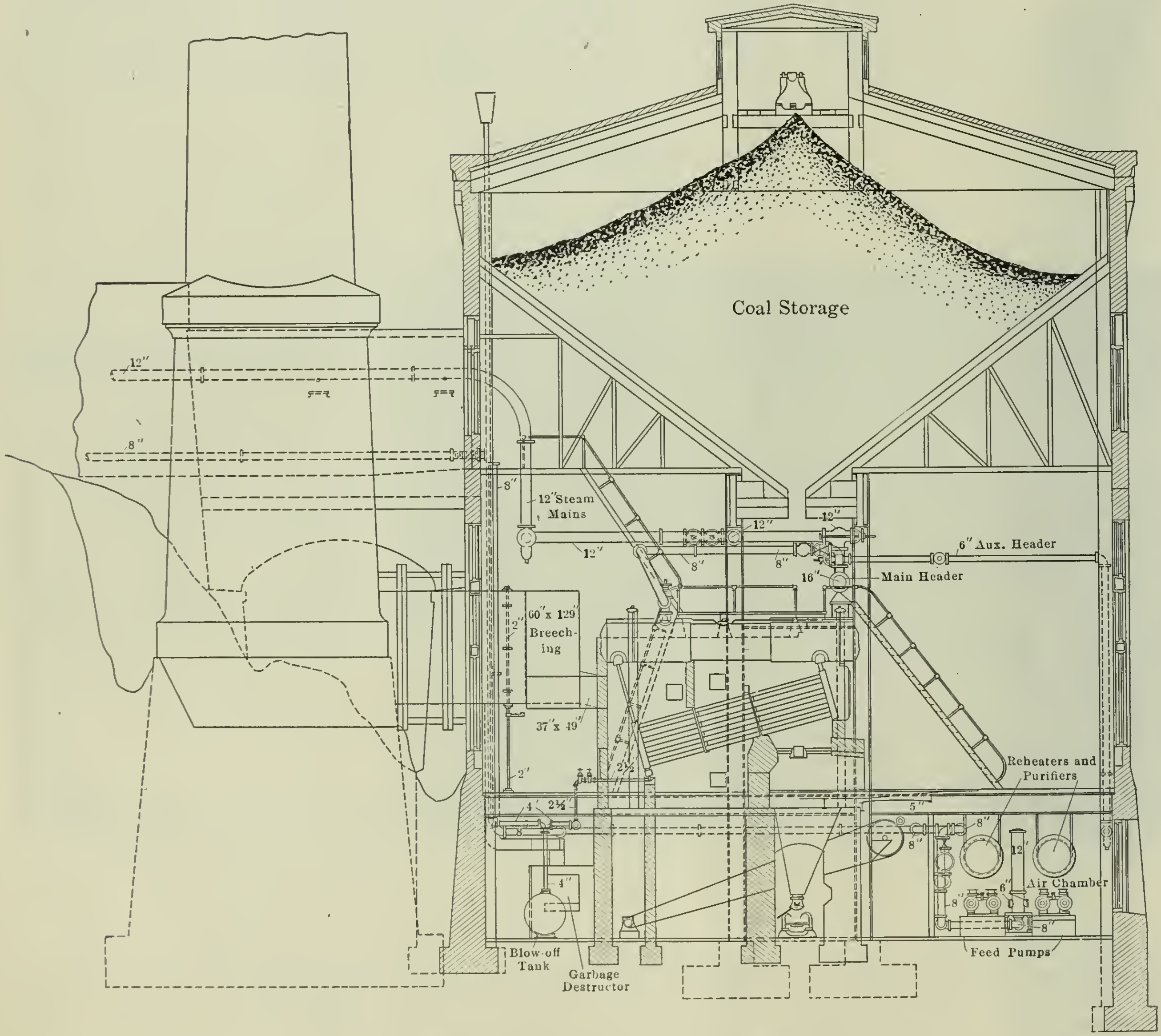
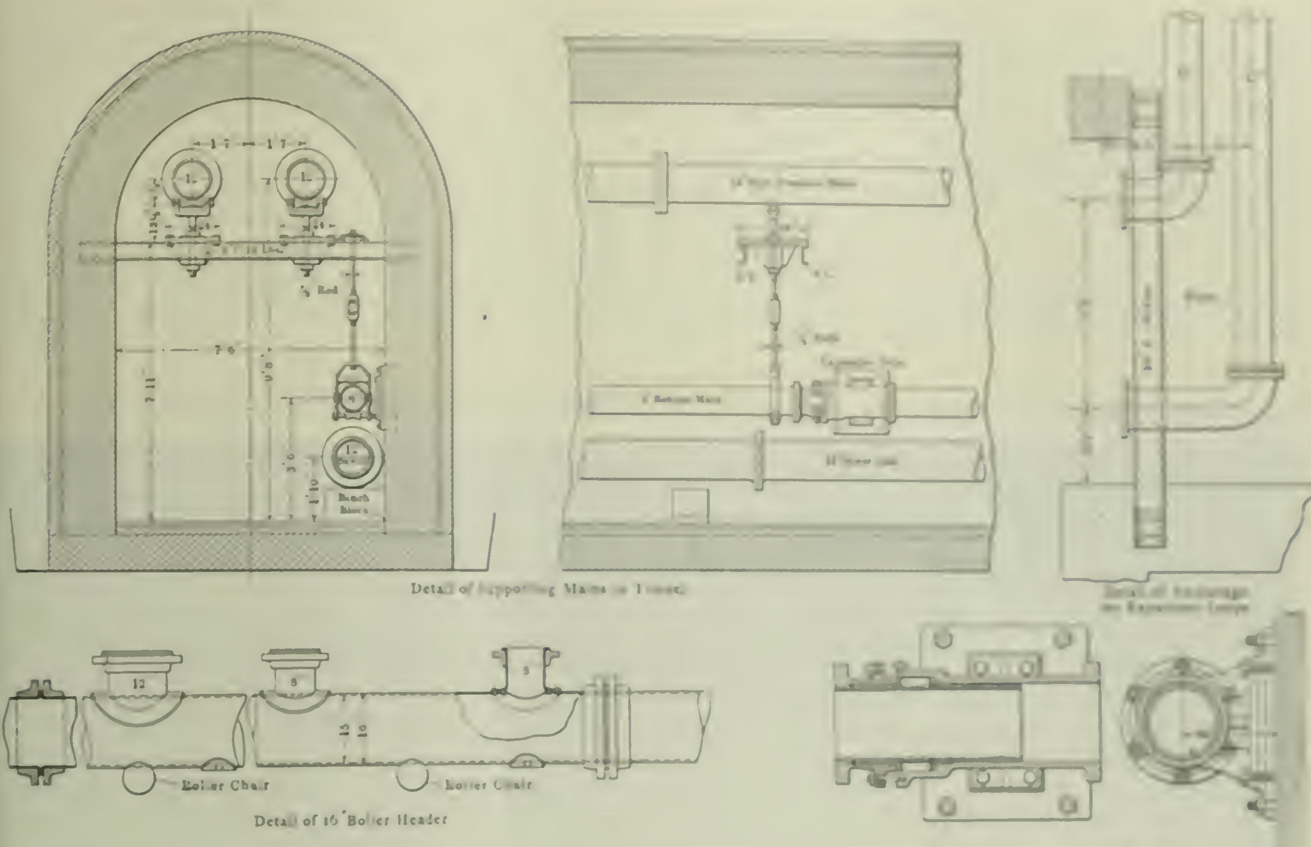


FIG. 4. TRANSVERSE SECTION THROUGH BOILER HOUSE



Detail of Supporting Mains in Tunnel

Detail of Anchorage on Expansion Loops

Detail of 16" Boiler Header

Detail of Expansion Joint

FIG. 5. DETAILS OF BOILER HEADER AND PIPING IN TUNNEL

main header on either side of the sectionalizing valve, and extends from the front of the boilers to the wall, where it drops to the basement to supply the auxiliary equipment.

The 12-inch supply lines are connected to the top of the main header and from angle valves run horizontally to the rear with long, sweeping bends and return to points in line with the tunnel. Here drip pockets are provided and the mains rise vertically 15½ feet to enter the tunnel, and at the entrance are bent on a 6-foot radius. In the tunnel their arrangement and method of support is shown in Fig. 5. The two supply mains occupy the arch of the tunnel and at points 12 feet apart are supported by 6-inch channels running transversely across the tunnel and imbedded in the masonry. The channels are 24 inches apart and between carry a block supporting an 8-inch roller conforming to the shape of the pipe. This roller is carried in trunnions on the upper ends of screw rods which pass vertically through the block and are adjusted by nuts above and below. At a bend in the tunnel near the center point the mains are rigidly anchored to the tunnel wall, so that expansion may occur in either direction. Toward the engine room expansion is provided for by U-loops extending horizontally and at right angles for a distance of 20 feet, and as the mains are rigidly anchored in the engine-room basement by means of a 10-inch channel attached to the steel work of the building, all expansion or contraction must be taken up by the U-loops.

Ample provision has been made for draining the mains. There is a drip leg at the bottom of the vertical rising from the boiler room to the tunnel, another at the center of the tunnel, and a third at the expansion loop near the engine room. The first two drips mentioned and those in connection with the main header in the boiler room are taken by a Wilson-Snyder 7½x4½x6-inch duplex drip pump and discharged to the suction side of the boiler feed pumps. The condensation from the expansion loops enters the engine room system of drips.

In the tunnel there are two other mains, one an 8-inch return from the Webster heaters and the other a 10-inch sewer line. The former is hung from the supply main channels by means of a rod provided with a turnbuckle, so that its elevation may be readily varied, while the sewer line is carried on bench blocks upheld by the tunnel floor.

It may be of interest to note that the tunnel is 9½ feet wide, 12 feet high to the

For 1½ Pipe

FIG. 6. DRIP-LEG TEES USED IN STEAM PIPING

crown of the arch, and from the engine room to the boiler-house wall has a total length of 410 feet. About 60 feet from the boiler house the tunnel emerges from the side of the ravine, and for the remainder of the distance is carried above ground resting on a heavy concrete arch where the sloping bank of the ravine necessitates.

Engine Room

In this department every effort has been made to secure a sightly appearance. At one end is a gallery floor 11 feet wide and 13 feet above the engine-room floor. Looking from this gallery nothing but the generating units and switchboard are visible. There is no auxiliary apparatus in the room, not a pipe is visible above the engine-room floor, and the cables are all concealed, including even the main generator cables, which enter the bottom of the flywheel pit and make connections at the bottom of the generator frame. Even in this pit a pier is built to within 18 inches of the generator frame to conceal as much of the cables as possible. The switchboard is all of white marble, and there is nothing to suggest electrical connections, except the switches and the instruments on the front of the board. The floor is laid with marble and on the walls a wainscoting of white-enameled terra cotta rises to a hight of 11 feet. The gallery is similarly finished, and in front is inclosed by a handsome brass railing. Five structural columns of the building are also covered with the white-enameled terra cotta, and the walls above the terra cotta are tinted. The ceiling is paneled and around the border is studded with glazed incandescents, so that the room, minus the machinery, might readily be mistaken for an elegant banquet hall.

To give the machines a setting, both the engines and generators are raised from the floor and rest on 8-inch capstones. Brass railings inclose the flywheels and generators, the floor stands to operate the throttle valves are polished, as is also the

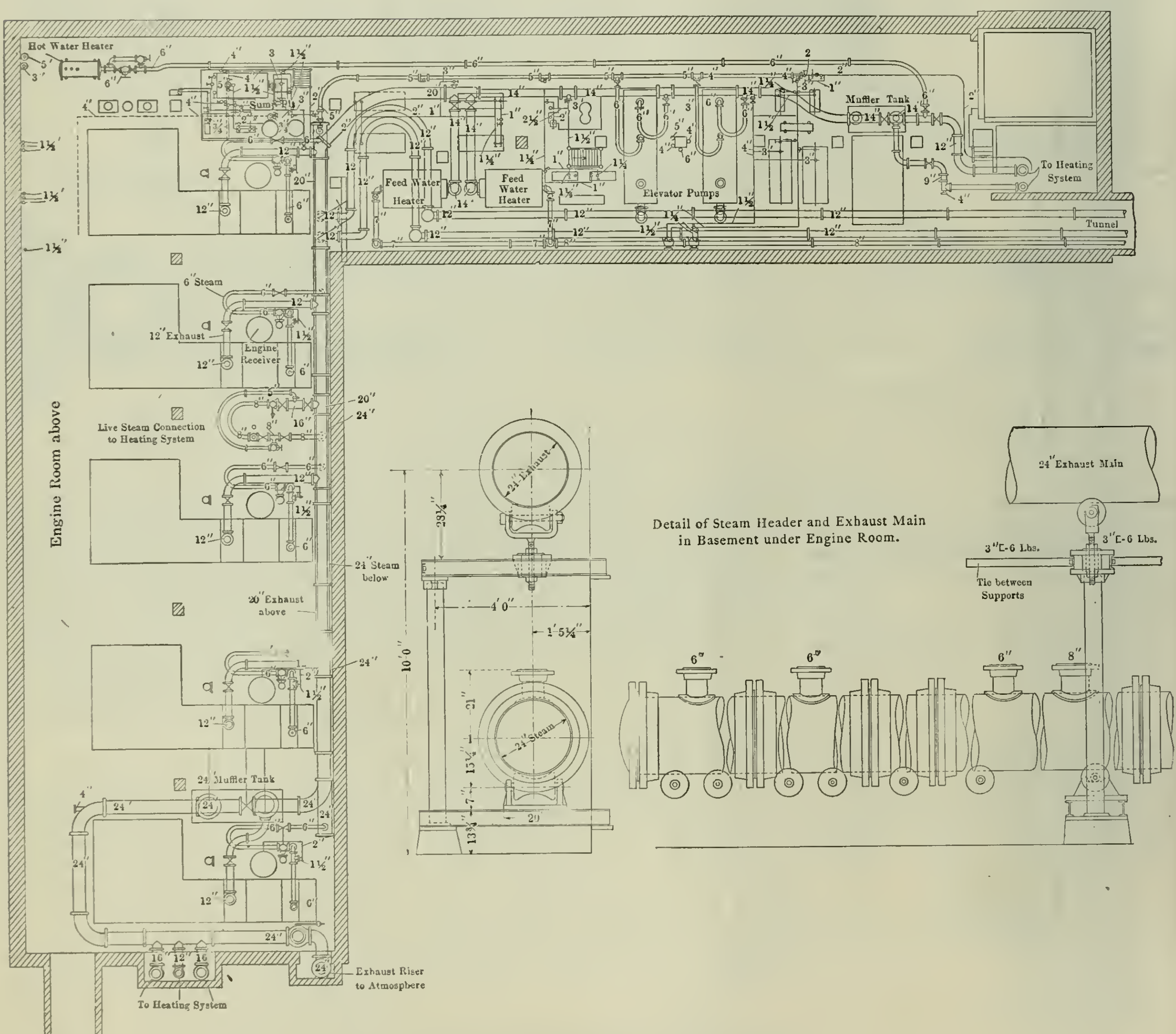


FIG. 7. PLAN OF PIPE CELLAR AND ELL EXTENSION AND STEAM AND EXHAUST HEADER DETAIL

Every little detail has been given attention, and the result is an engine room of surpassing beauty. The room is 45 feet 7 inches wide by 106 feet long, and has a clear head room of 24 feet. The engine-room floor is at a level 40 feet below the main floor of the building, and the location is such as to secure an abundance of daylight from a large open court. The generating units are spaced uniformly throughout the length of the room, and at valve gear, and the small oil piping to the bearings and cylinders is nickel-plated. Gold trimmings on both engines and generators add to the attractiveness of the machines, and the oil stands seen in the photograph have been specially designed for the plant and are made of highly polished brass. The combined effect of all these little features is most pleasing to the eye, and the universal verdict of visitors to the plant would in all probability be, "the most attractive engine room in the country."

This neatness and the extreme care of detail has not been limited to the engine room. In the tunnel the floor, walls and pipes are washed, and even the tops of the boilers and the steam piping above are cleaned at regular intervals. By no possibility must a piece of coal or a little ash be allowed to remain on the floor, and a can of grease or anything at all unsightly "dare not show its face." Even the firing tools are all concealed in a case provided for the purpose. This extreme cleanliness has made even the boiler room just as attractive to lady visitors as the

independently. A Rites centrifugal-inertia governor controls the speed. Richardson sight-feed oilers are provided for cylinder lubrication, and Lunkenheimer oil hand pumps are provided for emergency. A Schaeffer & Budenberg tachometer mounted on a floor stand and belted to the main shaft indicates the speed of the engines, which normally is 120 revolutions per minute. A Monarch speed limit, set for 130 revolutions per minute, is included in the equipment, and a Monarch engine stop is connected with each throttle. The stop is operated electrically at three different points, a push button being provided at the engine-room door, one on

system. The oil from the crank pit is drained to a set of Burt oil filters, and to prevent any oil from dripping to the engine base or the floor, the crosshead guides are similarly drained to a smaller set of filters of the same make. The oil is elevated by small pumps to a tank above the engine room, and provision is made for the usual gravity flow, the connections to the bearings and various points on the engine units being made by means of nickel-plated piping brought up through the engine-room floor.

ELECTRICAL EQUIPMENT

To the engines 300-kilowatt National

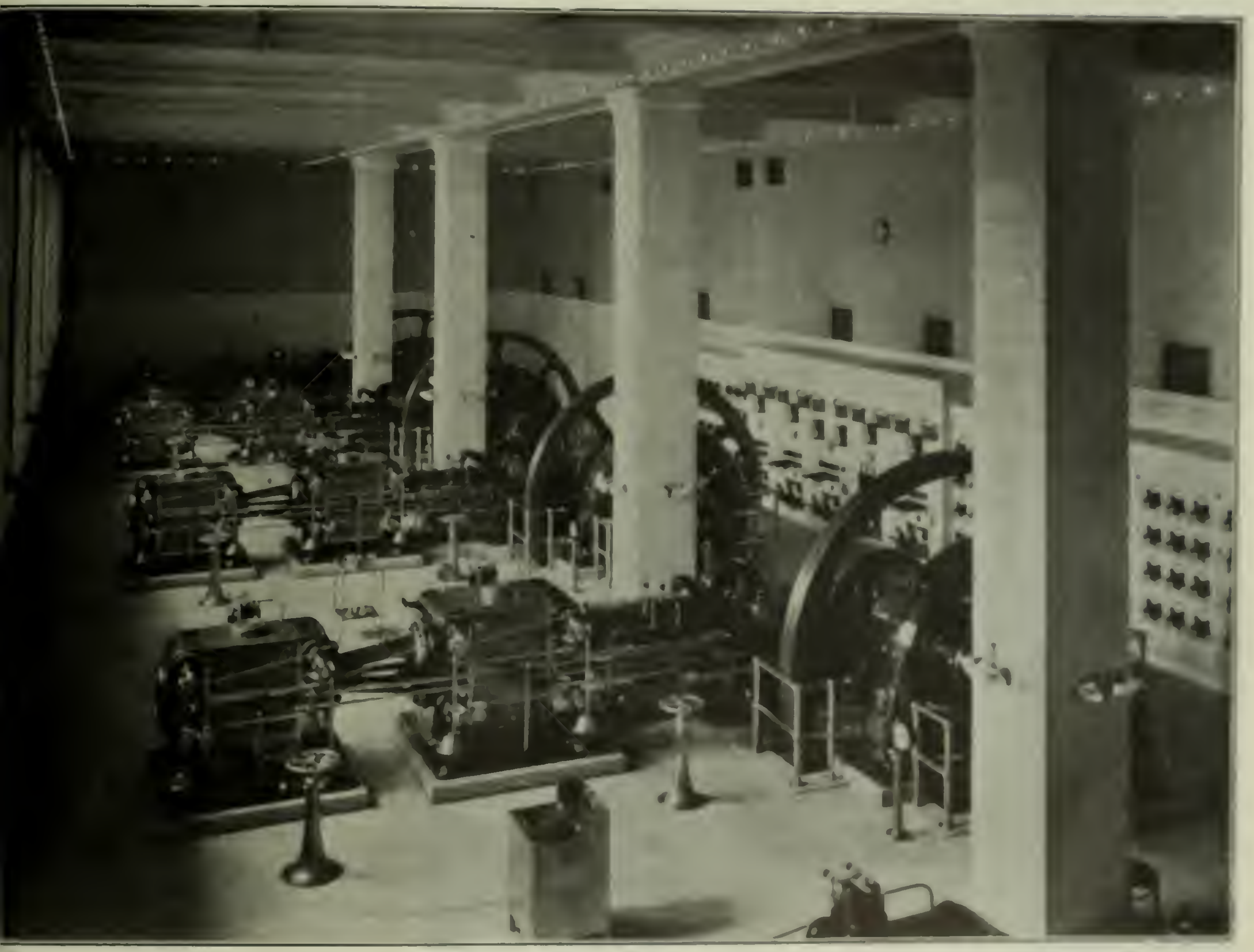


FIG. 8. ENGINE ROOM

art galleries or museums, and in going through the building, instead of receiving their last visit, it is usually the first place they go to.

The equipment of the engine room is five Rice & Sargent tandem compound engines, 18x26x36 inches. As is usual in the tandem compounds of this make, a third eccentric is provided, so that the valves may be operated by direct eccentric movement and no wristplates employed. One eccentric works all four steam valves, and each of the other two a pair of exhaust valves, so that the exhaust from each cylinder is controlled

the column near the engine and still another on the switchboard. In addition the stop is automatically operated by the governor, and by means of a lever on the floor stand can be cut out for the time being and the throttle closed by hand. It is the usual practice to shut down by means of the engine stop, alternately using the different points of control to insure that the system is always in working order. Four seconds is the time taken to close the throttle, and the closing within this time was demonstrated on different occasions for the writer's benefit.

Lubrication is effected by the gravity

Electric generators are direct-connected. These deliver 2400 amperes at 125 volts and operate in parallel to carry the load. The switchboard, which is located near the wall and is indicated in the cuts, has 14 panels—five for the generators, which are located in the center of the board, and the feeder panels on either side. The panel front is of white Italian marble, and as special pains have been taken to space the instruments and switches, the board has an unusually attractive appearance. The generator panels project some 6 inches from the feeder panels, and [illegible] running the entire length of the board and a base raising the panels about 8 inches from the floor add to the appearance of the board. Each generator panel is equipped with a Weston ammeter and voltmeter and a recording ammeter made by the French firm, Chauvin & Arnoux, of Paris; a circuit breaker on each side and the main knife switch for the generators. On No. 3 generator panel there is also a recording voltmeter of French make. The feeder panels show nothing but I. T. E. circuit breakers controlling the various circuits of the building, which are all two-wire. These circuits are further protected by Noark inclosed fuses at the back of the board and are provided with an electromagnet, which in connection with an annunciator board will immediately show, in the event of trouble, whatever circuit is out.

At the end of the engine room there is also a meter board of white marble containing 14 Standard brass-cased gages for indicating pressures of ammonia, air, steam and water, the steam gages indicating both boiler and heating pressures.

In addition to these instruments, there is a handsome recording board in the superintendent's office, some 200 feet distant. This contains five Whitney column-type recording ammeters, one for each generator, and one recording voltmeter made by Chauvin & Arnoux. These instruments are all inclosed in square glass cases resting on a marble base supported by brackets. In the space below these meters are some Standard pressure gages, one to indicate the pressure of the heating supply, another the pressure of the heating returns, a third to indicate the water pressure for elevator service and still another to show the air pressure for the Johnson system of temperature control.

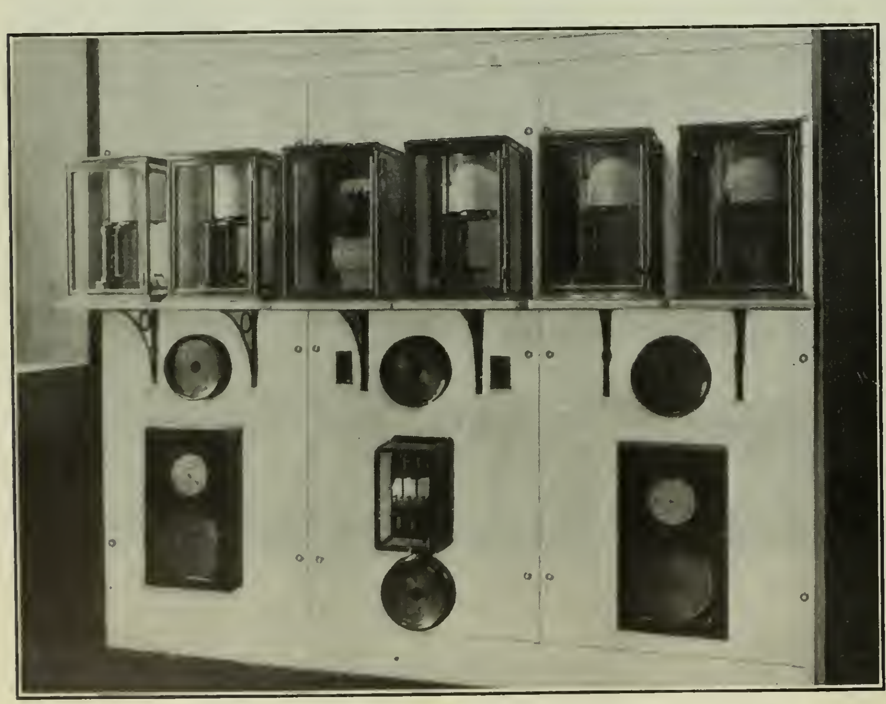


FIG. 9. RECORDING BOARD IN SUPERINTENDENT'S OFFICE

There is also a Dibble telethermometer to record the temperatures in the music hall 350 feet away, and a Queen & Co. telemanometer for recording the boiler pressure, and in addition a recording instrument to show the length of time each generating unit is on.

Both the French and Whitney meters are handled by Machado & Roller, of New York City, and were furnished on account of their accuracy and the small amount of current required to operate them. The French instruments are of the d'Arsonval type, equipped with mechanism of unusual size so that the torque is unusually large when compared to the friction of the pencil. The Whitney instruments are operated from the same shunt as the French recording ammeters in the engine room, that is, the two recording ammeters for each machine are operated in parallel, and the Whitney instruments at a distance of 200 feet from the shunt.

The operation of the Whitney meters is somewhat unusual, but broadly speaking, the principle on which the meter is based consists in causing the variations in the current to be measured to control the variations in pressure of a body of air in a closed vessel, these variations being in turn indicated by the rise and fall of a column of oil of comparatively large diameter, carrying a hollow float which supports the recording pen at its extremity. The chart drum is rotated 1 inch an hour by internally placed clockwork. The pen has a stroke of 6 inches and the drum a circumference of 24 inches. Fig. 10 shows the construction of the meter, and its operation may be explained as follows:

Air at a fairly constant pressure of about 1¾ pounds to the square inch is delivered to the pipe *A*, enters the chamber *B* and then flows through a series of porous diaphragms made of filter paper, whose prime function is to serve as an air resistance and incidentally to remove any dust particles. The air then enters the passage *D*, into which is drilled the opening *E* capped by the valve *F*. This valve

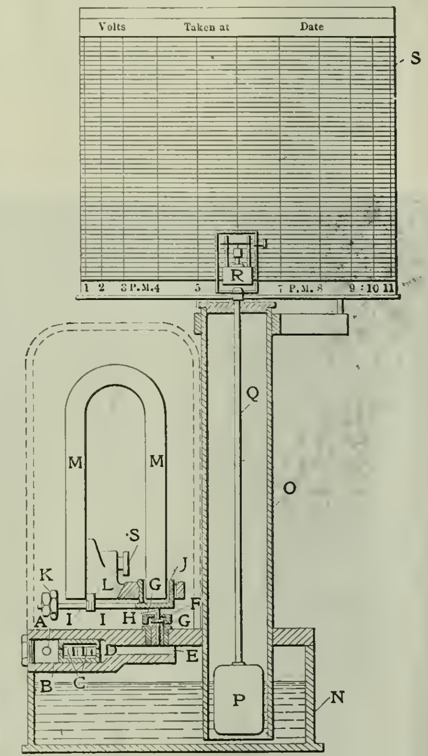


FIG. 10. CONSTRUCTION OF COLUMN TYPE METER

is a small flat disk resting on a circular seat with escape ports *G* below it and a pin *H* resting on top. On the pin rests a spool *J* carried on one end of the lever *I*, on the other end of which is the counterweight *K* by means of which the effective weight on the pin *H* can be adjusted. The spool is wound with wire through which the current to be measured is passed, this being done by means of the two thin, short copper ligaments *L* which support and form the pivots about which the lever can oscillate. A magnet *M* furnishes a field of force of such strength that the reaction between it and the current forces the spool down, with a force increasing as the current increases. The valve *F* is thus a variable-loaded safety valve whose blowing-off point is constantly and proportionately varied by the current variation. The counterweight *K* on the lever is so adjusted that when no current is passing through the spool, the weight on the valve pin is such as to give a zero reading on the scale. The air pressure cannot give a higher reading, as any tendency to increase simply results in lifting the valve slightly higher, whereupon more air escapes and the pressure falls back, and *vice versa* with the opposite condition, due to the constant flow of air from the high-pressure supply at A. The total motion of the spool is less than a hundredth of an inch, and the only work that the varying current has to perform is to control the air pressure. The actual energy required to move the liquid and to show the variation in current readings being supplied by an independent source. With these conditions, the instrument is extremely accurate and a drop of from 20 to 25 millivolts for full scale indication is all that the meters require.

Steam Supply and Exhaust

Below the engine room there is a pipe cellar and an ell extension which afford ample space for all the piping connections. In this cellar is located the 24-inch steam header and receiver which connects to the expansion loops at the end of the 12 inch supply mains and supplies all live steam used in this division of the plant. The header is 110 feet long and is supported 3 feet above the floor on roller blocks. Each engine is fed by a 6-inch branch taken from the top of the header and carried up with a long radius bend to a gate valve, which is operated by hand, and thence through a return loop to the throttle valve, which is controlled from the floor stand in the engine room and in nearly all cases is operated by the Monarch system of engine-stops. As the lines to the engines rise from the top of the header, no separators are required, and from each a 2 inch connection is made to the engine receiver for reheating purposes. To all the auxiliary equipment steam is supplied by a 5 inch branch, to which six lines are tapped to supply the various units. To the elevator pumps there are two 3-inch connections, another 3-inch to the two smaller elevator pumps, two 2½-inch pipes to the vacuum pumps and ammonia compressor, and a 2-inch tap extending to the drip-receiver pump and the two small pumps for oil circulation. There is an 8-inch connection to the main header to supply live steam to the heating system. The connection to the heating mains is made through two pressure reducing valves in tandem; usually live steam is not necessary, but this provision has been made so that in the case of extreme weather the boilers may be called into service to supply the demands of the heating system.

Exhaust from all the steam-using machinery is collected in a common main serving as the low-pressure supply to the heating system. The main is supported above the steam header in much the same way as the supply lines in the tunnel. In the ell extension to the pipe cellar it is 14 inches in diameter, increases to 20 inches as it enters the engine room, and again to 24 inches toward the west end of the room. Each of the engine units is provided with a 12-inch exhaust, two 6-inch mains connect the large elevator pumps to the exhaust main and a number of smaller connections to the 14-inch end of the line relieves the remaining equipment of exhaust steam.

From both the 14-inch and 24-inch ends of the exhaust main, delivery is made to the heating system through Utility combined grease extractors and muffler tanks. On the large end of the main the muffler tank is 5 feet in diameter by 14 feet long, and from a continuation of the 24-inch main past the muffler, two 16-inch and one 12-inch heating mains are taken off, and beyond this the exhaust may escape to atmosphere through a Kieley back-pressure valve into a 24-inch exhaust riser. At the smaller end of the exhaust main the muffler tank is 4 feet in diameter by 9 feet long, and from this tank connections are made to a 9-inch and a 12-inch heating main, and also to a 5-inch line supplying a hot-water heater. At the end of the 20-inch section of the exhaust main two 14-inch connections are made to the Webster heaters located in the ell extension. The system of piping just described is thoroughly dripped by means of traps which discharge to the sewer.

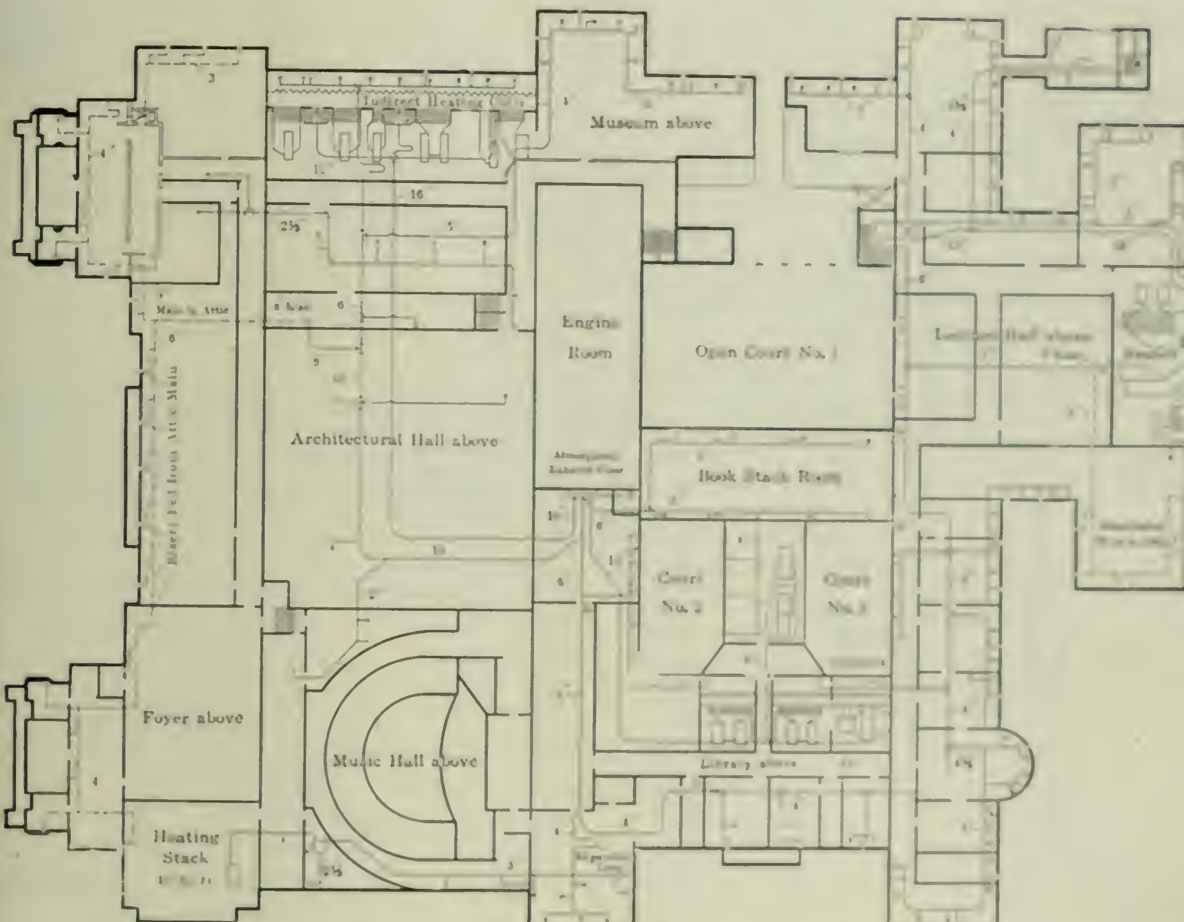


FIG. 11. GENERAL OUTLINE OF HEATING SYSTEM

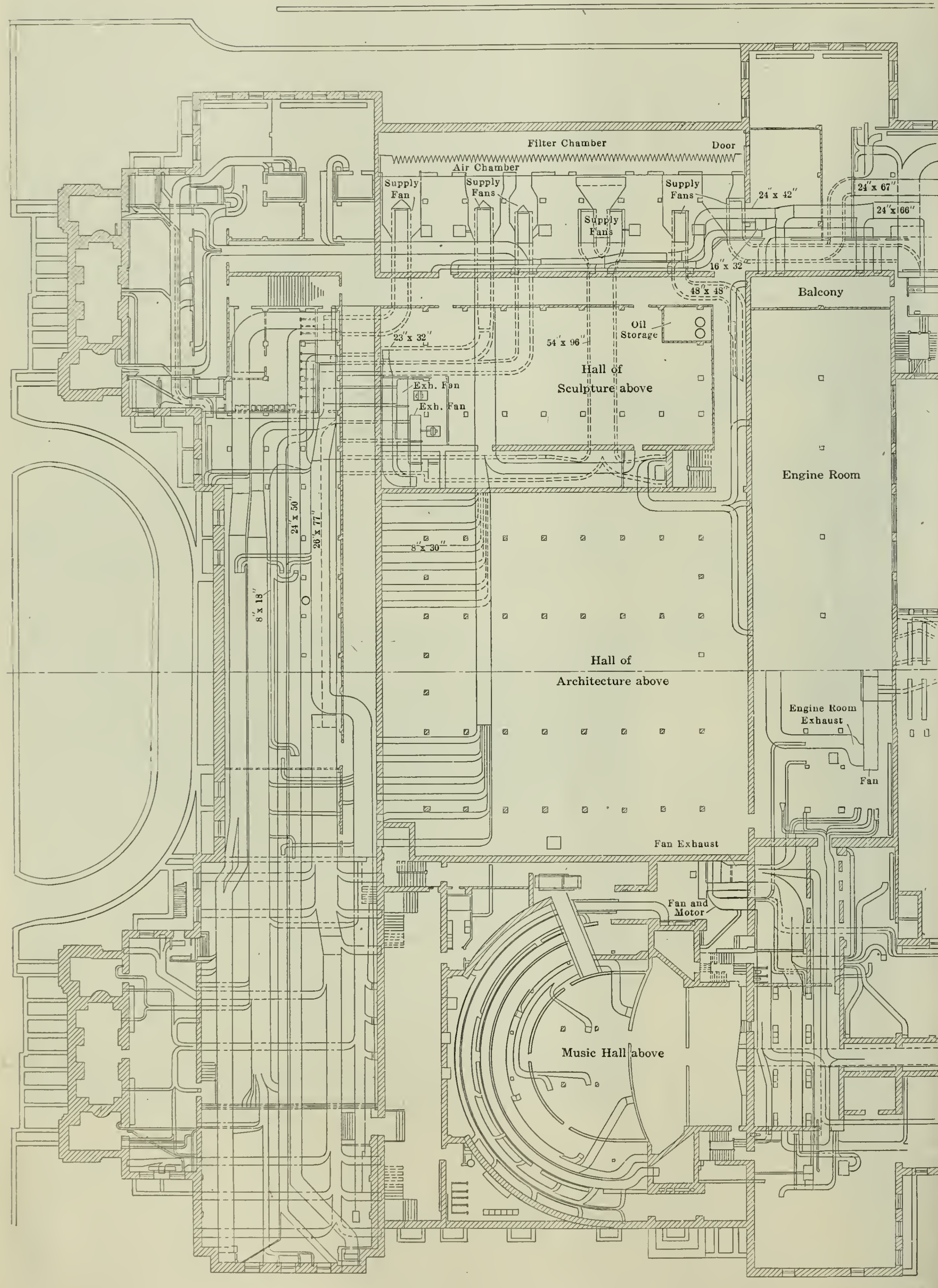


FIG. 12. VENTILATING SYSTEM IN LEFT HALF OF BASEMENT

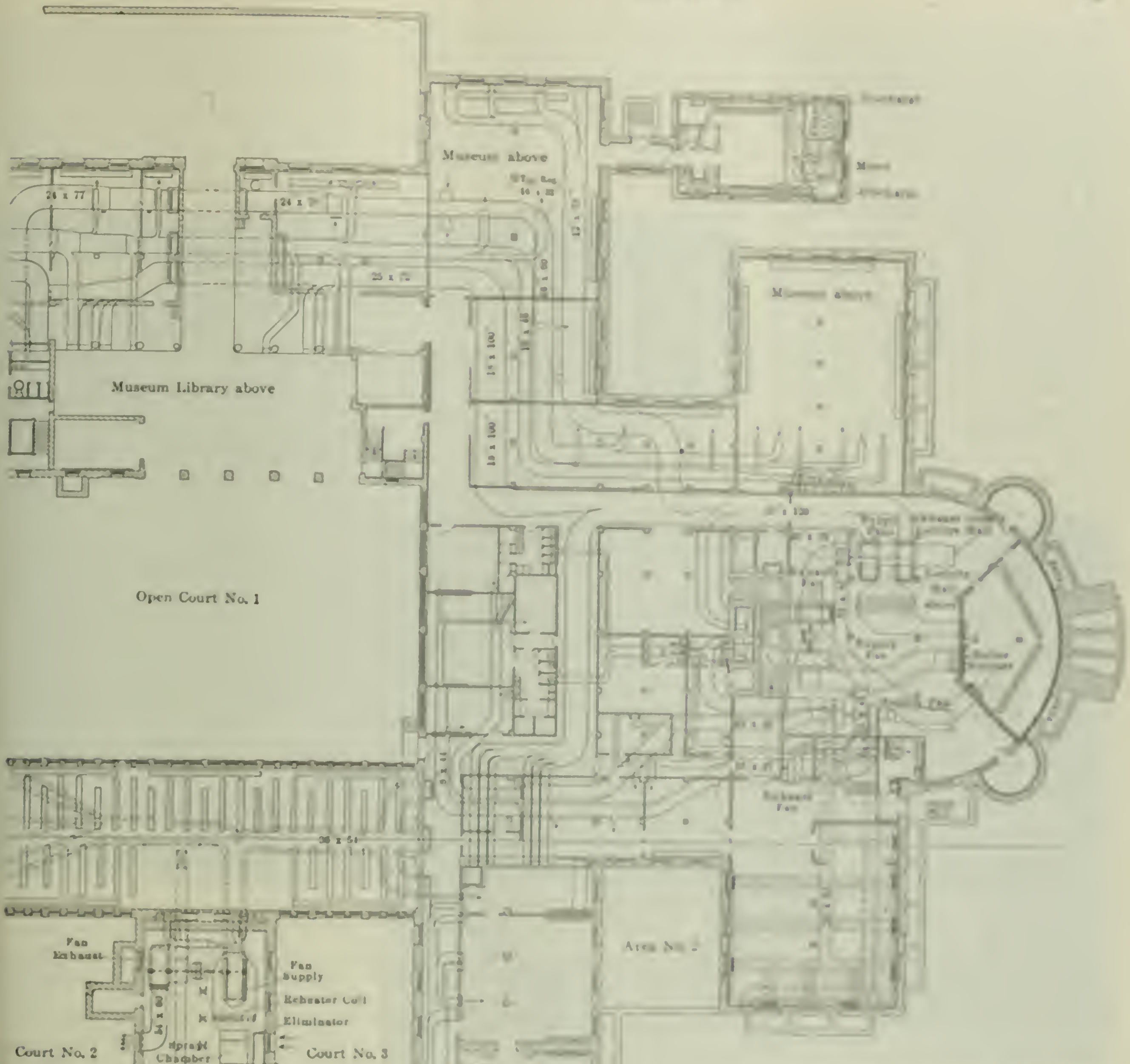


FIG. 13. VENTILATING SYSTEM IN RIGHT HALF OF BASEMENT

and all pipes, both high- and low-pressure, are covered with 85 per cent. sectional magnesia covering. On the exhaust this is 1 inch thick, and on the live-steam mains the covering is doubled.

Heating System

With the exception of the music hall, the entire building is heated by direct radiation, and the design of the system provides for maintaining the temperature at 70 degrees Fahrenheit during zero weather. To make this possible, over [illegible] square feet of direct radiation was required, necessitating an extensive system of steam supply and return piping. The supply system consists of nine distinct mains, three of which supply the tempering coils of the ventilating system. Two of the three lines are 10 inches in diameter, and the third is a [illegible] main. The other six lines, one 10 inches, one 8 inches and four 6 inches in diameter, lead from the [illegible] to the distributing mains which supply the risers to all parts of the building. The supply and distributing mains are suspended from the ceiling of the basement, and all are properly dripped, covered with magnesia pipe insulation, and ample provision has been made for expansion.

In all, 116 risers supply steam to over 36,000 square feet of radiation upon the upper floors, which is subdivided into units, varying from 42 to 972 square feet each. The risers vary in size from 1¼ to 2½ inches and are all drained at their lower ends. The pipes are anchored at the base, expansion upward is provided for, and all are concealed in chases in the walls, branch connections to the radiators being made in nearly all cases under the floors. Throughout the building the supply mains are paralleled by the returns, of which there are 114 returning to a header in the engine-room subbasement. All but nine of these return lines are ¾ inch in diameter; four of the nine are 1-inch pipes and five are 1¼ inches in diameter.

Bundy standard radiators, fitted with Jenkins radiator valves on the supply and Webster thermostatic release valves on the return end, are installed throughout the building. In some of the larger rooms Bundy circular radiators are used, this type being preferred when the side walls were required for exhibiting works of art. Radiators up to 40 square feet of heating surface are supplied with steam by ¾-inch pipes, from 40 to 90 square feet by 1-inch pipes, and from the latter size up to 250 square feet the pipes gradually increase in diameter, in proportion with the radiating surface, up to 1½ inches. Above this limit 2-inch supply connections are made. Up to the limit of 250 square feet of radiating surface, the returns are all ½-inch, and radiators larger than this are fitted with ¾-inch return connections.

The radiation is all operated on the Webster vacuum system, and from the return header in the engine-room subbasement the air and condensation is pumped by a duplicate set of Knowles 8x14x16-inch vacuum pumps to a 3x6-foot steelplate air-separating tank, which is provided with a 4-inch vapor connection to the roof. From here the condensation flows by gravity to the Webster open heaters, of which there are two, rated at 1500 horsepower each. From the heaters the condensation is taken as boiler feed and carried to the boiler room, as previously described.

All radiating surface is controlled by the Johnson system of temperature regulation; 333 thermostats of the Johnson pneumatic type are installed throughout the building, and these control a total number of 646 heat sources. In a large number of the smaller rooms a single thermostat controls all the radiators provided for their heating, while in the larger rooms a few thermostats control a large group of radiators, and are so placed as to secure the average temperatures of the rooms. Pneumatic pressure for the thermostats is supplied at 15 pounds pressure by a duplicate set of Marsh compressors in the pump room. A feature in the installation of thermostatic control was introduced in the form of push buttons to regulate the skylight radiation.

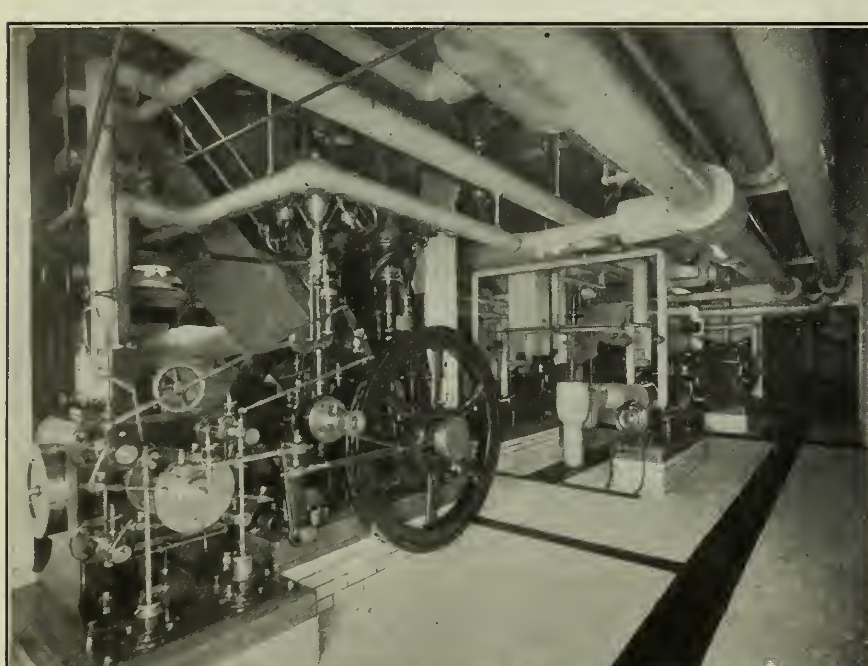


FIG. 14. AMMONIA COMPRESSOR IN PUMP ROOM

Ventilation

The entire building is ventilated mechanically, and the installation of fans required to supply the fresh air and exhaust the foul air is one of the largest ever placed in a single building. The supply fans have a capacity of over 600,000 cubic feet of free air per minute, and the exhaust fans a capacity slightly greater. For convenience, the fresh-air apparatus is arranged in 15 stations, containing in all 19 fans, and the exhaust equipment in 21 stations containing 30 fans. The equipment is Sturtevant, driven by C. & C. direct-current motors of the slow-speed multipolar type. The motors are direct connected to the fans and may be varied by field control from two-thirds to full speed. The fan wheels vary in diameter from 2½ to 10 feet, depending upon the service required.

For convenience in making duct connections the 19 centrifugal blowers are arranged in three general divisions: the first division including Systems 1 to 6; the second, Systems 7, 8 and 10, and the third, Systems 9, 11, 12 and 13. Even in this case some of the connections are 500 feet in length, but on the whole a convenient installation has been secured. In the first division all the fans have a common intake from a large continuous air filter, which is provided with fresh air from nine large outer windows. Within the intakes and between the filtering chamber and the fans are tempering coils, which, like the direct radiation, are controlled by thermostats. The air filters are of the usual cheesecloth type, with frames mounted in racks zigzagged to secure the maximum area of filtering surface. The areas of the filters for the different divisions are proportioned for velocities of 30 to 45 feet per minute.

For System 9 an air-washing equipment was provided instead of the usual type of filter. This consists of a spray chamber, an eliminator to separate the particles of water from the air and two sets of tempering coils: one to raise the temperature of the air above the freezing point in very cold weather, and the other for tempering the air the desired amount. The spray chamber consists of a system of piping, with a series of nozzles in staggered rows, which spread out the water in a thin sheet perpendicular to the direction of flow, and with the nozzles distributed in this manner a continuous sheet of water is provided for the air to pass through, which it does in this particular installation at a velocity of 10 feet per second. The water from the nozzles is used over and over again and is circulated by a small motor-driven centrifugal pump. When it becomes too dirty for further use, it is discharged to the sewer and a fresh supply taken. Between the spray chamber and the fan intakes is the eliminator, consisting of a number of rows of inclined baffle plates, which are in reality vertical strips of sheet copper 6 inches wide, provided with hook edges on the side toward the fan to catch the particles of water.

All of the supply systems except one are provided with tempering coils, which have a total heating surface of 87,042 linear feet of 1-inch pipe, and for the most part are 1-inch pipe screwed into manifolds on the steam and return ends on 2½-inch centers. From the fans to the flues making connection with the various sections of the building, connections are made by means of brick ducts underneath

FIG. 15. WATER FILTERS, COOLING TANK AND VACUUM CLEANING APPARATUS

the floor, or by means of galvanized-iron ceiling ducts. In general these connections are proportioned for a velocity of flow of about 1200 feet per minute, and the vertical flues for a velocity of 500 to 600 feet per minute. In practically all cases the ducts have been run below the piping system, so that it would not be necessary to pass the pipes through them. In the basement all fresh-air duct work is covered with magnesia block 1 inch thick, this is wired on and is covered with 10-ounce canvas. All flues at points above the basement are covered in the same way, and the tempering coils and fan casings and the connections between them, as well as the centrifugal exhaust-fan casings are covered with the same material 1½ inches thick. In practically all cases the registers in the various rooms are located in the upper portions, and the supply of fresh air directed downward.

For the exhaust system a total capacity of 640,000 cubic feet per minute, distributed among 30 fans, has been provided, and these are more generally distributed throughout the building than are the supply fans. Some of the equipments are located in the basement, but a larger number have been installed in the attic at points convenient to the exhaust flues.

Disk fans of the Blackman type were used wherever conditions would warrant, and in all there are 21 equipments of this type; 10 of these are located in the attic and are arranged to draw through vertical flues, the air escaping through roof discharge hoods. The other nine equipments were by necessity centrifugal exhaust fans, due to the long gathering duct lines and the long vent risers discharging the air.

REFRIGERATION

Some refrigeration for cooling the drinking water and for service in a kitchen to be installed in the building was made necessary, and a system of [illegible] tons capacity has been installed. A vertical Frick compressor, driven by a horizontal Corliss engine, compresses the ammonia which cools the drinking water. For this purpose the ammonia is expanded directly in coils in a [illegible]-gallon tank and cools the water to 42 degrees Fahrenheit. The water is circulated to the various outlets in the building by a Gardner piston pump, [illegible] inches. In the kitchen brine circulation is to be employed, and the brine tank and pump are ready for this service.

HYDRAULIC ELEVATORS

In this department there are three [illegible] plunger elevators for carrying passengers. These have a lifting capacity of [illegible] pounds each and were designed to run at a speed of 250 feet per minute. There is also a freight elevator, with a platform 13 feet 6 inches by 17 feet 9 inches. At the usual working pressure of 150 pounds per square inch, this elevator will lift [illegible] pounds, but its capacity can be doubled by the use of a jack pump, which is a Wilson-Snyder, [illegible] inches, of the duplex type. The regular pressure on the system is turned into this pump and is increased to 300 pounds, giving the freight elevator a lifting power of [illegible] pounds. The usual pumping equipment is a duplicate set of Wilson-Snyder outside-packed plunger pumps, which are duplex tandem compound, with dimensions [illegible] inches. Another elevator pump of the

FIG. 16. [illegible]

same make, [illegible] inches, has been provided for night service. The pumps all discharge into a large pressure tank [illegible] feet in diameter by [illegible] feet long, and the returns from the elevators are collected in a large open tank having a capacity of approximately [illegible] gallons.

Vacuum Cleaning

To be thoroughly uptodate, the building was equipped with a vacuum-cleaning system installed by the Vacuum Cleaner Company, of New York City. This is used principally to clean the floors and to draw dust from rugs and all upholstered work. The equipment consists of a double filter, in which the coarse dirt is removed first, and the air with the finer particles of dust is discharged under water into the second filter. A duplicate set of suction engines, 12x15 inches, is provided.

Compressed-air Supply

There is considerable use for compressed air in the plant. It is used to blow dust out of the generators, from the plumage of stuffed birds and similar uses, and is also required in the elevator pressure tank. The installation supplying the air is a National Brake and Electric Company compressor, which is single-stage and compresses the air to 90 pounds. It is driven by a 35-horsepower National Electric motor, running at 150 revolutions per minute, and at this speed the compressor has a capacity of 200 feet of free air per minute. The motor is automatically controlled from a Cutler-Hammer board. The air is stored in a reservoir 3 feet in diameter by 10 feet long, and is uniformly maintained at 90 pounds pressure by an automatic control.

Baker, Smith & Co., of New York City, were the engineers and contractors in charge of the entire installation, and to them much credit is due for the excellent arrangement and design of the plant.

In discussing the function of oxygen in the corrosion of iron Prof. W. H. Walker said that internal protection of boilers could be provided by merely keeping out the oxygen, ordinarily carried by feed water, by a preheater and a dry-vacuum pump.

Relative Rate of Heat Transfer to Water At and Below the Boiling Point

By W. M. Sawdon

The writer was much interested in the article entitled "Tests on Live Steam Feed Water Heating," by Sydney Bilbrough, in a recent number of Power and The Engineer. One of his statements is "that the rate of heat transmission through a boiler plate is exactly the same from a fire or flames to cold water as it is to boiling water."

On carefully reading this article it appeared that such broad generalizations on so simple and crude an experiment were not justifiable. This is especially true when we consider that his deductions are exactly contrary to the most modern thought along the lines of heat transfer. Mr. Bilbrough does not explain how he prevented radiation nor how he corrected for it and from his conclusions it would appear that he either forgot or neglected that very important factor. It does not seem fair, therefore, that such conclusions should be allowed to stand without further consideration and proof.

The heat lost by radiation from a small piece of apparatus not properly insulated is likely to be large and is in no wise to be neglected. It depends upon the character of the apparatus as well as upon the time or rate of heating. Unfortunately, tests for radiation corrections are difficult and likely to be misleading, but it is self-evident that when the temperature of the water and the surrounding air are the same, radiation will be *nil,* and that when the water is boiling, radiation will be greatest. Mr. Bilbrough's own experiments might then be used as proof of the falsity of his conclusions, since he found the apparent transfer of heat to be the same at the high temperature, when there was much radiation, as at the low temperature when the radiation was slight.

For the purpose of determining to what extent such experiments could be depended upon and wherein Mr. Bilbrough had failed in his observations, some simple tests of a similar character were made in the laboratory of Sibley College.

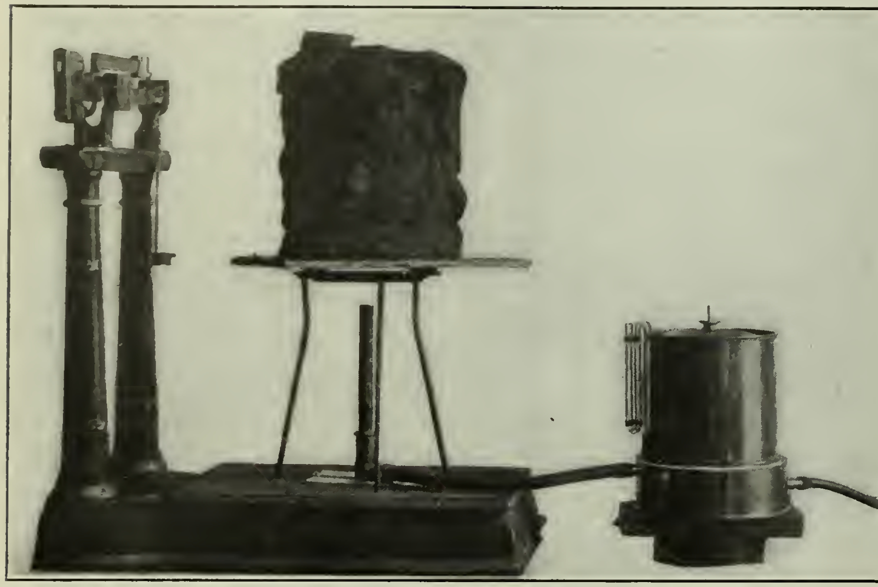


FIG. 1. APPARATUS FOR DETERMINING RELATIVE RATE OF HEAT TRANSFER

TABLE 1. TEST OF RATE OF HEAT TRANSMISSION AT AND BELOW BOILING TEMPERATURE.

WITH HAIR FELT JACKET.

Weight of water, 2 lb. Date, June 22, 1908.

Time.	Diff.	Temperature. Water.	Temperature. Air.	Temperature. Diff.	Temperature. Mean Diff.	Weight, Gross.	B.t.u. In Liquid Above Initial.	B.t.u. Taken up by Steam.	B.t.u. Total Above Initial.	Loss by Radiation. Per Min. From Curve.	Loss by Radiation. In Time Increment.	Loss by Radiation. Total.	Total B.t.u. Transmitted.
2:57		89.5	87	2.5		10.32							
3:00	3	108.0		21.0	12.0	10.32	37.0		37	0.04	0.12	0.1	37.0
03	6	150.0		63.0	42.0	10.32	121.0		121.0	0.42	1.5	1.6	122.5
06	9	182.0	88	94.0	78.5	10.31	195.0		195.0	1.30	3.9	5.5	200.5
09	12	207.0		119.0	106.5	10.30	235.0	9.5	244.5	2.5	7.5	13.0	257.5
*095	12.5	211.0		123.0	121.0	10.29	243.0	19.5	262.5	3.26	1.6	14.6	277.0
12	15	211.2	88	123.0	123.0	10.24	243.5	77.5	321.0	3.37	8.4	23.0	344.0
15	18	211.2		123.0	123.0	10.16	243.5	154.5	398.0	3.37	11.0	34.0	432.0
18	21			123.0	123.0	10.07	243.0	241.5	484.5	3.37	11.0	45.0	529.5
21	24		88.5	122.5	123.0	9.98	243.0	328.5	571.5	3.37	11.0	56.0	627.5
24	27			122.5	122.5	9.90	243.0	405.5	648.5	3.33	11.0	67.0	715.5
27	30			122.5	122.5	9.80	243.0	502.5	745.5	3.33	11.0	78.0	823.5
30	33		89	122.0	122.5	9.71	243.0	589.5	832.5	3.33	11.0	89.0	921.5
33	36			122.0	122.0	9.63	243.0	666.5	909.5	3.32	10.0	99.0	1008.5
36	39			122.0	122.0	9.55	242.5	744.0	986.5	3.32	10.0	109.0	1095.5
39	42		89.2	122.0	122.0	9.47	242.5	821.0	1063.5	3.32	10.0	119.0	1182.5
42	45			122.0	122.0	9.39	242.5	898.5	1141.0	3.32	10.0	129.0	1270.0
45	48			122.0	122.0	9.30	242.5	985.5	1228.0	3.32	10.0	139.0	1367.0
48	51		89.2	122.0	122.0	9.22	242.5	1062.5	1305.0	3.32	10.0	149.0	1454.0
51	54			122.0	122.0	9.14	242.5	1140.0	1382.5	3.32	10.0	159.0	1541.5
54	57			122.0	122.0	9.05	242.0	1227.0	1469.0	3.32	10.0	169.0	1638.0
57	60		89.5	121.5	122.0	8.97	242.0	1304.0	1546.0	3.32	10.0	179.0	1725.0
4:00	63			121.5	121.5	8.88	242.0	1391.0	1633.0	3.28	9.8	189.0	1822.0
03	66			121.5	121.5	8.80	242.0	1468.5	1710.5	3.28	9.8	199.0	1909.5
4:06	69		90	121	121.5	8.71	242.0	1555.5	1797.5	3.28	9.8	208.0	2005.5

*Boiling.

Apparatus

The apparatus was somewhat similar to that employed by Mr. Bilbrough and will be clearly understood by reference to the photograph, Fig. 1. The tank was made from an old Carpenter calorimeter from which the bottom had been removed. A stirring device, consisting of a ring of sheet metal turned down at the edge for stiffness and having a small rod soldered on for a handle, was inserted and then a new bottom soldered on. This left three holes in the top, one through which the stirring rod passed, one for the thermometer and the third for the steam to pass out.

A rectangular piece of asbestos board, 10½x12 inches and ¼ inch thick, was put cut at the center so as to fit closely over the outside of the calorimeter. This was slipped on so that the bottom of the board was flush with the bottom of the calorimeter. It served the double purpose of defining the heating surface (0.165 square foot) and of protecting any insulating material which might be placed around the calorimeter.

The heat supply was a gas flame from a special burner belonging to the Junker calorimeter and the pressure of the gas was kept constant by a pressure regulator. This pressure was equal to 10 millimeters of water and the gas was from the city mains.

The thermometer had a range of 220 degrees Fahrenheit, was graduated in degree divisions and could readily be estimated to ¼ degree. Readings closer than ¼ degree were not thought to be justifiable in this experiment and were not attempted.

The calorimeter was placed on two small square rods upon an iron stand and this, together with the burner, rested upon a small platform scale. The scale was graduated to [illegible] of a pound, permitting reading to hundredths of a pound.

METHOD

Two pounds of water was carefully weighed on an accurate balance and poured into the calorimeter. After allowing this to stand for a sufficient length of time for the temperature conditions to become steady, it was thoroughly stirred and the temperature taken. The gas was then quickly lighted and the time, temperature and weight noted. Readings were taken at short intervals until most of the water had boiled away.

The log and results of these experiments, both with a hair-felt jacket on the calorimeter and with no jacket, are shown in Tables 1 and 2, respectively.

Tests were also made for radiation by proceeding as before, but in this case the gas was turned off at the instant the water began to boil and the loss of heat from that time noted. The log and results for these two tests are shown in Tables 2 and 3.

RESULTS

The results of tests (Tables 1 and 2) are shown graphically by curves a and b in Fig. 2. The total heat above initial is the heat of the liquid above the initial plus the heat passing off with the steam.

TABLE 2. RADIATION TEST WITH HAIR FELT JACKET.

Weight of water, 2 lb. Date, June [illegible]

Time Actual	Time Diff.	Temperature Water	Temperature Air	Temperature Diff.	Temperature Mean Diff.	Weight, Grams	B.t.u. In Liquid Above Initial	Loss by Radiation Total	Loss by Radiation Diff.	Loss by Radiation Per Min.
9:24		78.5	80			10.32				
27	3	104.0	80			10.32	51			
30	6	145.0	80			10.31	133			
33	9	174.0	81			10.31	191			
36	12	203.0				10.30	249			
37	13	211.0				10.30	265			
*9:38	14	211.5	81	130.5		10.27	266			
40	16	210.0		129.0	130.0	10.26	263	3	3	1.5
43	19	206.5		125.5	127.5	10.25	256	10	7	2.33
46	22	202.0	81	121.0	123.5	10.24	247	19	9	3.0
49	25	197.5		116.5	118.9	10.23	238	28	9	3.0
52	28	193.0		112.0	114.5	10.22	229	37	9	3.0
55	31	189.0	81	108.0	110.0	10.21	221	45	8	2.67
10.00	36	183.0		102.0	105.0	10.20	209	57	12	2.4
05	41	177.5		96.5	99.5	10.20	198	68	11	2.2
10	46	173.0		92.0	99.5	10.19	189	77	9	1.8
15	51	169.0		88.0	90.0	10.19	181	85	8	1.6
30	66	158.0	82	76.0	82.0	10.17	159	107	22	1.47
45	81	149.0	82	67.0	71.5	10.17	141	125	18	1.2
11.00	96	142.5		60.5	64.0	10.16	128	138	13	0.87
15	111	136.5	84	52.5	56.5	10.16	116	150	12	0.8
30	126	132.0		48.0	50.5		107	159	9	0.6
12:00	156	123.5	84	39.5	44.0	10.13	90	176	17	0.57
2:30	186	103.0	87	16.0	28.0	10.13	49	217	41	1.37
5:00	336	96.5	89	7.5	12.0	10.12	36	230	14	0.09

*Boiling, gas turned off

TABLE 3. TEST OF RATE OF HEAT TRANSMISSION AT AND BELOW BOILING TEMPERATURE

WITHOUT JACKET ON CALORIMETER

Weight of water, 2 lb. Date, July 11, 1908

Time	Diff	Temperature Water	Temperature Air	Temperature Diff	Temperature Mean Diff	Weight Grams	B.t.u. In Liquid Above Initial	B.t.u. Taken up by Steam	B.t.u. Total Above Initial	Loss by Radiation Per Min. From Curve	Loss by Radiation In Time Increment	Loss by Radiation Total	Total B.t.u. Transmitted
8:24		75.5	75	0.5		9.55							
27	3	107.0		32.0	16.0		63.0		63	0.22	0.5	0.5	[illegible]
30	6	137.0	75	62.0	47.0		123.0		123	1.20	3.5	4.0	127.0
33	9	168.0		93.0	77.5	9.54	185.0	9.5	194.5	2.42	7.[illegible]	11.[illegible]	[illegible]
36	12	195.5		120.5	106.8		240.0	9.5	249.5	3.67	12.0	23.[illegible]	[illegible]
*8:38	14	211.0	76	135.0	127.8	9.53	271.0	19.5	290.5	5.22	10.[illegible]	34.0	[illegible]
41	17	211.0		135.0	135.0	9.48	271.0	67.[illegible]	338.5	5.67	17.0	51.0	[illegible]
44	20	211.0		135.0	135.0	9.42	271.0	125.5	396.5	5.67	17.0	68.0	464.5
47	23	211.0		135.0	135.0	9.35	271.0	193.0	464.0	5.67	17.0	85.0	549.[illegible]
50	26	211.0		135.0	135.0	9.28	270.5	261.0	531.5	5.67	17.0	102.0	[illegible]
55	31		77	134.0	135.0	9.19	270.5	348.0	618.5	5.67	17.0	119.0	[illegible]
9:00	36			134.0	134.0	9.07	270.5	464.5	734.0	5.60	28.0	147.0	[illegible]
05	41			134.0	134.0	8.97	270.5	560.5	831.0	5.60	28.0	175.0	1006.0
10	46			134.0	134.0	8.85	270.5	676.0	946.5	5.60	28.0	203.0	1149.5
15	51			134.0	134.0	8.74	270.0	782.5	1052.5	5.60	28.0	231.0	[illegible]
20	56			134.0	134.0	8.63	270.0	888.5	1158.5	5.60	28.0	259.0	[illegible]
25	61			134.0	134.0	8.53	270.0	985.5	1255.5	5.60	28.0	287.0	[illegible]
30	66			134.0	134.0	8.41	270.0	1091.0	[illegible]	5.60	28.0	315.0	[illegible]
35	71		78.5	132.5	134.0	8.30	270.0	1207.[illegible]	[illegible]	5.60	28.0	343.0	[illegible]
40	76			132.5	132.5	8.19	269.5	1314	1583.5	5.5	27.5	[illegible]	[illegible]
45	81			132.5	132.5	8.08	269.5	1420	1689.5	5.5	27.5	[illegible]	[illegible]

*Boiling

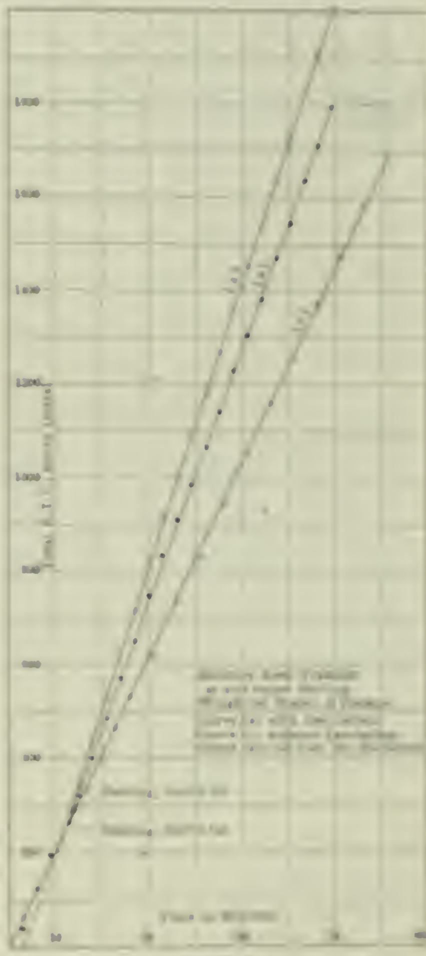


FIG. 2

This is used as ordinates and the time in minutes as abscissas in plotting the curves. Curve *a* is made up of two straight lines which meet in an angle at the boiling point and clearly shows that the rate of heat transfer is greater above than below this point. The dotted line is an extension of the upper end of *a*. Curve *c* is plotted in the same way and is one continuous straight line. This shows that with no insulation and no correction for radiation the rate of heat transmission remains the same. This result corresponds to that of Mr. Bilbrough and shows plainly wherein he failed.

In order to make the radiation correction, the mean difference in temperature of water and air for each small interval of time and the corresponding loss of heat per minute were calculated. These were then plotted as shown in Plate 2. As might be expected, the upper ends of

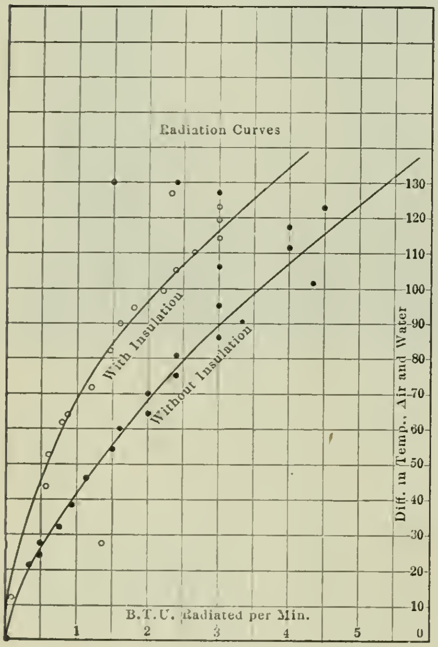


PLATE 2

these curves afford little definite information of the radiation at the higher temperatures. The reason for this is that parts of the apparatus such as the iron stand, the asbestos board and even the lower end of the hair-felt jacket acquire a temperature much higher than that of the water and these parts yield up heat to the water for a considerable time after the gas is turned off, and the radiation through this period appears to be only a small part of what it really is. The water equivalent of the apparatus might be found, but this would be useless since the temperature of the several parts could not be easily measured.

The best that can be done, then, in the way of correcting for radiation is to produce the curve found for the lower part of the range where it is consistent. This is the manner in which these curves were drawn and while they are not absolute they are conservative, especially in the case of the noninsulated test. From these curves the radiation was taken and applied to tests (Tables 1 and 3) and a curve *a'* so corrected was drawn on Plate 1. The corresponding curve for *c* falls so close to curve *a* that it was omitted.

If the efficiency of the heating surface remained the same with the jacket on the calorimeter as without, then these corrected curves should coincide, since the B.t.u. supplied times efficiency of transfer equals B.t.u. in liquid above initial plus B.t.u. carried away with the steam plus B.t.u. lost by radiation.

It is quite probable that the efficiency of transfer is slightly greater in the case of the insulated test since the hair felt near the bottom would become heated and transmit some heat to the water.

Summary

(1) Test with calorimeter jacketed, radiation disregarded. B.t.u. absorbed below boiling point (12.5 minutes) = 262.5 B.t.u. per hour =

$$\frac{262.5 \times 60}{12.5} = 1260$$

B.t.u. absorbed above boiling point (56.5 minutes) = 1535 B.t.u. per hour =

$$\frac{1535 \times 60}{56.5} = 1630.$$

Gain by hot water over cold,

$$\frac{1630 - 1260}{1260} = 29$$

per cent.

(2) Test with calorimeter bare, radiation disregarded. B.t.u. absorbed below boiling point (14 minutes) = 290.5 B.t.u. per hour =

$$\frac{290.5 \times 60}{14} = 1245$$

B.t.u. absorbed above boiling point (67 minutes) = 1399 B.t.u. per hour =

$$\frac{1399 \times 60}{67} = 1253.$$

Gain by hot water over cold,

$$\frac{1253 - 1245}{1245} = 0.64$$

per cent.

(3) Test with calorimeter jacketed and corrected for radiation. B.t.u. absorbed below boiling point (12.5 minutes) = 277 B.t.u. per hour =

$$\frac{277 \times 60}{12.5} = 1329$$

B.t.u. absorbed above boiling point (56.5 minutes) = 1728.5 B.t.u. per hour =

$$\frac{1728.5 \times 60}{56.5} = 1835.$$

Gain by hot water over cold,

$$\frac{1835 - 1329}{1329} = 38$$

per cent.

Weight of water actually evaporated = 1.61 pounds.

Weight of water evaporated per hour per square foot of heating surface =

$$\frac{1.61 \times 60}{69 \times 0.165} = 8.48$$

pounds.

TABLE 4. RADIATION TEST, WITHOUT JACKET ON CALORIMETER.

Weight of water, 2 lb. Date, July 11, 1908.

Time.		Temperature.			Mean Diff.	Weight, Gross.	B.t.u. in Liquid Above Initial.	Loss by Radiation.		
Actual.	Diff.	Water.	Air.	Diff.				Total.	Diff.	Per Min.
10:14		76.5	78.5			9.54				
17	3	107.5				9.54	62.0			
20	6	138.5				9.54	124.0			
23	9	170.0	79.0			9.53	187.0			
26	12	198.0				9.53	242.0			
*27½	13.5	211.0		132.0		9.52	269.0			
30	16	208.0	80.0	128.0	130.0	9.51	263.0	6	6	2.4
32	18	205.0		125.0	126.5	9.50	257.0	12	6	3.0
34	20	200.5		120.5	123.0	9.50	248.0	21	9	4.5
37	23	194.5		114.5	117.5	9.50	236.0	33	12	4.0
40	26	188.5	80.0	108.5	111.5	9.49	224.0	45	12	4.0
43	29	184.0		104.0	106.5	9.49	215.0	54	9	3.0
46	32	177.5		97.5	100.5	9.49	202.0	67	13	4.33
49	35	173.0		93.0	95.5	9.48	193.0	76	9	3.0
52	38	168.0		88.0	91.0	9.48	183.0	86	10	3.33
55	41	163.5		83.5	86.0	9.48	174.0	95	9	3.0
11:00	46	157.5		77.5	80.5		162.0	107	12	2.4
05	51	152.0		72.0	75.0		151.0	118	11	2.2
10	56	147.0	80.0	67.0	70.5		141.0	128	10	2.2
15	61	142.0		62.0	65.0		131.0	138	10	2.2
20	66	138.0		58.0	60.0		123.0	146	8	1.6
30	76	130.5		50.5	54.5		108.0	161	15	1.5
45	91	122.0		42.0	46.5		91.0	178	17	1.13
12:00	106	115.0		35.0	38.5		77.0	192	14	0.93
15	121	109.5		29.5	32.5		66.0	203	11	0.73
30	136	105.5		25.5	27.5		58.0	211	8	0.53
45	151	102.0		22.0	24.0		51.0	218	7	0.47
1:00	166	99.5		19.5	21.0		46.0	223	5	0.33

*Boiling, gas turned off.

Conclusions

(1) That with no protection from radiation the loss of heat may be sufficient entirely to eclipse the gain by boiling water.

(2) That there is a gain in the rate of heat transfer by boiling water over cold water of at least 38 per cent. in an apparatus of this kind. Actual boiler tests in the Sibley laboratories have confirmed this latter conclusion. As to whether this gain is due to rapid circulation of the water remains for future experiments to prove.

Coal; Its Composition and Combustion*

General Discussion of the Elements which Combine to Promote Combustion; How to Ascertain the Degree of Combustion Attained

BY WILLIAM H. BOOTH

It is usual to speak of heat under various names. It is thermometric, specific, or latent. By the first is meant that property of heat which sets up molecular vibrations in a substance, which are capable of transmission to surrounding bodies by radiation or by contact.

By specific heat we mean the amount of heat energy that is necessary to set up a certain degree of thermometric heat in a unit or mass of some body. The same addition of heat to a pound of lead that has made a pound of water comfortably warm would enable the lead to burn a hole through a man's hand.

By latent heat is understood heat that has become converted into energy of condition without thermometric manifestation, as when heat added to ice at 32 degrees Fahrenheit enables that ice to exist as a free liquid and still only to affect the thermometer to 32 degrees Fahrenheit. Here, heat represents mobility of the molecules.

In a wide general sense every chemical reaction may be cited as a combustion. Certainly the converse is true—combustion is a chemical reaction. All substances are, in a broad sense, fuels. Many are difficult to ignite. Many have already entered into combustion or are results of chemical processes so energetic that it is difficult to establish any other reaction. Lime, for example, is the product of a combination of the metal calcium with the gas oxygen, and the energy of union is so great that the metal calcium, though one of the most common of nature's so-called elements, is hardly known except as an oxide or a carbonate.

Aluminum is a metal that unites so firmly with oxygen that it will usurp the place of iron in a mass of burned iron, and convert a mass of mill scale into pure iron by itself becoming an oxide. Hence the thermit process. The fuels that are commonly regarded as fuels are wood and coal and mineral oils. These are found free in nature, and are easily burned and give out considerable heat. Ages of experience have taught us that air is necessary to combustion. The fire of wood burns the better when the wind blows upon it. The wind we can feel, if we cannot see it. The effect is to blow away the CO_2 and leave the fuel freely exposed to fresh supplies of oxygen.

Carbon gas is ideal only. Carbon exists as gas in the electric arc at 3500 degrees Centigrade. When carbon is burned to monoxide, CO, there are set free 4415 B.t.u. per pound. When this monoxide is burned to dioxide a further heat of 10,232 B.t.u. is set free. Why the difference? Physicists say that the first oxidation also generates at least 10,232 B.t.u. or 5817 units more than is thermometrically discoverable. They say that the 5817 units have become latent because the carbon which was solid is now gaseous in the CO. Therefore, the total heat of combustion of carbon gas, if carbon could be taken in its gaseous form, is $10{,}232 \times 2 = 20{,}464$ B.t.u. per pound.

Now, in CO_2 there are 12 degrees of C and 32 degrees of O, or

$$C : O = 3 : 8$$

Then

$$20{,}464 \times \tfrac{3}{8} = 7674$$

B.t.u. produced by the combustion of 1 pound of oxygen.

Now, for combustion with hydrogen. One pound of this gas gives 62,100 B.t.u. The ratio of the two elements H_2O is 1 : 8.

Now,

$$62{,}100 \times \tfrac{1}{8} = 7763$$

B.t.u. This is almost exactly the heat developed when oxygen is destroyed by gaseous carbon.

In each case three volumes of gas become two volumes, so there is no difference due to a different degree of condensation. Let there be next taken the heat of combustion of a series of hydrocarbons: C_2H_2, C_2H_4, CH_4, C_6H_6 and C_6H_6. These are shown in the second column in B.t.u. per pound of the hydrocarbon.

	B.t.u.		B.t.u.
C_2H_2 =	[illegible]	× [illegible] =	[illegible]
C_2H_4 =	[illegible]	× [illegible] =	[illegible]
CH_4 =	[illegible]	× [illegible] =	[illegible]
C_6H_6 =	[illegible]	× [illegible] =	[illegible]
C_6H_6 =	[illegible]	× [illegible] =	[illegible]
(as gaseous vapor)			
C_6H_6 =	[illegible]	× [illegible] =	[illegible]
(as benzine liquid)			

In the third column is the ratio of the oxygen consumed, and in the fourth the heat units per pound of oxygen used. This table gives room for thought. It shows, in the first place, a gradually decreasing result in heat set free per pound of oxygen destroyed. Between C_2H_2 and C_6H_6, two hydrocarbons with exactly the same proportions of carbon and hydrogen, using up exactly the same weight of oxygen per pound of each, there is a difference of heat set free of 17 per cent (nearly). Burned as vapor and burned as liquid, benzene or C_6H_6 gives a different amount of heat again. The figures become confusing when thus treated, and it is necessary to deal with them by the molecule, as they are treated by the chemist.

How coal is formed cannot be said with absolute certainty, but the probability is that the coal plants accumulated like the accumulation of the peat bogs and became buried in sand and gradually sank to a considerable depth in the earth. There under the influence of heat and pressure, the vegetable matter changed its nature. Its watery constituents were driven off and the remaining portions carbonized, and then were also set up those reactions that produced what we term the bituminous quality. There is no bitumen in coal, but what we mean by bituminous is known to all. Some coal was so much heated that its hydrocarbonaceous matter was driven off to be absorbed in other rocks, such as certain clay shales, or it escaped to the surface and was lost. Thus possibly the Welsh coal was formed with its short flaming qualities that earn for it the term "smokeless," because, though not smokeless in all circumstances, it can be burned without smoke if any simple precautions are taken. Exposed to still greater heat or pressure or both almost all the hydrogenous matter is driven off and the coal is converted into anthracite, a fairly hard variety of carbon.

If samples of coal be examined their composition cannot be regarded as so different as is their behavior. There is a substance found in parts of the West Indies which resembles anthracite in appearance, but it is plastic beside. It is said not to contain more than 1 per cent of hydrogen to 99 of carbon. Yet this 1 per cent entirely changes the nature of the carbon, producing a smoky fuel and the capacity of becoming soft with but a moderate heat. Ordinary bituminous coal contains very much more hydrogen but does not soften at the same low temperature, and when it is exposed to heat it softens or ignites and gives off its vapors. Nothing is known really of the chemical composition of coal. It can be found out easily and with close accuracy just how much hydrogen, how much carbon, oxygen or sulphur a piece of coal does contain, but how the atoms of these

*Abstract of paper read before the Association of Engineers-in-Charge (England), December 9, 1908.

elements are joined together seems quite beyond finding out. Thus, if a piece of coal be exposed to distillation in a retort and the different things collected that are produced, there will be found tar, creosote, carbolic acid, cresylic acid, hydrogen, various light and heavy hydrocarbon gases, and so much water and ammonia. But it cannot be said these substances are present in the coal. They have simply been built up or broken down from the material of which coal is really formed, and for anything known to the contrary, a piece of bituminous coal is homogeneous throughout in chemical composition and only splits up into many and various bodies when heated. But since it cannot be known what this substance is there is no reason further to inquire into it. And it may be inferred that if the coal begins to split up as soon as heated so it will continue to split up as more heat is applied, the material splitting up more and more into lighter and heavier portions so that nothing but pitch remains in the still, and after a little further heating, even this is resolved into coke and vapor.

When coal is burned in a fire exposed to air, there is a perhaps more complicated set of reactions put into operation. These are operations both of distillation and combustion. An experiment first shown by Horace Allen was the sprinkling upon a red-hot plate of porcelain of some finely divided bituminous coal. At once vapor commences to be given off and a dark spot surrounds each bit of coal. The coal does not glow so long as the vapor is coming away from it. When the vapor ceases to escape the coal begins to get hot and the dark spots on the plate disappear. The coal now begins to glow, to sparkle—in fact, to oxidize and disappear.

Now, from this experiment much may be learned. First, that the primary effect of heating coal is to drive off its volatile portions. Actually, of course, heat renders the coal partly volatile and drives this part away. The vaporizing of this demands heat and the vapor renders so much heat latent that it dulls the surface of the plate. When this chilling effect is finished by the escape of all vapor, the remaining bit of coke gradually becomes hotter. But it does not oxidize brightly until it has attained a high temperature. These actions teach that coal upon a grate will be very seriously cooled if fresh coal is thrown upon it, and that the volatile matter must be thrown off any piece of coal before its carbon skeleton will begin to burn. In a thick bed of coked coal on a grate the chilling effect of fresh coal may not extend right down to the grate surface and the fuel next the grate will burn with the incoming air at the same time as the gas from the green coal burns on the surface. If the fuel bed is thin, the carbon dioxide first produced on the grate comes to the surface as dioxide, and hinders the combustion of the volatile matter. If the fuel be thick the dioxide may be converted into monoxide in its upward passage through the fuel, and this will again hinder the combustion of the volatiles. The final gaseous mixture above the fuel will be very complex, and usually it will be by no means very hot. Experience tells, as explained by Mr. Swinburne, that this mixed mass ought to be kept hot in a nonabsorbent furnace until combustion is complete.

What now deserves attention is a simple means of examination of a fire with the object of ascertaining to what degree combustion has attained. This is blue glass of a deep tint. Blue glass will not permit the passage of light of a wave length greater than blue. It is because it will not permit this that it is blue. High-temperature radiation has the shortest wave length. Violet light has double the number of waves per inch that represent red light, and red light has millions of times the waves per inch of sound notes. Sound would become visible to a man moving fast enough toward its vibratory origin. Low-temperature flame is red, orange, yellow; blue is hot; violet is so potent that it brings about various chemical reactions, as in photography. A red-hot brick seen through blue glass becomes drab, and gives no illumination. A brilliantly incandescent brick-lined furnace seen through blue glass appears of a light French gray, and is of illuminating quality.

Now, if a dull flaming fire be observed, such as is obtained if badly mixed gases rise directly upward from the fire to pass among cold tubes, there will be seen through blue glass no illumination above the fire beyond about 6 inches. The flames are resolved into dark streams of gas; no light comes from them. But if the interior of a furnace be observed when properly lined with brick, and with suitable direction of flow and air mixture, the whole will be illuminated. Streaks and splashes of dark gas will be seen coming forward over the fire, and these melt away as they travel, and burn and help to keep up the temperature. The dark streaks are simply gas not hot enough to give violet light. They are red or yellow flames of burning gas ready to produce smoke if sent upon cold surfaces. Kept off cold boiler plates, they complete their high temperature combinations, and may then be used for heating anything.

It is not that blue glass marks the state of combustion beyond which one must pass, but it seems certain that if a properly mixed gas attains this temperature before exposure to cold surfaces, it will be properly burned. It would be interesting to experiment with red, yellow, and green glass, so as to find how these help in analyzing the state of a fire. It is certain that if blue glass cuts the flame very short there is imperfect combustion.

Now I have not told you much about coal, for I know nothing myself of the way it is put together. All I can infer is that a very small amount of combined hydrogen will change the physical nature of much carbon. Analysis of coal seems to point to the presence of oxygen as the patent cause of so-called bituminosity. Knowledge of the phenomena of heat—such as latency—teaches that the fuel bed must be chilled when fresh coal is giving off vapor.

On the supposed atomic arrangement of hydrocarbon, speculation may be indulged in on the facts that hydrocarbon is first attacked by the oxygen, and that the carbon is set free by itself or in some different combination with hydrogen, and so readily condenses on the first cold surface. And so it is learned to mix atoms of oxygen in excess of what the hydrogen atoms will snatch up and to maintain everything hot until the carbon has had its chance to find its own atoms of oxygen. And as it may be inferred that a thick fuel bed implies shortness of oxygen above the fire—for the fire has perhaps been converted into a gas producer—so it may be learned not always to regulate combustion at the chimney damper, but to keep this open sufficiently to pull in all the air we need as a maximum above the fire, and to regulate the combustion by combined movements of the door grids and ashpit dampers.

Safety valves are locked up from tampering; why not also lock the chimney damper? It should be locked, for it is not fit to be used as a regulator of the combustion of bituminous coal, for this is a double process, the coal burning partially as solid fuel on the grate and partly as gas above the fire, and each operation requires separate and yet conjoint air regulation.

Ordinary coal has a calorific capacity of about 14,000 B.t.u. per pound. The volatile matters distilled from it have a capacity of 18,000 to 24,000 B.t.u. The extra 4000 to 10,000 heat units they now possess are borrowed from the heat of combustion of the solid fuel on the grate, and when the green gas is wasted unburned it is carrying with it the latent heat of distillation. Assuming 20,000 as its average heat value and assuming one-third of the coal to be volatile, the green gases carry off nearly half the heat value of the coal.

Though the molecular structure of coal may not be discoverable, there can be no doubt as to the results of the systems of combination ordinarily adopted. If fired on the coking system, the gas is driven off more or less steadily and continuously, and places less of a tax on the surface at any one moment in respect of maximum air supply above the fuel to burn the gas than is levied when fresh coal is spread heavily over a fire at more or less wide intervals of time.

The heat of combustion of carbon and hydrogen together is sometimes more and sometimes less than the heat necessary to liquefy or gasify the carbon and to liquefy the hydrogen.

In solid fuel the carbon has not changed its state, but any hydrogen has been somehow rendered solid by its combination with carbon.

The gaseous hydrocarbons become liquid when their molecular weight gets up to about 70 to 80, and solids begin to appear when the molecular weight reaches 128 or 136.

The trouble with coal is that it is not simply a hydrocarbon of even unknown proportion, or a mixture of hydrocarbons. It contains oxygen built into its solid structure, and this oxygen is not necessarily there as water with some of the hydrogen as H_2O. But it is there, and it comes off in distillation, and forms that complex substance—tar. Tar contains phenol, which is C_6H_6O, the carbolic acid basis; and there are phenols with eight and nine carbon atoms, and even ten.

It would fill this whole paper only to name the known carbon organic compounds containing the three elements C, H and O variously hooked together. But with all the knowledge of the many substances given out from tar, it cannot be said they are present in coal in the form they take on. But the main facts of physics can be relied on. Heat is swallowed up when solids are liquefied or liquids gasified, and these are the things that happen to coal when burned. They retard its perfect combustion, and the engineer who can best fit practice to meet nature's laws on proper conditions will best utilize coal as regards economy and cleanliness. The knowledge of what happens thermochemically in the life history of the hydrocarbons furnishes ample explanation of the failure of ordinary methods of burning it without heat or temperature conservation. The behavior and properties of the gaseous hydrocarbons may be regarded as the gaps in the bounding walls of knowledge through which glimpses may be had sufficient to serve as the jumping-off point of the flying machines of speculative imagination; and after all it is imagination which differentiates the engineer from the mere mechanic. Armies are never likely to be conveyed by either balloon or flying machine, but both these frail craft may serve to point the way by which an army may best proceed. The mere speculative engineer will not perhaps carry out work so well as the constructional man who follows beaten paths, but his speculative habit of mind does enable him to point the way for others to follow.

Individual Motor Drive for Woodworking Machinery

In the town of Sheffield, Penn., the Central Pennsylvania Lumber Company has located a new lumber mill for sawing rough boards, as well as finished lumber. The total capacity of the plant is about 175,000 feet of lumber per day, largely hemlock. The mill is of concrete construction throughout, securing as great protection from fire as is possible in a woodworking mill.

As is the case with nearly all new mills, electric power has been determined upon for driving the entire equipment. Wherever possible the machines are direct-connected to their driving motors. Three-phase, 60-cycle, 440-volt, alternating current was decided as the most satisfactory under all the conditions of service, and a complete power equipment, including boilers, engines, generators, motors, and all the necessary measuring instruments and controlling devices, has been installed and arrangements made to burn the refuse from the mill under the boilers.

The logs are conveyed up the incline from the pond by a "log chain," or "log jacker," into the mill, the jacker being driven by a 15-horsepower back-geared motor running at 850 revolutions per minute.

FIG. 1. MOTOR DRIVING AN 8-FOOT BAND SAW; 150 HORSEPOWER

The chain is 190 feet in length and carries 22 steel dogs for gripping the logs. From the top of the incline the logs are rolled either to the right or the left, as the equipment is provided in duplicate; that is, on the right are band mills, gang edgers and trimmers arranged for receiving the lumber from the left, and there is a similar equipment on the left for receiving lumber from the right.

The logs are first sawed into lumber by the 8-foot band mills, each of which is operated by a 150-horsepower motor running at 580 revolutions per minute. From both the band mills the sawed lumber is carried by live rolls and transfers to the re-saw mill. Each set of [illegible] live rolls is operated by a [illegible]-horsepower [illegible]-revolutions-per-minute motor through a back gear on the motor.

The re-saw mill cuts the lumber into thinner planks and boards, except in the case of the larger sizes, where the first cut by the band mills is sufficient. The re-saw is driven by a 150-horsepower motor, 580 revolutions per minute. On this re-saw mill are two 8-foot band wheels with 14-inch face. The motor is connected by belt to the lower band-wheel shaft and gives to the saw a speed of about [illegible] feet per minute.

From the re-saw the 1-inch and 2-inch material is carried by transfers to the two gang edgers, which saw the broader boards into standard sizes, as 10¼ inches, 8¼ inches, 6¼ inches, [illegible] inches, or [illegible] inches, etc. Each gang edger has eight saws, 24 inches in diameter, and is operated by a 50-horsepower, 1200-revolutions-per-minute motor, direct-connected to the shaft of the edger. After the lumber has passed through the edgers it is

FIG. 2. TRIMMERS DRIVEN BY 30-HORSEPOWER MOTOR

carried by line rolls to the trimmers, which consist of a row of saws mounted on swinging arms driven by belts from a line shaft. from which they are hung. The saws are spaced for trimming off the lumber ends, leaving standard lengths. One trimmer has eight saws and the other ten. Each set is operated by a 30-horsepower motor running at 840 revolutions per minute. The motor also operates a No. 2 Clark Brothers pintle chain for conveying the lumber away. The ten-saw trimmer is known as the 6 to 22-foot automatic trimmer, and will handle material up to 6 inches in thickness. The eight-saw trimmer is rated as a 6 to 24-foot automatic trimmer for use on material up to 11 inches thick.

After being trimmed the lumber is conveyed on a chain through the assorting shed where it is loaded onto cars by manual labor. The chain travels at the rate of 32 feet per minute, being driven by a 15-horsepower back-geared motor running at 1120 revolutions per minute.

Provision is also made for the removal of the refuse material by means of conveyers from the different mills. All sawdust is conveyed directly to the boiler room and automatically fired. From the band mills and the edgers the slabs are carried to slasher saws, which are saws

FIG. 3. RIGHT-HAND BAND MILL DRIVEN BY 150-HORSEPOWER MOTOR

mounted on a shaft and 4 feet apart. From the slashers the 4-foot lengths are taken, together with other refuse from the mills with the exception of the sawdust, by conveyers to a machine known as a "hog." A certain percentage of this material, however, before reaching the hog is taken out of the conveyer by hand and loaded into cars for shipment to paper manufacturers. This pulp wood is used in the manufacture of paper and must have a length of 16 inches and over. The balance of the refuse is cut into chips by the hog, from which it is dumped into cars for shipment to nearby tanneries.

The slasher is operated by a 30-horsepower, 840-revolutions-per-minute motor, which also operates six conveyer chains, each 100 feet in length. The hog is driven by a 75-horsepower motor, 690-revolutions per minute, direct-connected. It has a large rotating element weighing approximately 2000 pounds, which carries 24 knives on a diameter of 60 inches. Owing to the weight of the moving element of the hog, the starting conditions are particularly severe, but the motor, which is of the slip-ring type, brings the machine up to speed quickly without undue overload. The main refuse conveyer for carrying refuse to the boiler room is operated by a 10-horsepower, 1120-revolutions-per-minute motor.

The woodworking equipment was supplied very largely by Clarke Brothers, and the motor equipment by the Westinghouse Electric and Manufacturing Company.

The Small Fan in the Engine Room

By W. H. Wakeman

Many engine rooms are too hot to be comfortable, because no attention is paid to proper ventilation, but by locating a

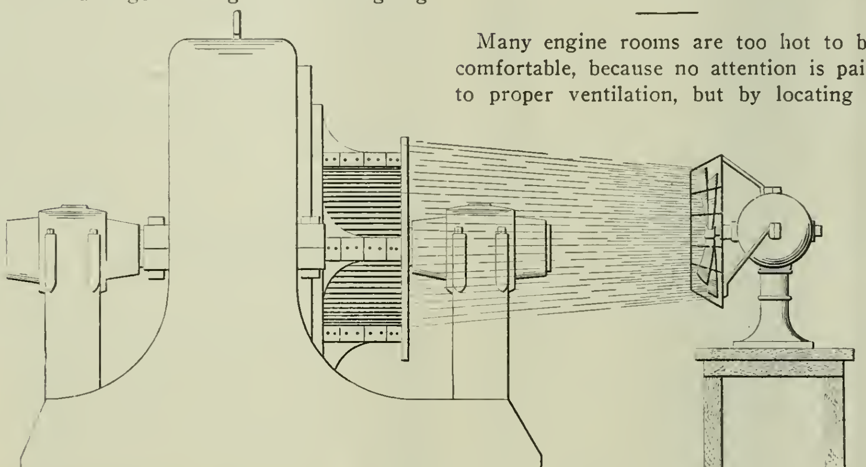


FIG. 1

small fan near a desk where the daily log is written, or if it can be moved from place to place in order to be near various repair jobs, it will add much to the comfort of those employed in this work, not only by admitting fresh air, but by keeping that which is already in the room from stagnation.

The brushes and commutator on one of my dynamos were running quite warm, and it was not practical to shut down or reduce the load. A small fan was located where it could circulate air rapidly over these parts, as shown in Fig. 1. By holding a hand in this air blast, not only near the fan but also after it had passed the dynamo, the difference in temperature was plainly felt, thus showing that much heat was dissipated by the swiftly moving air. In a short time the brush holders were as cool as before the machine was started. This is also a very good plan for blowing out dust that accumulates in the armature and field coils of dynamos and motors.

The success of this experiment suggested similar action when a main bearing began to heat and the result was very satisfactory. This is illustrated in Fig. 2, and it is much cleaner and better than the barbarous plan of turning a stream of water on a bearing that is warmer than it ought to be.

As the air blast carried off much heat in these two cases, why will it not do good work in the case of a gas engine, as illustrated in Fig. 3? It might not be sufficient for hard service, but it is worth trying, as it will save some or all of the expense of water for the jacket, and this is a comparatively large item in some cases.

Fig. 4 illustrates a fan blowing air on the cylinder of an air compressor, thus preventing an excessive accumulation of heat where it is not wanted. There are other places where the air blast from a portable fan will facilitate operations, or

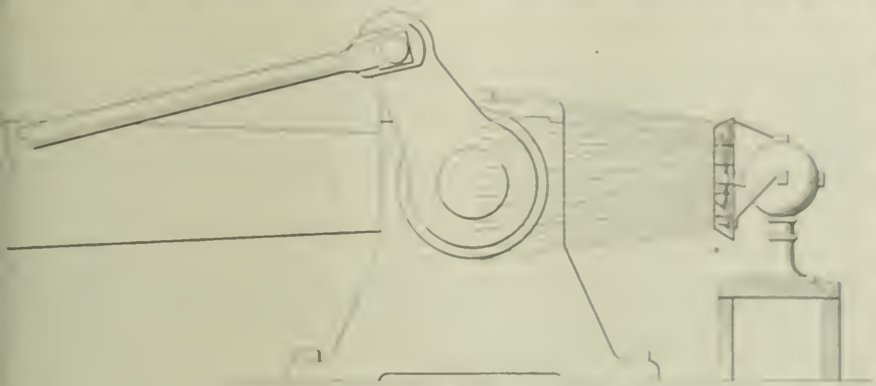


FIG. 2

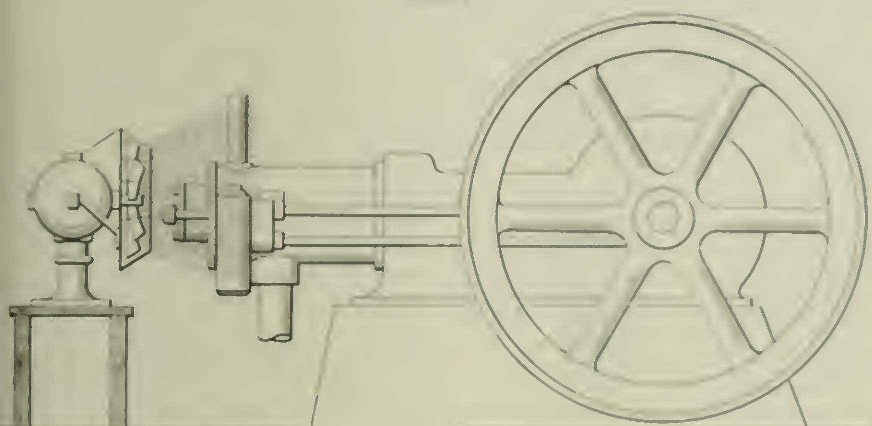


FIG. 3

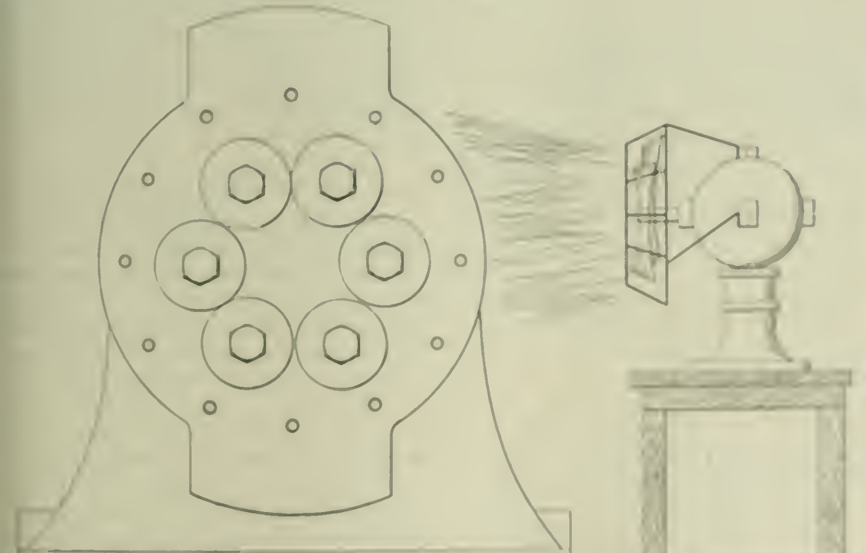


FIG. 4

render disagreeable work more comfortable, the details of which will occur to those engaged in such work after considering the foregoing incidents and suggestions.

The Operator for the Gas Producer

By J. C. Miller

The discussion that has been going on as to what grade of man is required to secure the best results from the gas producer, is very interesting to the writer and should be to anyone else who has started and operated different types of gas producer and had to secure satisfactory results from them.

The one element that must be considered above all others in gas-producer operation is reliability. Economy, ease of operation, adaptability to load and other good qualities fade into insignificance when compared with reliability. Reliability in a producer plant means, first, an ability to furnish a regular supply of cool gas of a uniform quality; second, a gas of uniform heat value regardless of the quantity supplied; third, means for cutting, removing ashes and clinkers and supplying water as required, without affecting the heat value or quantity of gas furnished.

The writer is convinced by his experience that more judgment is necessary for the proper operation of the gas producer than for that of the steam boiler. In the case of the steam plant, water must be kept at a certain level; the gage glass shows this. Pressure must be maintained; the steam gage shows what it is. Inspection of the fire may be made at any time by opening the fire door; ashes may be removed and the fire cleaned when the fireman wishes and while the plant is operating. With the boiler there is a guide for all operations and judgment is needed only in emergencies. The gas producer is a different proposition. The operations are concealed; no good view can be had of the fire; the heat value of the gas is a matter of judgment, and good judgment, too. No continuous record is at hand to guide. Gas-storage capacity is small, so the producer must be constantly in good condition to secure quick response to demands. The quality of the gas is affected by the depth of the fire, the steam supply, the demand, and atmospheric conditions, all of which are points upon which judgment must be exercised.

Salesmen's Unwise Claims

The salesman often tells the buyer that he can put in a charge of coal once or twice a day and leave the producer to its own care. This is untrue in practice and the claim is not necessary in order to sell the goods. If the demand for gas is uneven or if the heat in furnaces is to be maintained at constant value, attention at frequent intervals is necessary.

The gas-producer plant has no place for a cheap operator without judgment. The engineer of a steam plant will make the best man for it, if he comes with no prejudice. He will lead the novice in power-plant practice by all he has learned previously in boiler and fire management. If he operates a gas engine in combination he will find more place for judgment than in his steam plant.

Steam applied to the piston of an engine will produce motion and the engine will operate. With the gas engine it is different. Several operations must take place in perfect unison in order to make the engine operate and more things are liable to get out of order. Better judgment is needed to operate a gas-engine plant than a steam plant.

Some Recent Steam Engine Failures

Description of a Number of Interesting Accidents Which Were Reported by the Engineering Expert of a Casualty Company

BY HOWARD S. KNOWLTON

Four or five months ago, in Power and the Engineer, a number of steam-engine failures were presented, as drawn from the practice of one of the large accident-insurance companies during the past two or three years. A number of additional failures have since come to hand from the same source. Every casualty company dealing with accidents to power-plant machinery has exceptional opportunities to point out instances of poor practice and their remedies, and these practical considerations are independent of the locality in which the machinery is operated, in great measure. In the following notes upon some typical accidents to steam engines the report of the casualty company's engineer has been followed closely, and a few sketches have been included by way of illustration.

Condenser Water Backs up into Cylinder

One notable failure was of an engine of the cross-compound type, with cylinders 26½x40¼x54 inches, making 40 revolutions per minute with a boiler pressure of 80 pounds. Each cylinder had a slide valve at each end, and gridiron expansion valves of automatic type were used on the high-pressure cylinder. At the time of the accident the engine began to gain speed suddenly. The engineer shut the stop valve and the speed fell, but before motion ceased the bedplate on the low-pressure side broke and the crank pedestal was forced forward ½ inch. The piston was driven 1/16 inch up the cone of the rod, the cotter bent and the crank pin loosened. The speed increase was due to the governor losing control of the valves through the slackening of a set screw. The damage was caused by water in the condenser, as the engineer did not shut off the injection or break the vacuum. The speed was so slow that the water was forced into the condenser more rapidly than it was removed by the air pump, and thence flowed back into the cylinder through the exhaust pipe. An automatic cutoff gear and a vacuum breaker have since been installed at the suggestion of the casualty company.

Crack in Crank Pin

In another case an accident occurred to a horizontal tandem-compound engine with cylinders 20x43x54 inches, normal speed 52 revolutions per minute, and a boiler pressure of 125 pounds. The crank was of forged wrought iron or steel supposed to be shrunk upon the shank of the crank pin, which was also secured by a key. The journal of the pin was 9½ inches long by 6 11/16 inches in diameter, and the shank 7¾ inches long by 7½ inches in diameter; and between the two was a collar, as illustrated in Fig. 1. As far as was known the pin was put in when the engine was built, but it was not known when the key was put in. The large end of the connecting rod began to run warm and to knock, and red oil began to ooze out of the crank eye around the pin and key. A faint crack was noticed on the end of the pin at the back of the crank. The key was taken out, refitted and driven up tight; the bleeding continued and the crack extended until it reached entirely across the end of the pin.

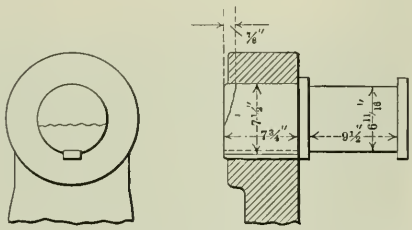


FIG. 1. CRACK IN SHANK OF CRANK PIN

As the pin was evidently slack and moving, it was thought best to take the pin out for examination, particularly as the extent of the crack was unknown. After some trouble and heating the crank eye with gas, this was done. It was then found that the shank of the pin had been bearing at the back and front at opposite ends of the diameter, lying in the plane of the line of centers of the engine, and that it had been moving and had worn the crank eye oval. A wedge-shaped piece had also been split off the end of the shank. The only probable solution was that the pin was turned out of an old crank shaft with a crack in it, which gradually extended when the pin began to get slack, and the pressure of the crank eye upon it became concentrated on the semi-detached piece.

Piston Bent by Closing Stop Valve before Breaking Vacuum

A case of piston bending occurred in a high-speed inverted triple-expansion engine making 383 revolutions per minute, with 14x20½x30x14-inch cylinders. The engine was direct-connected to a dynamo. The exhaust steam from the engine was led through a valve in the exhaust pipe to a jet condenser, or when this valve was closed, through an automatic atmospheric-relief valve to the outer air. The condenser was cleared by a pair of Edwards air pumps driven by an electric motor, the latter receiving current from the dynamo driven by the engine. Water for the condenser was taken from a pond whose surface was about 15 feet 7 inches below the centers of the cylinders. Thus, if the air pumps did not clear the condenser, the water from the pond would be forced into the low-pressure cylinder if the pressure in it were less than 8 pounds absolute per square inch.

The usual practice of shutting down was to close first the engine stop valve and then the valve in the exhaust pipe to shut off the condenser. On the evening of the breakdown this practice was followed, but the engine, instead of coming gradually to a standstill as usual, stopped suddenly as the engineer was about to close the valve in the exhaust pipe. The cause of the stoppage was an inrush of water from the condenser into the low-pressure cylinder, which bent the piston and stretched the bolts in both ends of the connecting rod. The accident was caused by the closing of the engine stop valve before the vacuum was broken. If the engineer had destroyed the vacuum, either by closing the injection valve, or shutting off the condenser, or by opening the atmospheric valve before touching the engine stop valve, the accident would not have happened.

Imperfect Weld in Piston Rod

An accident occurred to a 1500-horsepower horizontal tandem-compound engine, the normal speed of the engine being 39 revolutions per minute with a boiler pressure of about 100 pounds per square inch. The low-pressure cylinders were next the cranks. The piston rods, 5¾ inches in diameter, were cottered into the crossheads at the front ends and swelled at the back ends to receive the pistons. The enlarged ends were also bored to receive the front ends of the high-pressure piston rods, which were secured by the same cotters as the low-pressure pistons. One morning the rod of the low-pressure cylinder on one side broke without warning, about 22 inches in front of the piston. The cover at the back end of the cylinder was driven off, leaving pieces of the flange upon some of the studs. The other studs were broken. The high-pressure cylinder was split at the back in two places, and a piece measuring about 20x18 inches was knocked out of the side. The back cover was broken in pieces, which were blown against the end of the engine house, damaging the wall. Curiously enough, the pistons were undamaged save for the breaking of the rings. The rod was of steel and had been welded four years ago on account of a crack at the cotter hole at the back end. The appearance of the fractured surface showed that the weld had been very imperfect; the two pieces broken had been joined only upon the surface.

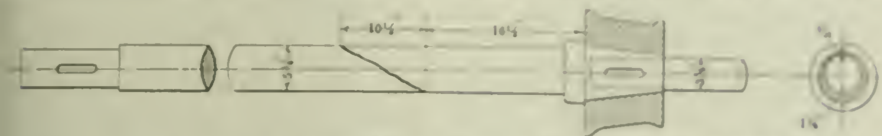


FIG. 2 BREAK IN LOW-PRESSURE PISTON ROD DUE TO IMPERFECT WELD

Crank Shaft Breaks Repeatedly

A case of shaft breakage occurred in a high-speed inverted vertical noncondensing double-acting two-crank engine, cylinders 9x15½x8 inches, direct connected to a dynamo and running 425 revolutions per minute, the boiler pressure being 140 pounds per square inch. The engines were installed in 1900. In 1905 the crank shaft was found to be slightly bent and was replaced, the old shaft being kept as a spare after being trued up by skimming up the bearings in a lathe. In 1907, after having run less than two years, the new shaft broke through the web of the crank next the dynamo, and a third shaft was ordered, the spare shaft first mentioned being used to keep the engine in service. The cause of the breakage was not ascertained. The company's inspector reported the shaft to be hard and brittle, but the makers of the engine stated that it was made from their standard quality of steel, of about 32 tons tensile strength. They considered the breakage to have been caused by the bearings being out of line or level, and advised that these bearings should be lined and adjusted before a new shaft should be put in. The dynamo armature was accordingly lifted, the brasses were relined with white metal and leveled, and the new shaft bedded upon them. Eight weeks later the new shaft broke in the same place as the old one. The two surfaces of the fracture were quite close when the inspector saw them, but when the shaft was taken out two patches of white metal were found imbedded in the crack. The makers of the engine again attributed the fracture to the bearings being out of line, but the casualty company's engineer decided that it came from improper treatment of the steel during manufacture.

A test gave an ultimate strength of 31.1 tons per square inch, an elongation of 18.5 per cent. in 2 inches, with a reduction of area of 41.56 per cent. The carbon was 0.36 per cent. The appearance of the fractured surfaces indicated overheating of the steel, though it was possible that with a speed of 425 revolutions per minute it might have been the result of excessive stress produced by cumulative vibrations synchronizing with the period of the engine.

Crack in Valve Chest

Another accident occurred to a horizontal triple-expansion engine installed in 1902. The high-pressure piston was 20 inches in diameter and one low-pressure piston, 37 inches in diameter, was coupled to the crank pin of the other, the cranks being set at right angles to one another. The stroke of all the pistons was 60 inches, and the speed about 62 revolutions per minute. The boiler pressure was 160 pounds per square inch. The high-pressure cylinder consisted of a plain cast-iron liner shrunk into an outer casing, with which were cast Corliss valve boxes and connecting passages. Longitudinal and transverse sections taken through the middle of the cylinder are shown in Fig. 3. After working five years, steam was observed coming from below the lagging, and on removing the latter a crack 31 inches long was found as indicated at *A A*. The weakness of the design, notwithstanding the cross ribs which stiffen the flat top of the steam passage, is self-evident and the fracture is not surprising. The danger of admitting steam at high pressures into cylinders and valve chests of weak design cannot be overestimated. In the case described a new cylinder was the only remedy, and while its construction was pending the old cylinder was kept in operation by strengthening the flat surfaces by clamps and stay-bolts.

was encountered in the instance of an engine, with 22x32x48-inch cylinders, making 52 revolutions per minute under 120 pounds boiler pressure. A new low-pressure cylinder was fitted to this engine which was a rather old machine. The cylinder was a casting about 8 feet long and of rectangular cross-section 45½ inches wide and 15 inches deep, the back, front and sides being flat and varying in thickness from ¾ to ⅞ inch. It was divided vertically by a flat portion of the same thickness into two passages, one next the cylinder of about 24x4½ inches internal measurement, which received the steam from the high-pressure cylinder and led it to the top and bottom steam valves, the other being farther from the cylinder, 24x7½ inches, for leading the steam from the top and bottom exhaust valves to the exhaust pipe and condenser.

The partition was stayed to the front and back of the casting by ribs near the top and bottom, but a central portion of more than 3 feet was unstayed. The pressure in the steam passage was about 25 pounds absolute, and the pressure in the exhaust passage about 3 pounds absolute, so that the unbalanced pressure on the partition was about 22 pounds per square inch, and on the front of the casing about 12 pounds per square inch. During the temporary absence of the engineer a piece 38x24 inches was blown out of the partition dividing the steam from the exhaust passage, and a corresponding piece of nearly the same size was blown out of the front wall of the casting dividing the exhaust passage from the air. The vertical cracks in both occurred at the junctions of the flat surfaces with the side walls of the box and extended the full length of the central portion unstiffened by the ribs. All were old, and those in the partition had worked their way through the full thickness of the metal for a length of about 18 inches on each side. Those in the outer wall had not penetrated very deeply. The defect was evidently brought due to working stress variations of pressure and possibly undue pressure when starting the engine. The final fracture was brought about by the low water level, the lever on the end of the bottom steam valve

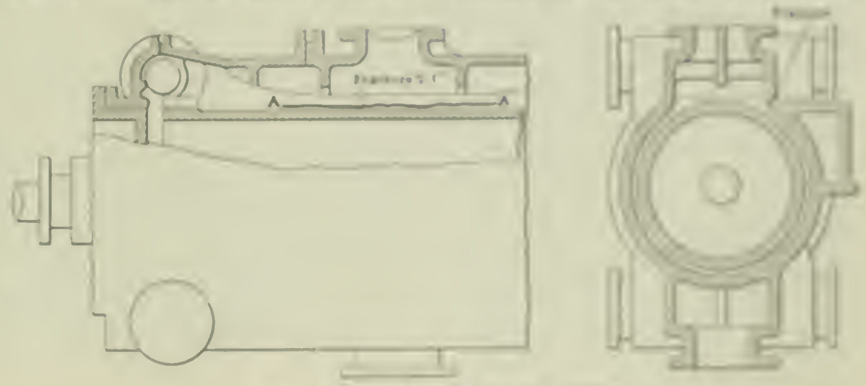


FIG. 3 LONG CRACK IN VALVE CHEST

Disadvantages of Rectangular Castings

An important case of cylinder breakage

spindle becoming loose and falling out, leaving the valve stationary and, as it happened, covering the port, so that the steam discharged from the lower end of the cylinder could not get into the lower end of the condensing cylinder, but remained in the cracked casting, practically doubling the pressure in it. The accident illustrated the great disadvantage in using rectangular flat-sided castings for holding steam. The existence of the cracks in the partition and of the incipient cracks in the outer wall, all running vertically up the junctions of these surfaces with the flat sides of the box, prove the inferior design of this form of cylinder even when stressed within the limits of ordinary practice, while the accidental loosening of a key is but one of the many other accidents which may occasion dangerous rises of pressure in the valve chests of the low-pressure cylinders of compound engines.

A Distorted Cylinder

Another engine to suffer accident was a vertical triple-expansion unit with 20¾x33x53-inch cylinders having a 36-inch stroke, running at 110 revolutions per minute and supplied with superheated steam at a pressure of 180 pounds per square inch by water-tube boilers. The engine was placed in service in the summer of 1907, and almost at once the high-pressure piston rings began to break and the piston to show signs of scoring. The trouble was attributed to priming, which was admitted to have occurred. The piston was taken out, filed smooth, and fitted with new rings. Later on these broke, and it was noticed that the piston and cylinder were scored at each end of a diameter and not all around the circumference. To shorten the stoppage in case of the rings again breaking a complete new piston was made, and to lessen the risk of binding the allowance between the diameter of the cylinder and piston was increased to 0.0265 inch. This piston was installed and appeared to work well. A little later the cylinder cover was taken off to test the tightness of the valves. When the steam was turned onto the valve chests, leakage was observed near the lower end of the cylinder bore, and a circumferential crack 8½ inches long was discovered. The cylinder was found to be scored in the vicinity of the crack and diametrically opposite it. The corresponding parts of the piston were also deeply grooved. Evidently the cylinder had changed its circular form when heated and became oval, the allowance made on the piston not being sufficient to compensate for its own expansion and for the deformation of the cylinder barrel. This allowance was increased to 0.04 inch when the new cylinder was put in. The deformation is readily accounted for, as the cylinder casting was very complex, containing not only the cylinder barrel, but four chests for drop valves, steam and exhaust nozzles and brackets for attachment to standards to which it was bolted. The position of the crack was just below the top of the bottom steam-valve box. Whether it was the result of heating or of stresses set up during the cooling of the casting is uncertain, though the former is probably the cause, for such circumferential cracks are not uncommon when there has been "seizing" between cylinder and piston.

In another case the horizontal low-pressure cylinder of a compound engine was found grooved and cracked in the same way after working for a short time with a piston 0.012 inch in diameter less than itself. The grooving was clearly traceable to the distortion of the cylinder bore, since it occurred in two places diametrically opposite each other. Similar circumferential cracks were found cutting through the grooves scored in the liner of the cylinder of an internal-combustion engine where the piston had evidently been too large, and having run hot had seized the cylinder wall. In this case the cracks

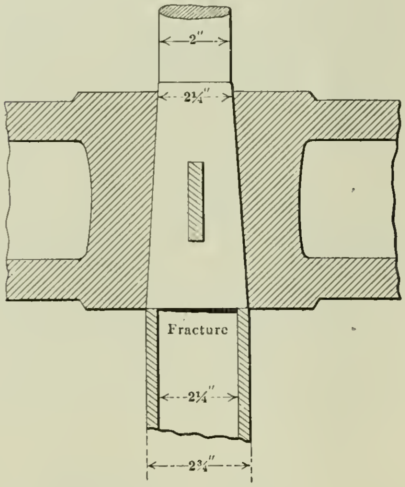


FIG. 4. FRACTURE IN PISTON ROD OF AIR PUMP

had clearly not been the result of cooling strains, as the liner was a simple pipe. These cases indicate that in turning pistons for cylinders of complex shape, allowance must be made not only for expansion due to the heat of the working fluid, but also for the distortion resulting from the unequal expansion of unsymmetrical shapes.

Fractures of Rod and Beam

A case of rod fracture occurred in an air pump run in connection with a horizontal cross-compound engine making 73 revolutions per minute. The air pump, single-acting, vertical, 19x21 inches, was driven from the low-pressure piston-rod crosshead by links, bell-crank levers and links to the pump crosshead. The crosshead was cottered into a cone upon the rod, as shown in Fig. 4, and the rod was guided below the crosshead by the gland in the air-pump cover and above by a brass bushing in a cross arm fixed to the engine bedplate, and not by the method of slide blocks on the crosshead arms. The upper part of the rod which passed through the guide bushing was 2 inches in diameter. The conical part on which the crosshead was cottered tapered from 2¼ inches at the upper end to 2¾ inches at the lower end, and the part below the crosshead was reduced to 2¼ inches in diameter, the shoulder at the junction of this part with the lower end of the cone being square. The lower part of the rod was sheathed with brass ⅜ inch thick. The rod broke at the abrupt change of diameter at the lower end of the cone where the brass sheathing began. The appearance of the surfaces of the fracture showed that the rod had been cracked nearly half way through before the final break. The fracture was caused by the bending stress produced by the horizontal component of the diagonal thrust of the links connecting the bell-crank levers to the crosshead, intensified by the abrupt change of section. Air-pump rods guided like this one, above and below the crosshead, but not by the crosshead, frequently break, but generally through the cotter hole, the hole being usually driven, as in this case, in a plane passing through the center line of the engine, so that the bending stress is concentrated at the edge of the cotter hole where there is little material to resist it. This is a typical case.

Another case of a broken beam may be cited, not as an illustration of the effect of overloading, but by way of a hint to those who have engines connected by shafting or gearing to other engines or turbines. In this case the engine, a condensing beam unit, with cylinders 28 inches diameter by 48 inches stroke, running at 33 revolutions per minute, was coupled to a water wheel by shafting and gearing. On the occasion of the breakdown, the water wheel was, as usual, started first, and immediately the engine beam broke off short between the air-pump gudgeon and the main center. Whether the breakage occurred before the piston had completed its first up-stroke or immediately after the driver had begun to open the stop valve to admit steam was not known, but it was clear that the water caused the trouble—presumably accumulation of condensed steam leakage on the top of the piston. There were no safety valves on the cylinder.

Wherever there is a line shaft attention should be given to keeping the shaft clean. Aside from other considerations an accumulation of dust and grease on the shaft is an added fire hazard. The easiest way to prevent dirt and dust from collecting is to provide each shaft with loosely fitting disks of strawboard, leather or other material, which are free to whirl, and as the shaft rotates, will travel back and forth preventing any deposit or accumulation of dust or oil.

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Dimensions and Capacity of Rectangular Tanks

While tables are published showing the capacity, in gallons, of cylindrical tanks of standard size, the same is not true of rectangular tanks, for the possible combinations with three variables is so great that a complete table would be both cumbersome to handle and difficult to use.

The accompanying chart is designed to show graphically the dimensions of tanks having capacities up to 1500 gallons and multiples thereof. It being very easy in case the tank is of such dimensions as to contain over 1500 gallons, to halve one or two of the dimensions and multiply the capacity by two or four, as the case may be, or to find the capacity for 1 foot in hight and multiply by the hight. The chart may also be used where the capacity is given and the size is desired, or where the capacity and one or two of the dimensions are given and others are required.

The two following examples show how the chart is applied: What is the capacity in gallons of a tank 4x9x2½ feet? Starting with 2½ feet on the right-hand scale, read up to the line designated as 4 feet, then across to the 9-foot line and down to 675 gallons.

What is the hight of a tank 6x9 feet, to contain 1200 gallons? Starting at the 1200-gallon point, read up to 6 feet, then across to 9 feet and down to 3 feet.

W. L. D[illegible]

Brooklyn, N. Y.

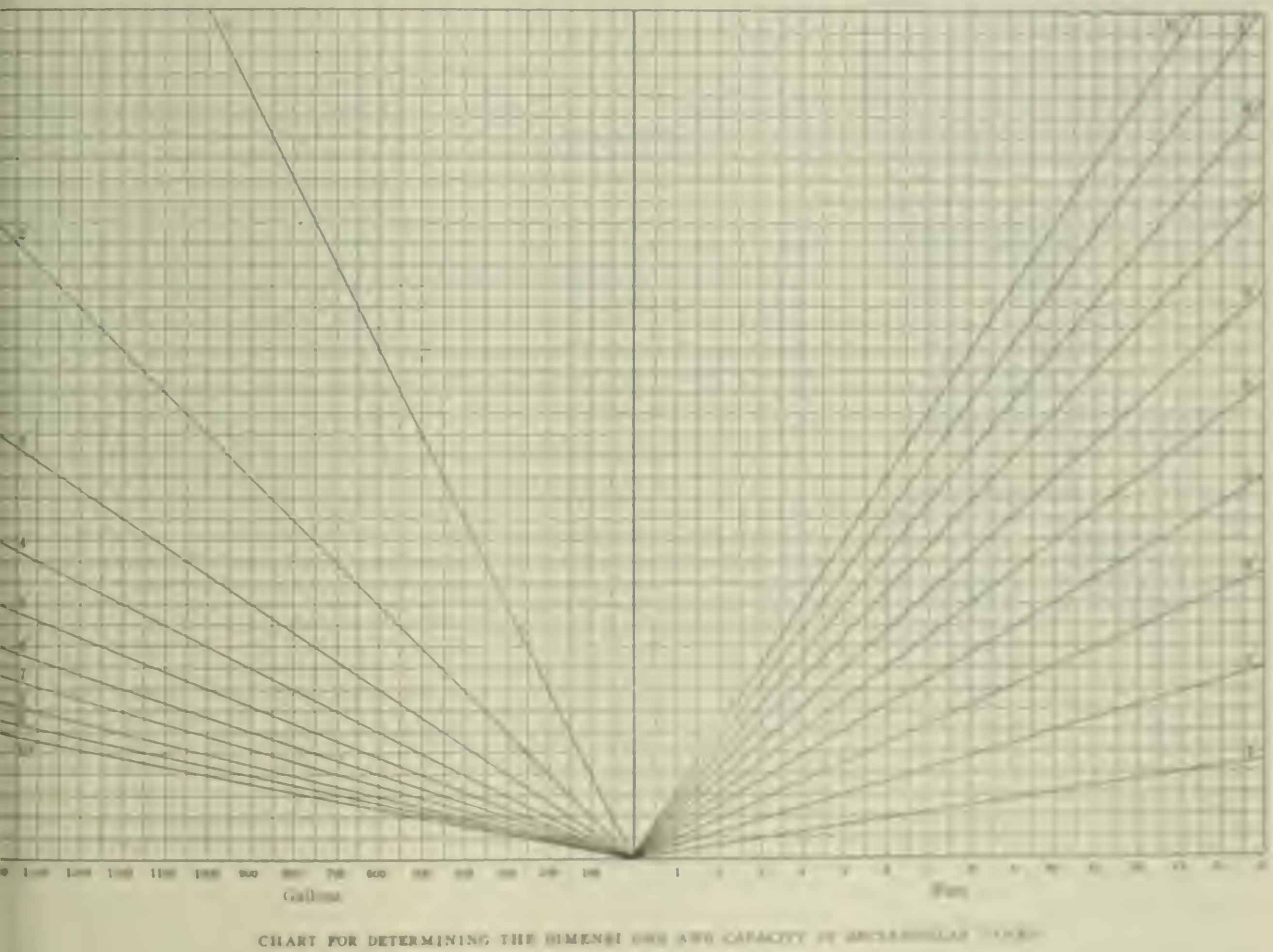


CHART FOR DETERMINING THE DIMENSIONS AND CAPACITY OF RECTANGULAR TANKS

To Handle Wood Economically

We are burning from 600 to 800 cords of wood per month. It is delivered by contract, as near the plant as possible to pile it, and we find that the rehandling from the pile to the boilers is an item of considerable expense. The plant is located on the side of a mountain, the inclination of which, at the point, is [illegible] as 45 degrees.

I hope that some of the readers will make suggestions as to the economical handling of such an amount of wood from piles on the mountain side to the boiler room, where [illegible] space allows only six cords to be piled at a time. The wood is cut [illegible] inches long.

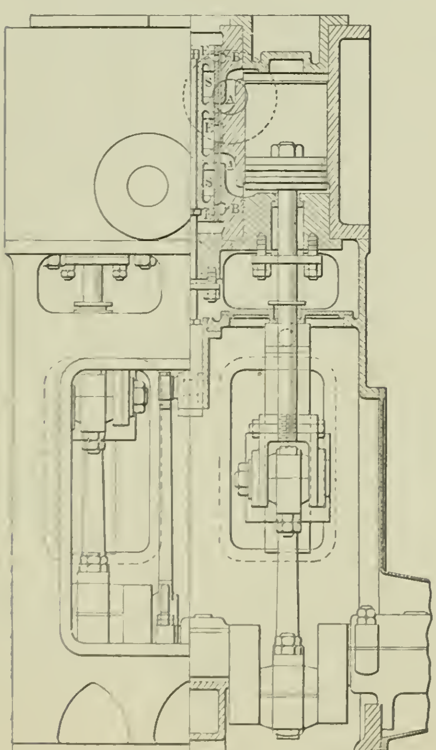
[illegible]

[illegible]

Central Valve Engines

Having seen in a recent issue an illustration of a central-valve engine of English design, I am inclosing a sketch of an American product which has proved to be very practical. The cranks of the engine are set at 180 degrees, as shown, with the single eccentric mounted on the shaft between them. The valve travels in a removable bushing, in which the ports are accurately machined; the valve, as shown, is in its central position. The spaces *S* are in communication with the steam pipe, while the spaces *E* lead to the exhaust pipe. At *A* and *A'* are ports to the right-hand cylinder, while *B* and *B'* lead to the left-hand cylinder.

The action of the valve is similar to any slide or piston valve, and if displaced upward an amount equal to the steam lap, steam will be admitted on one side through the port *A'* and on the other side through the port *B*, the exhausts at the same time being through ports *A* and *B'*, respectively. Cutoff and compression follow on the return motion of the valve.



AN AMERICAN CENTRAL-VALVE ENGINE

In practice the steam lap is a trifle greater for the top end of the cylinders and the exhaust lap greater for the bottom end. This in a measure offsets the irregularity due to the connecting rod and gives an earlier cutoff at the top and more compression at the bottom, as is customary in vertical engines.

H. L. Dean.

Hyde Park, Mass.

The Centrifugal Pump

In the December 1 issue, George P. Pearce takes issue with my statement in a previous number that when the discharge opening of a centrifugal pump is closed no further power is required by the water within the impeller after having been brought up to speed. As pointed out in the original article, a certain amount of

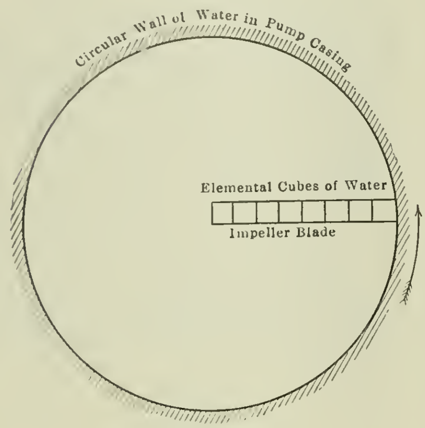


FIG. 1

power would still be required to overcome friction and to supply the energy wasted in eddies, but, as I understand Mr. Pearce, that is not in question and need not be discussed.

Mr. Pearce's position, and that of a number of other contributors, is indicated in the following paragraph from his letter:

"Surely a centrifugal pump running with suction open and discharge closed is operating under a considerable load, for the shape of the impeller is such that it is constantly trying to throw more water into the outer casing, and as this is impossible then it is forcing its way through the water against the resistance due to the pressure built up in the casing, due to its circumferential velocity."

No power or expenditure of energy is required to withstand a pressure as long as there is no flow, in the same way that no mechanical work is performed by a man carrying a hodful of brick on a level walk. The man does work in a mechanical sense only when he begins to climb the ladder and to create a flow of bricks from a lower to a higher level.

To put the case more graphically, consider Fig. 1. Let the radial line be one of the impellers of a centrifugal pump, and let the circle at its extremity be a solid circular wall of water in the casing of the pump. The little squares on the radial line represent cubes of water. Now, when the impeller is rotated the cube on the end will press outward by reason of the fact that it is continually constrained to change its direction of motion, and will exert a pressure upon the circular wall of water in the casing. The next cube will similarly exert a pressure on the first cube, and so on down to the center o[f] rotation. Each cube will try to push tho[se] ahead of it off the impeller, the resu[lt] being a certain definite pressure pe[r] square inch between the outside cube an[d] the stationary water in the casing. A[s] long as the impeller is rotating with uni[-] form speed, this pressure will be main[-] tained, and if it is assumed that the who[le] space within the circle be filled wit[h] water, there will be uniform pressure a[ll] around the circle. If it could be mad[e] a further condition that there would b[e] no friction between the outside cubes an[d] the surrounding wall of water no powe[r] would be required, once the mass of wate[r] in the impeller were brought up to spee[d] and at the same time the pressure woul[d] be maintained.

What actually happens is that a certai[n] amount of power is lost in skin frictio[n] in overcoming viscosity and in the pro[-] duction of useless eddies, both within th[e] impeller and in the surrounding cham[-] ber, but this consumption of power neve[r] amounts to as much as the power re[-] quired by the pump when delivering wate[r]. In fact, this loss of power due to frictio[n] and eddies remains, roughly the sam[e] whether any water is being delivered o[r] not, but an increased amount of power [is] required for accelerating new masses o[f] water as soon as delivery begins.

It is probably true, as Mr. Pearce state[s] that the eccentric casings used with som[e] centrifugal pumps cause an increase of th[e] losses due to eddies. On the other han[d] however, the casings of all, except th[e] last stages of most multistage pumps, ar[e] concentric with the shaft.

Mr. Pearce also refers to the shape o[f]

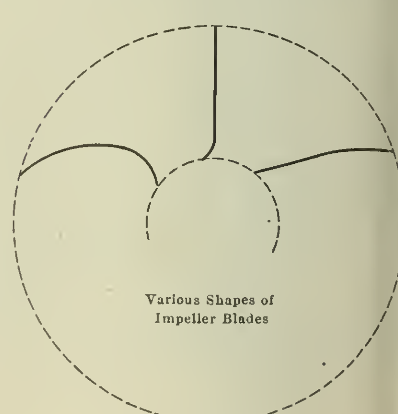


FIG. 2

the impeller being such that it is co[n]stantly trying to throw water into t[he] casing, and he will therefore probably [be] surprised to learn that the blades of i[m]pellers may have different shapes, [as] shown in Fig. 2, and that as long as t[he] delivery pipe is closed off these sha[pes] have little influence upon the amount [of] power consumed or upon the pressu[re] generated. As soon as flow begins, h[o] r, pumps with the different impellers ibit different characteristics.

Ir. Pearce asks if the charts which ompanied my first letter, showing that power required falls off as the flow is uced by throttling the discharge, were tted from actual tests or from theoreti- formulas. They were plotted from s and nearly all charts, wherein the ver consumed by centrifugal pumps is tted as one coördinate and water de- red as the other, show the same thing, power consumed at no load being newhere around a quarter or third of power consumption at the point of timum efficiency, upon which the nomi- rated capacity of the pump is usually ed.

George H. Gibson.

ew York City.

Commutator Trouble

he commutator trouble A. L. Baker tions in a recent issue might be caused number of things, among which are following: Brush position; running t does with a weaker field than that which the machine was designed, the hes will probably need a greater for- d lead than at normal voltage. Brush ing; if the several sets of brushes are spaced equally around the commu- r, sparking will occur; this spacing best be checked by aid of a strip of r of a length equal to the commutator umference, on which has been marked as many equal divisions as there are h-holder studs; the paper should be ed to the commutator and each stud so that the toe of the brush will come he mark; care should be taken that brushes all lie in line with the commu- r bars. Tight brushes; every brush ild be gone over to see that it fits ciently loose in its holder to allow spring to press it against the commu- r; dark streaks are often caused by t brushes; on the other hand, a brush fits too loosely in its holder will cause trouble. Brush contact; too h care cannot be taken in sanding the hes; a coarse paper may first be used, the finishing touches should always be with a very fine grade, the brush g under the tension of the spring; smoothing should always be done in direction of rotation. Metal bridges; smoothing or turning off the com- ator, it should be carefully examined copper bridges across the mica strips een the bars; if these exist they ld be removed; a knife blade will lly accomplish this very success-

there are no errors in the design of machine, a rigid application of the going hints should produce better mutation.

Edward Cheney.

henectady, N. Y.

Interesting Indicator Diagrams

Tracing Fig. 1, it will be noticed that both ends are joined. I have noticed several diagrams like these for five years past. None of us has been able to give the cause, although various arguments have been advanced. In the present case

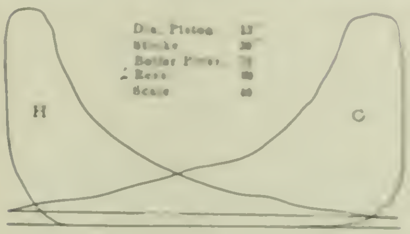


FIG. 1

the instrument was an outside-spring Tabor indicator, with Houghtaling reducing motion. The piping was ½ inch, with an angle valve at each end and there was an indicator cock between the indicator and piping. My assistant could not help making these diagrams, while I could not make one after him. I could not detect

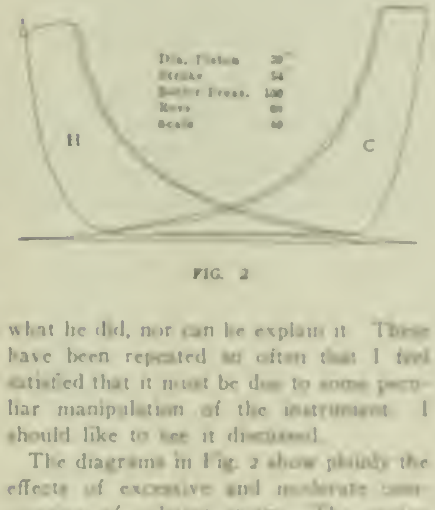


FIG. 2

what he did, nor can he explain it. These have been repeated so often that I feel satisfied that it must be due to some peculiar manipulation of the instrument. I should like to see it discussed.

The diagrams in Fig. 2 show plainly the effects of excessive and moderate compression of exhaust steam. The engine was an old one which had just been re-

FIG. 3

fitted. The condition of the engine can be considered fair. There was a marked difference in economy of fuel and possible load to carry. As refuse (wood) was the fuel used, I have to accept the report from the owner and the engineer that such is the case. The engine ran perfectly smooth in the last condition.

In Fig. 3, as the engine was with excessive compression, it ran jerkily. As left, it ran like a clock, as the saying is. The fuel here was mixed. In the last condition very little coal was required. I am told that the saving was about two tons per week.

J. R. Lamb[illegible].

Toronto, Can.

Graphite in Boilers

One of the jobs I had in my earlier experiences was that of boiler washer in a plant containing six 250-horsepower water-tube boilers. These boilers were washed out every six weeks. When I close up a clean boiler, I put 2 pounds of flake graphite in each drum.

When a boiler was opened up after this treatment, and the turbine cleaner run through the tubes, the scale came off very readily. By examining the side of scale which was next the tube, graphite could be seen clinging to it. The same condition was found existing in the drums.

Since I received my license and had charge of boilers, I have used this same idea and find it works fine, especially in return-tubular boilers, where the tubes are harder to clean.

Frank Wolfer.

Chicago, Ill.

Storage Battery Troubles

In a recent number J. M. [illegible] states that he is having trouble with his storage batteries and that the plates were buckled when he received them. If that is the case, the batteries had been charged at some time, and very probably emptied of the electrolyte without properly discharging the batteries. In placing new separators they should be of the proper thickness, but the plates should not be scraped off to make them thinner. The plates should not have stood in the acid an appreciable length of time without charging, which should commence when the electrolyte is placed in the cell.

In reference to the batteries becoming dead, if sulphating has occurred it can be determined by the plates being lighter in color than they were originally, and pure white sulphate flakes may form over the affected parts. To remedy this the batteries should be charged for a long time at about one-fourth the normal rate. This must not be done unless it is positively known that sulphating has occurred, as low charging is harmful to batteries.

The batteries should also be examined to see that there is no deposit in the bottoms of the cells. The plates should not rest on the bottom, but should be raised enough to allow room for a reasonable amount of deposit under them. Careful examination of the connections between the batteries should be made, as a poor joint will corrode and, although the battery may be fully charged, it will be impossible to get any current.

Short-circuiting is a very prolific source of trouble. If current has been taken from only a few of the batteries instead of the complete set, it may be possible that those used most have been discharged too low. By connecting these batteries in the circuit they could be brought up and then placed in service again.

If 1.210 electrolyte is used, it should not go below 1.170 in density. When water is added, the electrolyte should be stirred with a glass tube, as the water is lighter and may remain on top.

C. A. DAVIES.

Cincinnati, O.

Some Indicator Diagrams

One feature of F. L. Johnson's article, entitled "Some Indicator Diagrams," needs to be discussed. It can hardly be denied that compression does lower the maximum output of an engine, but the

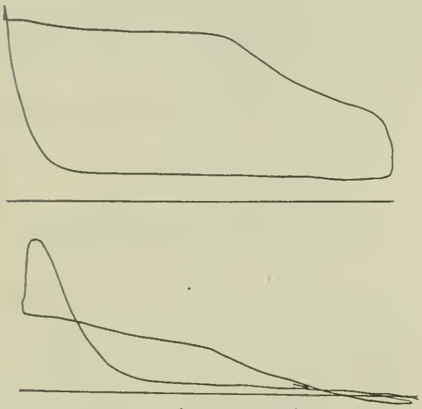


FIG. 3 (REPRODUCED)

case he cites, of an engine that was unable to carry its load after losing the vacuum, is not a fair argument against compression. The valves could have been set so as to retain the compression and a greater load could have been carried.

My idea would have been to ignore equal distribution of load between the cylinders and adjust the low-pressure cylinder cutoff equal to the ratio between the high-pressure and low-pressure cylinders. This would result in little or no drop between the high-pressure cylinder and the receiver and, although the low-pressure compression would be more than desirable, it would not rise above the admission line and make the loop (in his Fig. 3), which is negative. The loop at the other end of the card would also be eliminated, and the engine could carry a heavier load than it did under the conditions mentioned.

A. L. HOYLE.

Philadelphia, Penn.

I should like to know why the admission line leans in above the atmospheric line in Mr. Johnson's Fig. 4, which is a low-pressure card. I get practically the same result from the engines I am running.

WILLIAM HOPKINS.

Hastings, Mich.

[In the case mentioned the valve was set with little lead; the piston, therefore,

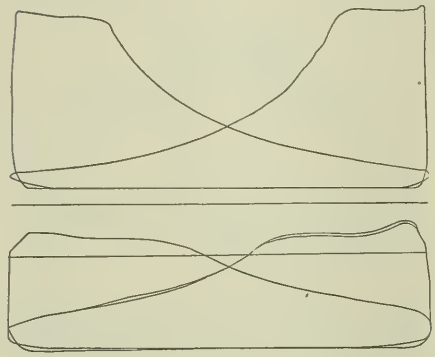


FIG. 4 (REPRODUCED)

began its stroke before the valve opened the port enough to supply the steam pressure necessary to produce a vertical line to the top of the diagram.—EDITORS.]

Location of Steam Traps

In Fig. 1 is shown the ordinary arrangement of the small trap, in connection with the steam separator, which is a fair example of the way they are found in active practice. I have observed, in

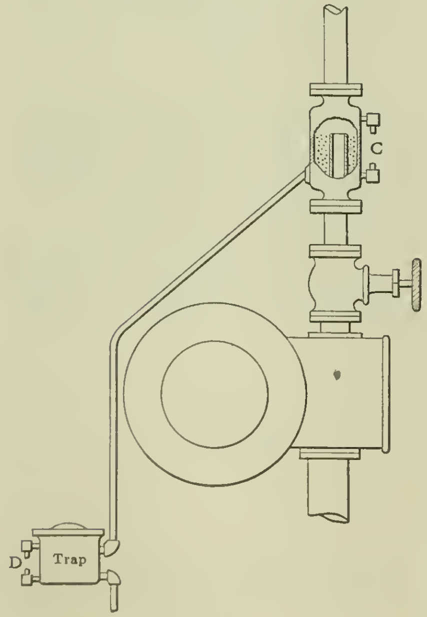


FIG. 1

connection with the placing of traps, that a long pipe of small size is run from the separator to the trap. While the trap may discharge the accumulated water quickly, the new discharge has to come through this small pipe. Some bad water wrecks have occurred from this arrangement.

A steam separator or trap should be no larger than necessary to do the work, as the two appliances present radiating surfaces which are wasteful even though they are well covered. This is no reason for selecting one so small that it will not work satisfactorily, however.

The placing of the steam drums to be drained by the trap may be so as to give the trap more advantage and facilitate the safe working of the whole system. An example is shown in Fig. 2. A better arrangement would be to have the steam drum as shown in Fig. 3; this is a much safer drum and costs no more than the other type.

The entering pipe should not be placed too close to the lower surface, as room must be allowed for the collection of the condensed water going to the trap, otherwise a counter current might be started

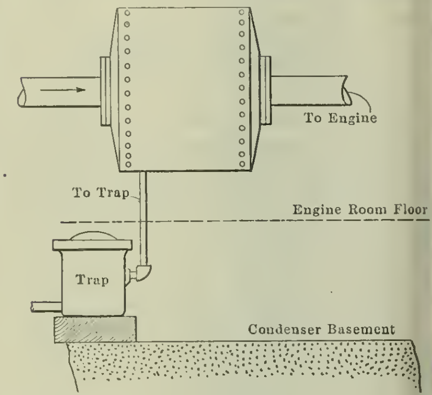


FIG. 2

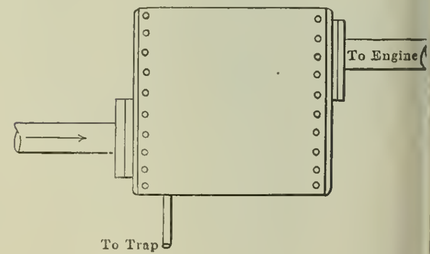


FIG. 3

and carry the water through the main t the engine.

C. R. McGAHEY.

Lynchburg, Va.

Probable Cause of Air Compresso Explosions

On one occasion I had to look for th cause of two air-compressor explosion The air was compressed to 17 pounds pe square inch. In both cases the pipe were ruptured. Various theories wei investigated, such as simple failui of the pipe, oil spray in the pip oil ignition at the extreme end, po grade of oil, leaky discharge valves. Tl last-named offered the most plausible e: planation, as air which had been con pressed evidently leaked back into tl cylinder where it became recompresse This recompression will make it hott ıd hotter until it either reaches a point here radiation will take the heat faster an the temperature can rise, or the temerature will rise until the oil catches e. The best of oils will take fire if eated enough.

F. W. Hollmann.

Baltimore, Md.

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xtraneous Supervision of Power Plants

The recent quotation from a pamphlet nt out by the Engineering Supervision ompany, of New York, and which Power w fit to comment upon editorially in the ecember 29 number, needs more than a ssing glance.

The statement made in reference to gineers being led astray by ambitious ents to the extent of receiving from 10 50 per cent. of the cost of work done d possibly of supplies purchased is aritable to the engineer, because he has en led by the ambitious agent. Such statement is an insult not alone to the gineer, but also the agents. A wide perience with engineers and supply ents, combined with a practical experice of more than 20 years, forces me to ate that the author of the pamphlet in estion should quickly join the famed nanias club. The statement that more an one-half of the plants are afflicted such practice is most absurd and shows nclusively the attempt of the company belittle the engineer in the eyes of his nployer simply to gain the business they ek. Such tactics are contemptible and neath the consideration of any fairinded man. A concern which tries to cure business by any such methods is neath the consideration of business men, ho readily recognize the despicable arguents as being in keeping with some busiss firms which try to injure competirs by just such tactics.

Any concern which feels that it is not ing used right by the engineer has the ivilege of making a change at any time, d while there may be some engineers ho are out for graft, the percentage is r from the 50 per cent. mark referred in the circular. The practice may have en in vogue in years past, but today the gineer realizes that the better the relts produced by himself the more valuae his services are. He knows this beuse he sees his fellow associates being evated to higher stations, and while he looking for advancement he knows full ell it cannot be attained by following up e methods referred to.

Agents who have meritorious articles r sale are able to make good without ying to bribe the engineer. They realize w impossible it would be to do it, for eir association with engineers has educated them to the realization that engineers are as honest a body of men as exists in the world today. An agent will hesitate before trying to sell a worthless article by any such methods, for he fully realizes that the law is waiting for him; he also realizes that a sale made under such conditions means that he can control the business only until some other man like himself underbids him. The cost to a firm conducting business under the specified conditions is beyond recompense where an article of any worth is sold, and the sale of an unworthy article is followed, as it would work a serious injury to the man recommending the purchase.

The attempt to belittle the competency of engineers by referring to them as nontechnical, is somewhat modified by reference to their practical knowledge received through hard knocks.

Experience has told the employer that the man who has received practical education is the man to employ, if results are desired. Men of this class have their minds broadened by the world's greatest teacher. While they have no sheepskin to show that they graduated from some engineering college, they are in the large majority capable of giving engineering advice about the installation and operation of plants that will be worth more than that given by the technical man without practical experience. Practical experience is only gained by the work required in actual operation of a plant. It cannot be obtained by casual observation, or from a few days spent now and then in making some test. The president of one of the largest technical schools in the world once said that they did not turn out engineers, but simply prepared them, and out of the graduates not 50 per cent. ever became engineers. There is good reason for the above statement, for unless a man has an aptitude for engineering he will never be a success, whether he be college bred or practical.

The technically educated man has an advantage if he will only improve it. To do so he must of necessity start at the bottom of the ladder and work his way through the hard school of practical experience and with the advantage of his early training he will reach the goal far in advance of his less fortunate brother and be a far better man, provided he is adapted for an engineer's life. Such a man will be able to give to his employer the very best there is, but until technical men are willing to start in a menial position and work their way up, the present type of practical man, who has some technical education obtained by home study, by absorption from the mechanical press and through the engineering associations, will prove far more efficient. Possibly a little more coöperation on the part of an employer, by the devotion of time to consider the problems that confront his engineer, would be profitable.

The proposed scheme of supervision would lead to the complete control of the various plants. As the pamphlet has decidedly stated that more than one-half of the engineers are grafters, it might not be amiss to suppose the supervisors to be slightly affected along the same line. It is a possibility so to supervise that the employing firm would in a short space of time be forced to expend a large sum to bring the plant back to its past efficiency. It would make no difference to the supervisors, as they would have theirs and that is all they are looking for. It is no charitable game, just business which they are trying to obtain by false representation. It is a serious proposition to be considered by engineers in general and also by business firms before accepting any proposals from such a concern. The engineer will be forced to lower his station in life to that of a mere businessman. His compensation for a like service will be less than the common laborer gets. The business firm which enters into a contract with such a company will be badly stung and the end will be a return to present methods. A competent engineer with coöperation on the part of the employer makes a combination that cannot be beaten.

T. N. Kelley.

Lowell, Mass.

What Reversed the Polarity

In answer to the recent inquiry under the above heading the writer wishes to state that he has had the same experience on three occasions in operating a 75-kilowatt DeLaval steam-turbine dynamo set, consisting of two 37½-kilowatt 125-volt generators connected to a three-wire system, for the operation of lights at the mills and a motor or two. In each case the trouble manifested itself on attempting to start the set in the morning.

I therefore concluded that the polarity was reversed in shutting down, due to a poor connection in the armature or field circuit of one machine, which caused the voltage to drop more rapidly on this machine than on the other. With any other motors running, or any other apparatus on the 250-volt mains, the machine with the lower voltage would naturally be reversed.

After three tests occurring calls to get this machine to generate correctly, I decided to supply the field windings of both machines from one of them, and I have had no trouble from this source since. As more than two years have elapsed since this experience, I feel that it is a permanent remedy for the trouble cited.

James D. Lynch.

Plymouth, N. Y.

The Plunger Hydraulic Elevator

Operation of the Valves in the "Standard" Plunger Freight Elevator Clearly Explained; How the Lifting Cylinder is Designed

BY WILLIAM BAXTER, JR.

For the operation of freight elevators the Standard Plunger Elevator Company provides simple hand-rope-operated valves. These valves are made to be moved by a lever if the car speed is very low, by single-geared rack and pinion for moderate speed and by a double-geared rack and pinion for high velocity; they are also of the balanced and unbalanced types. An

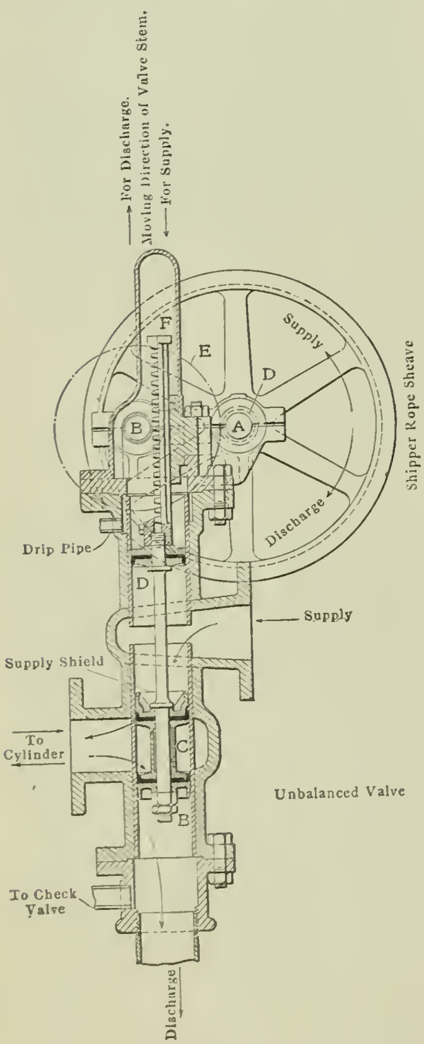


FIG. 287

unbalanced-type valve with double-geared rack and pinion is shown in Fig. 287, and a balanced valve of similar design in Fig. 288. The unbalanced valve is not, strictly speaking, unbalanced; it is only so when used in an installation where the discharge tank is located higher up than the valve. Looking at Fig. 287 it can be seen that if the pressure acting upward against the under side of piston *B* is the same as the pressure acting downward on piston *D* the valve will be perfectly balanced, because the pressure from the supply tank acts equally against the under side of *D* and the upper side of *C*. The pressure of the atmosphere acts on top of *D*, and if the discharge tank is on a level with the valve, the same pressure, or nearly so, will act under *B*; therefore, the valve will be fully balanced. If, however, the discharge tank is several feet above the valve, the pressure acting under *B* will be greater than that acting down on *D*, and the valve will not be fully balanced. The valve in Fig. 288 is fully balanced, no matter whether there is a back pressure from the discharge tank or not, because this pressure acts equally against the under side of piston *B* and the upper side of piston *A*; and the pressure of the atmosphere acts equally against the under side of *A* and the upper side of *D*. For slow-speed cars this type of valve is better than the complicated pilot valve, with its accompanying automatic stop valves, because it accomplishes all that the more complicated and expensive construction can accomplish and, being far more simple, is not as liable to get out of order. It is not desirable for fast-running elevators, however, because the movement of the car cannot be controlled with as great precision by means of the hand rope, owing to the rapid motion of the car and the long distance through which the rope has to be pulled to effect a stop. This is the only advantage of the pilot valve with car-lever control. With it a fast-running car can be stopped even with the floors of the building by anybody after a few days' practice, but with the hand-rope control only the most experienced car operators can obtain results that are at all satisfactory in large office buildings.

Lifting-cylinder Design

The casting that forms the upper end of the lifting cylinder is made in several designs by the Standard Plunger Elevator Company, one design being shown in Fig. 289, which is a vertical sectional view. The main casting is marked *A*; at *B* is the stuffing box and *C* is the upper end of the top-pipe section of the cylinder. The casting *A* is provided with a brass sleeve *D* that fits the lifting plunger and serves as a guide for it. This sleeve fits tightly at the upper end all the way around the circle, but at the lower end it is held in the central position by means of radial webs *A' A'*, which are narrow enough to afford free passage for the water but at the same time firm enough to give the sleeve proper support. Their construction is more clearly shown in Fig. 290, a horizontal section through the lower end of *A* and *D*. The stuffing box *B* is pro-

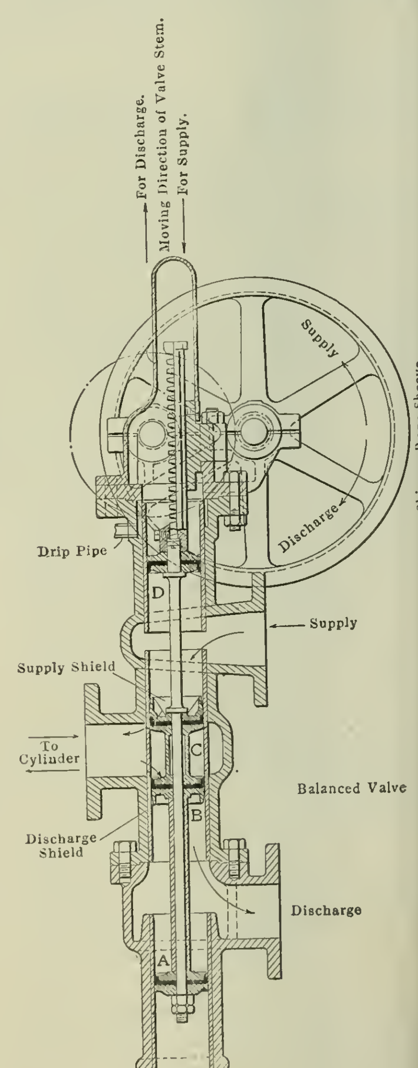


FIG. 288

vided with a gland *E* pressed down by studs *F*. The box itself is secured to *A* by studs *F'*. The packing may be of hemp, or any good, soft packing material, but usually a special design of double cup packing is used. The stuffing box is made with a rim *B'* which forms a basin to catch any water that may leak out of the cylinder. A drain pipe *B"* is tapped in

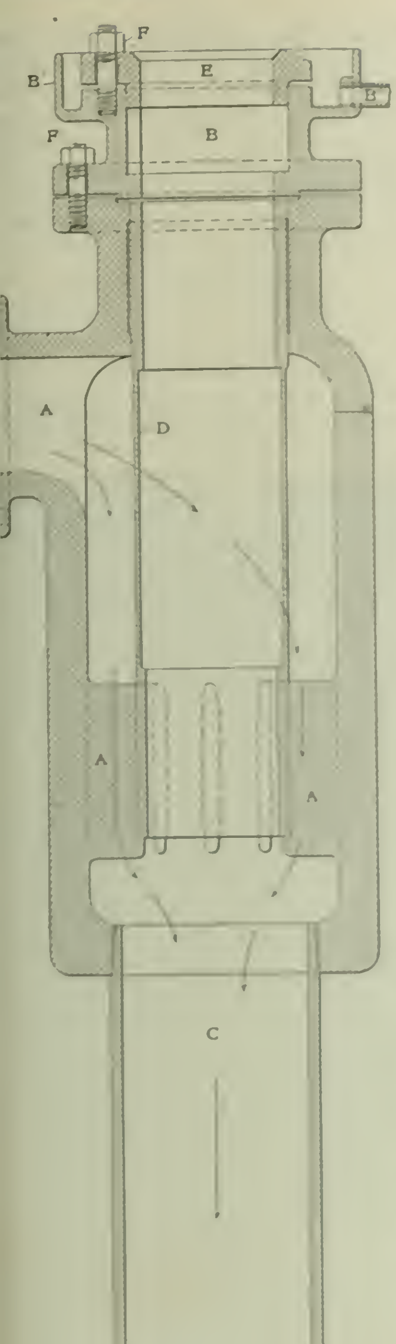


FIG. 289

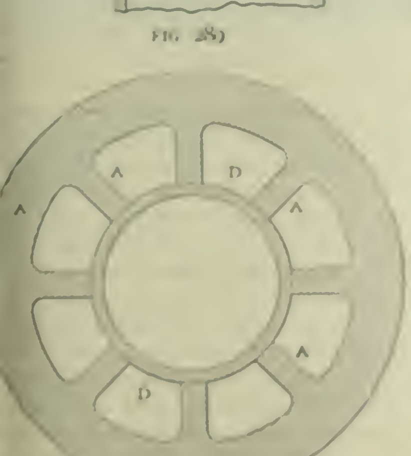


FIG. 290

on one side to remove the water as fast as it accumulates.

Fig. 291 is a vertical section of the plunger end used in connection with the cylinder top shown in Fig. 289. This end is made up of the parts *A*, *B*, *D* and *F*, which are held together by a long central bolt *G*. The upper part *A* is screwed into the lower section of the plunger *P*. The parts *B*, *D* and *F* are pressed tightly against each other by the bolt *G* and nut *C*, and all these parts are held firmly against *A* by screwing the end of *G* into *A*, as shown. The parts *A* and *D* are made of cast iron, which would rust in time, as this part of the plunger does not ordinarily run up into the sleeve *D* of the cylinder-top casting, Fig. 289. On this account these parts are incased in brass, as shown at *A'* and *E*. The construction of the upper part *A* is simple, but the part *B* is better illustrated in Figs. 292, 293 and 294, the first being a view similar to that in Fig. 291, the second a horizontal section through *L L*, Figs. 291 and 292, and the third another horizontal section on a line just above the nut *C*.

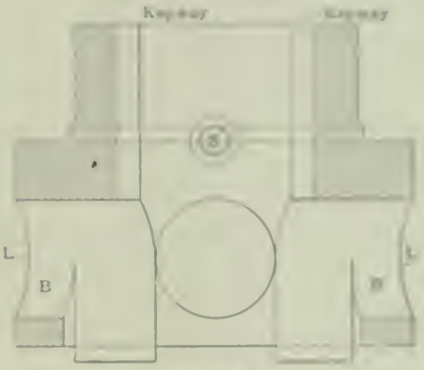


FIG. 292

Fig. 291. This piece, it will be noticed, has four holes marked *B'* that radiate from a central opening larger in diameter than the bolt *G* opposite and below these holes. Above the holes the center hole of *B* fits the bolt *G* and the latter is kept from turning in it by the two keys *K K*, Figs. 292 and 294.

The part *D* is simply a cylindrical piece shaped at its ends to fit over a projection depending from the under side of *B* and into a recess bored in the upper end of *F*, this construction being designed to bring the parts central when the bolt *G* is screwed up into the part *A*, as may be seen in Fig. 291. In this latter illustration it will be noticed that a screw *S* is run into the joint between *B* and *A* so these two parts cannot turn around with reference to each other and work the bolt *G* loose. The keys *K* prevent *G* from turning in *B*; as all these parts are securely locked, therefore, the nut *C* cannot turn, but even if it did it could do no harm because after bolt *G* is screwed up tightly in *A* the nut is not depended upon; in fact, its principal object is to hold the lower parts together when this

FIG. 291

are disconnected from part *A*. The lower casting *F* has a longitudinal opening through it considerably larger than the bolt *G*, and this opening has lateral connections with the exterior of the casting. As the part *D* is also hollow, there is a free passage through the end of the plunger from the bottom of the casting *F*

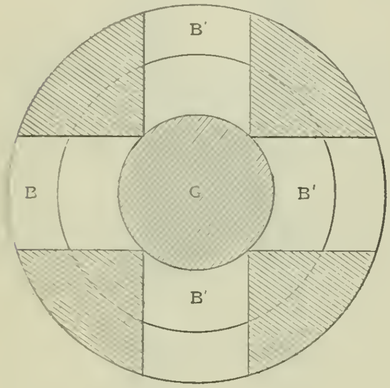


FIG. 293

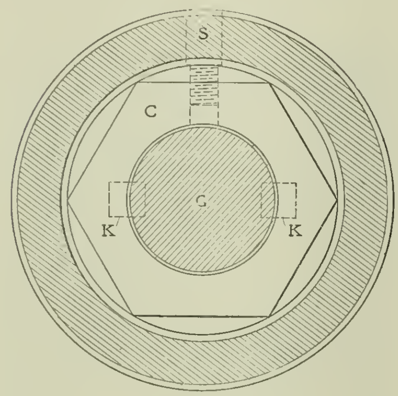


FIG. 294

to the holes *B' B'* in the part *B*. The object of this construction is to provide positive means for stopping the upward movement of the elevator car before it reaches the overhead beams, if for any reason it should fail to stop at the upper floor. When the elevator is in perfect running order, the top automatic valve will stop the car even with the upper floor and then the holes *B' B'* will be some distance below the stuffing box in Fig. 289, but if the stop valve fails to operate and the car continues upward, it will not rise far enough to strike the overhead beams before the holes *B'* will pass above the stuffing box, the water in the cylinder will find an outlet and the plunger will rise no farther.

Saturated Air as a Cooling Agent

By Arthur Pennell

Whenever it is desired to liquefy steam or other condensable vapor, some cooling agent must be employed which has the ability to absorb the heat evolved by such condensation and act as a vehicle for its disposition by some natural means. Cold water, the most obvious agent for the purpose, is often unattainable or too expensive. Air, which is omnipresent in unlimited quantity, also possesses properties which render it an efficient cooling agent.

Some Properties of Air

Absolutely dry air does not exist in the lower strata of the atmosphere. It always carries, mechanically mixed with it, more or less water vapor. Air is said to be saturated with water vapor when a cubic foot thereof consists of a cubic foot of water vapor at the elasticity due to the temperature and a cubic foot of dry air whose elasticity is the difference between the barometric pressure and the elasticity of the water vapor. The humidity of such air is 100 per cent. The two mixed form one cubic foot of saturated air at barometric pressure.

Everybody must have witnessed a white fog in a valley on a bright summer morning. The air in the fog must have been completely saturated inasmuch as minute vesicles of liquid water were visibly floating therein. As the sun rose higher and higher, the fog gradually dissipated. Sufficient heat had arrived both to vaporize the liquid vesicles and warm the air sufficiently to be able to absorb it. If, at such moment, the shade temperature was 62 degrees Fahrenheit and the barometric pressure 29.92 inches of mercury, each cubic foot of such air would have weighed 0.0761 pound and consisted of a cubic foot of water vapor at an elasticity of 0.556 inch of mercury weighing 0.000881 pound, and a cubic foot of dry air at an elasticity of 29.92 —0.556 inches of mercury, weighing 0.0747 pound. Further, each pound of dry air present would have carried 0.01179 pound of water vapor. By noon, we will assume the shade temperature had risen to 82 degrees Fahrenheit. The air was no longer saturated but carried the same load of water vapor in a state of superheat. If such air had the opportunity of passing

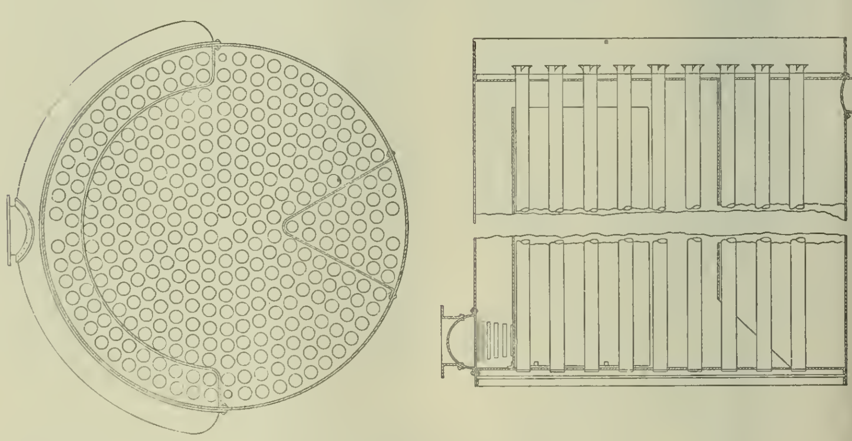


FIG. 1. SURFACE CONDENSER USING AIR AS COOLING AGENT

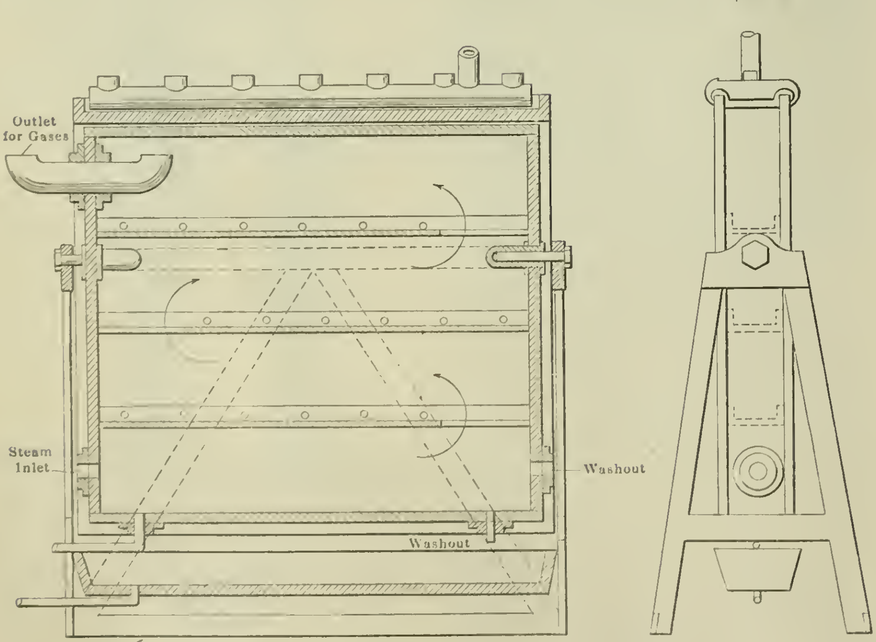


FIG. 2. SINGLE UNIT OF PENNELL FLASK-TYPE STEAM CONDENSER

over a wet, hot surface, it would absorb water vapor at the expense of the heat of the surface. Should it succeed in saturating itself with such water vapor at 82 degrees, the pound of dry air would be mixed with 0.02361 pound of water vapor and would have absorbed 0.01182 pound of water vapor from the hot, wet surface. A familiar practical example of the foregoing occurs whenever a freshly sprinkled street pavement is drying under a hot breeze.

Some Test Data

Fig. 1 shows sections of one of a pair of condensers using saturating air as a cooling agent, erected on the premises of the Armour Packing Company, of Kansas City. They were designed to condense, at atmospheric pressure, the exhaust steam from a number of simple engines developing a total of about 1100 horsepower. As one of them, while clean, was able to perform the duty, and a compound engine was being installed, the second outfit was equipped to condense the steam from the compound engine. The results of a [illegible]-hour test follow, this condenser operating upon a York cross-compound refrigerating engine, 30x58x48 inches, running at a speed of 45 revolutions per minute:

Average steam pressure at engine gage, lb.	[illegible]
Average vacuum per engine gage, in.	[illegible]
Average temperature in condenser, deg. F	123.7
Average temperature of circulating water, deg. F	118.4
Average temperature of city water, deg. F	52
Average temperature of outside air, deg. F	81
Average temperature of saturated air at condenser, deg. F	108
Average draft in stack of condenser, in.	0.1
Average humidity of outside air, per cent.	87
Total amount of steam condensed, lb.	71,[illegible]
Average amount of steam condensed per minute, lb.	12[illegible]
Total amount of circulating water used, 16,700 cu.ft., or lb.	[illegible]
Average amount used per minute, 235.17 gal., or lb.	1911.22
Total amount of city water used, [illegible] cu.ft., or lb.	31,[illegible]
Average amount used per minute, [illegible] gal., or lb.	[illegible]
Ratio of circulating water and steam condensed	[illegible]
Ratio of city water and steam condensed	[illegible]
Average horsepower per hour as engine during trial, per indicator cards	[illegible]
Average pounds of steam used per I.H.P.	[illegible]
Average horsepower required to run air pumps	[illegible]
Average horsepower required to run circulating pump	[illegible]
Total amount of condensing surface, sq.ft.	[illegible]
Amount of steam condensed per sq.ft. surface per hour, lb.	[illegible]
Cost of city water for [illegible] hours [illegible]	[illegible]
Cost of circulating condensing water [illegible]	[illegible]
[illegible]	[illegible]
Cost of water for 500 indicated horsepower for 24 hours, under existing conditions, $	[illegible]

FIG. 3. AN ICE-PLANT INSTALLATION OF THE [illegible] CONDENSER

Assuming water being pumped direct from the Kaw river at a temperature of 75 degrees Fahrenheit, a lift of 40 feet, and the condenser requiring 9.2[illegible] pounds of circulating water per pound of steam condensed. Five hundred indicated horsepower (7075 pounds steam) will require 65,[illegible] pounds of circulating water per hour, or, 1,088.75 pounds per minute; lifting 1088 pounds per minute would require 1.32 horsepower; adding 50 per cent. for friction, 1.98 horsepower, which at 15 cents per horsepower for twenty-four hours, would cost 29.7 cents.

The elasticity of vapor at this condenser temperature, 123.7 degrees Fahrenheit, is 3.827 inches of mercury, which deducted from the average barometer reading for this day, 28.98 inches, shows the ideal vacuum would be 25.153 inches; however, this ideal is impossible to obtain by mechanical means. About 21½ inches should be obtained under best conditions.

It will be noted that the total weight of steam, condensed at a temperature of 123.7 degrees Fahrenheit, was 71,530 pounds. The condensation was effected by the atmospheric vaporization of [illegible] cubic feet, or 31,130 pounds, of water. The weight of water atmospherically vaporized was only 43.5 per cent. of the weight of the steam condensed. This result will be corroborated by the result of another test made elsewhere, several years later, on another type of condenser.

The amount of steam condensed per square foot of surface per hour was [illegible] pounds, when the condensing temperature was 123.7 degrees, while the initial and final temperature of the circulating water was 118.4 degrees. This figures out [illegible] B.t.u. transmitted per square foot of surface per hour for 1 degree of difference. The surface was somewhat coated with scale. The draft, due to 40 feet of flue was 0.1 inch of water. Manifestly, to obtain the low condensing temperature necessary for high vacua, artificial draft, capable of supplying three times the volume of air, would have to be installed.

A new field is now being opened for a suitable modification of this type of condenser in oil refineries, for condensing petroleum vapor. As these vapors arrive at temperatures ranging from below 100 degrees Fahrenheit to over 600 degrees, the facility of controlling the cooling agent is of considerable economic value.

Fig. 4 represents a flash type of condenser for steam at atmospheric pressure for use in ice plants. The steam enters near the bottom, follows the course indicated, condensing as it goes toward the outlet at the far end of the top line, where the noncondensable gases escape into the air. The condensation water is led away from an outlet at the bottom. The circulating water is caused to flow in a thin sheet over the surface, thoroughly wetting it down, to be received in a collecting trough and thence into a catch can, from which the circulating pump returns it to the distributing system on the top.

Conditions were such that only 10-minute tests were practicable, the results of one of which is appended:

Time, Min.	Surface, Sq. Ft.	Condensed Water Entering Hot Well, Gal.	Decrease in Connecting Can, Gal.	Temp. Circulating Water, Deg. F.	Temp. Issuing Gases, Deg. F.
10	24	6	3	183	150

It will be noted that the circulating water reached a temperature of 183 degrees or 19 degrees below that of the condensing steam inside. In this case, the surface was new and absolutely clean. Calculation shows that 416.4 B.t.u. were transmitted per hour per square foot for each degree of difference. Further, the amount of water required to "make good" will be noted. The atmospheric vaporization was 50 per cent. of the amount of condensation water delivered. In this case the steam came direct from the boiler and was probably more nearly dry than in the other test. The amount of "make good" water varies with the weather conditions, probably ranging from 33 per cent. in zero weather to 66 per cent. in hot, dry summer weather.

Power Transmission in Great Britain

By W. H. Booth

A paper read some time ago by Mr. Snell before the Institution of Electrical Engineers in London appears to be the first public recognition by an electrical engineer that the electrical transmission of energy has limits to its commercial application. The fact that electrical driving of machinery can very often be shown to have effected enormous economies and often to have resulted in better work and improved output has too frequently been confounded with electrical-transmission economies. In order to transmit electricity a power plant must be laid down consisting of steam engines and boilers much in excess of the power sold, and of costly electrical generators also in excess of the power sold, for there must be a plant to make up the various losses of transformation and transmission. But the power user may himself be in as good a position to manufacture electricity as is the big supply station and the power user can adopt electric driving just as easily as if he purchased current. In Great Britain electricity has been attempted to be transmitted to users who are themselves as well placed in respect of fuel as is the power station, and whose load factor is far superior to the best load factor ever yet obtained by any power station. Power-transmission enthusiasts, encouraged by the economy of electric driving of the isolated scattered machinery of an iron-works, a shipyard or a system of docks, have imagined they could obtain equal economies in driving cotton-spinning mills, with their steady loads and load factors of 92 per cent., and they have overlooked a most important factor of the problem.

Excepting only a few of the warmer days of summer, a spinning mill requires to be constantly warmed by artificial heat. Approximately one-tenth of the heat value of all the coal burned for power appears as heat in the factory, for practically no work gets out of the factory and all the power taken by the machinery appears as heat, and, in really hot weather, provides more heat than is wanted. But every night, Sundays, and all the time for three-fourths of the year, there must be additional steam heat which the mill owner must generate in boilers, no matter how he obtains his main power. Thus, if he purchase transmitted electrical power, he must still have a couple of boilers. Even if small, he must pay a fireman, build a chimney, and must pay for main power, to a profit-making company, so much per unit as will pay that company for the coal they burn in generating electricity at a poor load factor, and for the large capital sunk in transmission lines. Now it is not possible under equal fuel conditions for any such power station to compete with a steady load of 1000 indicated horsepower produced by the user's own plant; for the cost of the user's plant is not more than the cost of the plant at the power station per 1000 horsepower, and there is no costly transmission line. The user practically saves nothing in wages, for he must have a heating plant, and he can borrow money at 4 per cent. on bonds or debentures, and that is less than the usual interest that power-transmission companies have to pay for borrowed capital.

Cotton factories in Great Britain are very usually placed along canals for the benefit of condensing water and there seems no reason why a group of mills should not obtain power from a common power station near to each member of the group; so near, in fact, that artificial heat would be supplied from the same center, thus saving every mill the expense of boilers and chimney and the wages also, for one fireman at a central station could probably supply heating steam for a dozen mills. The load factor of the central station would be better than that of any one of the factories and might be 95 per cent.

Ordinary central power stations owe their poor load factors of 25, 30 or 40 per cent. to the very bad load factors of their very few customers. The central-station man goes to the little user and says: "I can supply power for 4 cents per unit which costs you 12 cents." So the little man says he will take it and then there begins an attempt to explain the maximum demand system of charging. The little man goes away from the interview understanding that his current will cost anywhere from 4 to 16 cents, more probably the latter, but that he may hope to approach but never get down to the former figure if he will keep the small drill and the forge fan at work from 7 to 9; run two light lathes from 9 to 11, the big lathe on a light cut from 11 to 12, warm the shop and boil coffee from 12 to 1, and so on throughout the day, endeavoring to keep a steady load all day with no peak in it. The result is he does not become a customer, nor do four thousand other little would-be users of current, all of whom the central-station man insists upon fining heavily because he himself has failed to grasp the true essentials of successful business. Every electrical supplier ought to receive some training in an insurance office so that he may grasp the significance of the great laws of average.

There are four thousand little users with perhaps 20,000 horsepower of plant, and if the power station could get hold of them all they would give perhaps a load factor of 80 per cent. on a plant of 500 or 1000 horsepower and current could be sold at a flat rate of 6 cents to every little user.

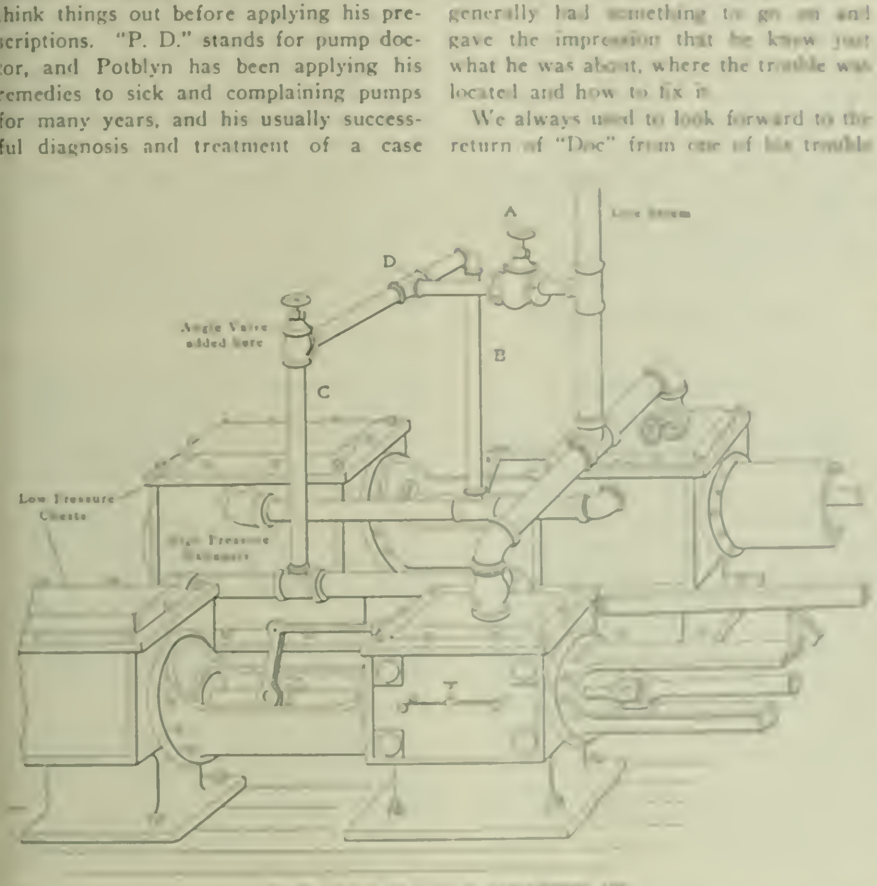
Power users differ from light users, for light users practically use light at the same moment, and numbers do not greatly reduce the abnormal peak load. This can only be dealt with by an enormous plant excess above average demand, or of a system of cheap storage such as the gas people possess. It is certain that the paltry little power stations of small municipalities cannot be expected to compete with a user's own plant when there is the added difficulty of heat supply to contend with, nor can big stations successfully supply current to large users with a high load factor. These facts, combined with the paralyzing effect of the maximum demand system of charging, and the too optimistic views of power-distribution companies, have brought the business to its present poor condition. Power stations have even been put up to sell current to coal mines and others who had their own plant and simply purchased any excess power they happened to require. Coal-burning stations have been erected to produce power in the middle of a lot of blast furnaces whose waste gases would have been equal to the supply of many times the power.

The paper of Mr. Snell much resembles a bomb in the camp, for it points out to electrical engineers facts against which they have shut their eyes and ears, and which have finally compelled recognition.

Potblyn, P. D.

By John Watson

No institution of learning had ever given him permission to write M. D., Ph. D., or anything else after his name, nevertheless the school of hard knocks, common sense and experience had surely given him the right to sign his name "Potblyn P. D." Do not suggest the addition of "Q" to the title, for the old "Doc" was not noted for the celerity of his movements, but, on the contrary, was rather slow-going and took his time to think things out before applying his prescriptions. "P. D." stands for pump doctor, and Potblyn has been applying his remedies to sick and complaining pumps for many years, and his usually successful diagnosis and treatment of a case



HOW THE PUMP WAS CONNECTED UP.

surely entitle him to some sort of a doctor's degree.

We have had "troublemen" working for the concern, whose idea of fixing an unsatisfactory pump was to go at it the first crack with wrench and hammer, open it up, slam around, and give a great impression of being busy and doing something. Old "Doc's" method was quite different. He might be sent to a plant where everyone, from manager to oiler, was swearing at a pump that appeared to be incapable of performing the service for which it was bought, and perhaps it was pounding and slamming and making noise enough to disturb the whole neighborhood. "Doc" would saunter in, present his card and have a cheerful "Good morning, glad to meet you" for office boy, manager, superintendent, chief engineer and everyone he met as he passed down the line. On reaching the pump room one would think that pumps were the least of all his interests. You all know the kind of cheery, old family doctor who, when he enters a sick room, starts a general conversation on the topics of the day, meanwhile studying the patient out of the corner of his eye. So "Doc" would leisurely take off his coat and start talking politics or prize fights, or anything but pumps. His eyes and ears were all wide open, taking everything in and sizing up the situation so as to have some idea of where the trouble lay before he made any move. He was a "wise old guy," for when he did get started he generally had something to go on and gave the impression that he knew just what he was about, where the trouble was located and how to fix it.

We always used to look forward to the return of "Doc" from one of his trouble trips, for he always came up to the drawing room to talk it over. Aside from the entertainment and amusement afforded by his descriptions, we always got some valuable information in regard to points which should be covered in future constructions. It was a rather poor trip when "Doc" did not "invent" something and have some new scheme to show to us. I remember one time in the early days of his employment with the company, before he had acquired the wisdom and skill which have made him such a valuable man, when we were especially anxious to hear his story.

We had a large compound condensing direct-acting pump working against a low head in a far Western city. In spite of all that the running engineer could do the pistons would hit the heads at every stroke. They wrote about it a number of times and everybody from chief engineer to blueprint boy took a shot at the solution of the difficulty. We sent them a number of suggestions as to the cause and remedy, but all failed to give relief. We went over the drawings very carefully (as we thought), but could find nothing in the design that would account for the trouble. Potblyn was called into the office and asked if he had any suggestions to offer. Not a suggest.

"Can you fix it?" said the manager.

"Yes," replied "Doc."

"Then go out there and don't come back until you get it fixed."

"All right, sir."

The easy confidence of youth would tackle any job and although it involved a large expense to send a man such a distance, it seemed to be the only chance of locating the trouble. In a few days we had a letter reporting his arrival and stating the conditions as he found them, but nothing about a remedy. This was followed by daily reports detailing all of his experiments and investigations. He opened up all of the cylinders and examined the vitals, juggled the "lost motion," pumped air into the air chamber, put on a larger suction chamber, plugged the suction re[illegible], varied the speed up and down, and tried everything that he could conceive. He took indicator cards and sent them home, asking for suggestions. They appeared to be all right and we had no further suggestions to offer.

Potblyn was "clean discouraged" and began to figure on some "boom pieces" kind of a network of piping and valves to provide a live-steam cushion for the low-pressure pistons. At the shop we started to lay out a cutoff arrangement to be applied to the high-pressure cylinders. We had it all planned out and the drawings made, just ready to go into the shop, when a telegram came in:

"The mystery solved. Potblyn."

That was all that we heard until, several days later, "Doc" strolled into the drawing room with his hat cocked over one ear and his mouth spread east and west so far that the corners were out of sight.

"By Tobey, you're a pack of chuckle-headed clams," was his greeting. "You fellers here get second prize for dunce heads."

"What about first prize?" the chief draftsman asked.

"Oh! I've got that medal myself, and all of the medals that go with it; just you wait until I go down to the shop and tell everybody down there a bit and then I'll come back and tell you all about it."

We cornered him, however, and made him tell his story. He had to tell it in his own way and there was no use trying to pin him down to the part we were anxious to hear about until he reached it in the course of his narrative. He described all of the experiments which he had tried and finally reached the point where he said that he was ready to give up.

"I sat down on the floor that afternoon with my back against the wall and as I smoked my after-dinner twofer I watched that cussed pump run down and bang on the end of every stroke. I wasn't much like the gay lad that came in there a week before confident that he could fix anything on earth. I was homesick. I wanted to see mama. I thought of all the gay and happy children at home, and there was I and there was that damn pump. The engineers cast pitying smiles on me as they passed. Talk about your markdowns, I felt like a left-over from a rummage sale. I was staring across the room without seeing anything in particular, when somehow my eye fixed itself on a piece of pipe leading from the high-pressure exhaust connection. Unconsciously my eyes followed it to its other connection and, say, the light that broke on me had Luna Park illumination 'skinned a mile.' I wanted to kick myself, but I thought I had better hold off until I found out whether the light was a real beacon or only another lightning bug. I couldn't do anything until the pump was shut down, but I did cheer up some, voted myself a fresh cigar and went out and threw stones at the frogs.

"Soon as they shut the pump down I went at it, broke a union, took out a section of pipe, put in a valve, and had it all done before the engineer got onto what I was doing. You bet I was on hand when he started up in the morning and, say, that darned old shebang started off and ran just as nice and quiet as a rubber-tired baby carriage when the kid's asleep.

"Not a bang, not a murmur; she's all right from then on, but as I may have remarked you're a lot of blasted idiots not to have known what was the matter, and I'm another not to have found it sooner. Some chump put in a bleeder for live steam to the low-pressure cylinders to use in starting. That's all right and worked all right, for we had to use it to start up, but the fourteen kinds of a fool connected it as shown in this drawing. [See sketch.] He put in only one valve at *A* and he connected the two branches into the high-pressure exhaust pipes, thus forming a cross exhaust from *B* to *C*. It was only a 1½-inch pipe on a 26-inch cylinder, but it was just enough to make all of the trouble and cost the company some hundreds of dollars. I put an angle valve in place of the elbow between *C* and *D* and fixed the whole trouble. Now, if the cheerful idiot that did it will come outside we will kick each other and feel better."

But, alas, "the cheerful idiot that did it" had "graduated" shortly after laying out the piping for that job. He should have known better than to make such a connection, but he slipped up on it somehow and it was such a comparatively small pipe that in checking the drawings and in erecting the pump it escaped notice. It probably would not have made any trouble but for the fact that it happened to be on a compound pump handling a large quantity of water against a low head. The momentum of the water column is liable to cause trouble under such conditions and this crossover connection, or "cross exhaust" as pump men call it, added just enough power at the end of the stroke to overcome the cushion and make the pistons strike the heads.

Do you wonder that special instructions were issued to all draftsmen to look out for all possible cross-exhaust connections however small?

Potblyn had "solved the mystery" and gained a reputation. His telegram has become a byword in the shop and whenever a pump gives trouble we suggest to Potblyn that we have another mystery for him to solve. He is very good at it and is particularly keen to spot a cross-exhaust connection, even if it is only where some engineer has failed to put the necessary valves in his cylinder-drip piping.

Some Queer Definitions

By J. E. Woodwell

Someone has said, "There is nothing new under the sun." It is certain that this person never had the pleasure and the enlightenment which comes from the perusal of civil-service examination papers. Those who have had this privilege have learned many new things, and the end is not yet. If originality is a desirable quality in electricians and engineers, Uncle Sam has an abundance of good material to select from. The writer has frequently drawn up technical examination questions, and later in reading the replies has made many startling discoveries, some of which should prove interesting to the profession.

Noah Webster was not a mechanical engineer, but we prefer his definitions to some of those given by candidates for the title. For instance, a toggle joint is variously described as: "An imperfect joint," "a bad joint," "a substantial 'soldier' joint," "a peculiar connection used in bringing two ends of the conductor together or making it as one conductor; the combination of splicing of two ends," "toggle joints are used on flexible shafts and on corner braces such as electricians use."

The definitions of an eccentric are even more eccentric than the object itself. We are of the opinion that the entire engine would be eccentric under the following conditions: "Eccentrics are used on engines, air compressors, and 'varies' other machines, and is generally connected to the piston rod." Lest any of the readers should be ignorant of the connection, we will give this man's explanation of how it is done: "A bell-crank lever is used to connect the piston rod of an engine to the eccentric." Another who described eccentric as meaning "lively; full of energy," possibly had in mind this same application.

There is evidently a difference of opinion regarding the bell-crank lever. A certain individual states that it serves to give a "Double or 'thrible' motion." Still another definition is that "A bell-crank lever is a lever shaped like a bell; a lever used to ring a bell."

In answer to the question: "Describe the construction of a self-oiling bearing on a motor or dynamo," this response was received: "Have the oil cup full of oil with a small plug in the outlet." We feel morally certain that this man does not own stock in the Standard Oil Company.

The public should not be deprived of the benefits of the information contained in the statements that:

"Armature cores are laminated to separate each layer of wires. The disks extend outwardly."

"Armature cores are laminated for their magnetic influence on the field coils. The disks extend relatively to the north and south poles."

"They are laminated in order to make the break between the positive and negative poles."

"Armature cores are laminated so as to give them more surface to 'effect' the magnetic."

The man who said that an idle pulley is "One that remains idle on the shaft" did not venture far into mechanics. Another replies, "Idle pulley: where the belt should run when the machine wants to be stopped." This machine is evidently endowed with greater intelligence than the operator.

The author of one of the descriptions of a bushing mat possesses a fine legal mind, but displays a decided lack of training. It reads thus: "A bushing is a mechanical term used to designate the part that fits into another part to separate the third part that may or may not go into the bushing; or, in other words, it is the part that separates two parts which fit into one another either tightly or closely."

The man who described a circular mil as, "A round cutter or a cutter that cuts while revolving, as a saw or milling cutter," was more of a machinist than an electrician; but the man who described it as "A table used in determining a certain value of electric current representing a part of one ohm," has not yet found his calling.

In this practical age seeing is believing, and a certain applicant in describing an ampere-turn said: "It is something I never saw on a motor." Here are other definitions of the same term:

"Ampere-turn is used to measure the voltage with."

"Ampere-turn is the turn given in its rotation around the armature."

"Ampere-turn: number of coils wound on."

"Ampere-turn is the power obtained by the resistance of a volt."

"A turn that the amperes take in a resistance coil to reduce the 'amprereage'."

"Ampere-turn is the number of turns of wire on the armature."

There is room for a difference of opinion in most of our human affairs, and there is always a chance for intelligent men to vary in their statements, but it is hard to reconcile all the following descriptions of back lash. We cannot imagine anything which would fulfil all these requirements:

"Back lash is a term applied to a strap on an engine."

"To lash and lash back."

"To throw back the table after having finished the work, making a reverse motion."

"The back lash is used in lacing a belt."

"The loose side of a belt running 'acrost' two pulleys."

A certain very cautious individual consistently avoided becoming involved in technical matters beyond his reach. He said: "Back geared means a machine constructed with gears on back instead of any other part of same."

One ambitious man, who drew from his imagination rather than his education or experience, made heroic attempts to answer most of the questions. To a portion of them, however, he hopelessly realized that this method of solution would not be applicable, and when he came to certain of the definitions and descriptions inserted, in lieu of an answer, the words: "Pass it up."

We believed this to be good advice, and have accordingly selected these few examples from a great number of papers and "passed them up" for the edification of all persons interested.

Pressure on the Eccentric and Crank Pin

By M. R. Casey

Fig. 1 shows four positions of a crank pin during one cycle. The approximate dimensions of the pin are 2 inches in diameter by 2½ inches long and 6.28 inches in circumference, which, multiplied by the length, will give the area

$$6.28 \times 2.50 = 15.70$$

square inches. As the pin only touches on one side, it has a useful area of one-half of the whole, or 7.85 square inches. With a piston 7 inches in diameter and having an area of 38.48 square inches, with a constant pressure of 30 pounds per square inch, there will be a total approximate pressure of 1154.40 pounds.

Of course, there is a period in the cycle of movement when no pressure is exerted upon the crank pin. The crank rotates at a speed of 300 revolutions per minute, and the center of the pin travels 37.69 inches in the one turn, which, multiplied by 300, equals 11,307 inches. The center of the crank pin would travel 942.25 feet in one minute, while the piston speed has been 600 feet.

Referring to Fig. 1, we find a given point C of the crank pin, and when one-fourth of the cycle has been made we find that the point C has changed its relation to the point of pressure. When the pin has made one-half of the cycle this point is opposite the working point, and at the three-fourths turn it is still farther around. The linear movement of the pin has only been 6.28 inches during one turn, while the body of the center of the pin has passed through 37.69 inches, just for one turn; the linear movement of the surface of the pin has been 1884 inches when the engine is running 300 revolutions per minute, or the surface of the pin has traveled at a velocity of 157 feet, while only approximately 78 feet has been under a working pressure. This linear velocity of the pin's surface is one reason why we can lubricate a crank pin as easily as we do.

Fig. 2 shows an eccentric, the point C of which travels at one velocity in a circular path, while the point D travels at another velocity in a circular path. In Fig. 3 the extreme extension of the eccentric travels on the line O. Being 6 inches in diameter, this point must necessarily travel 18.85 inches when it has made one revolution, and for one minute 5656 inches, or 471 feet, nearly equaling the speed of the piston. This speed is much in excess of what it is supposed to be by some engineers when running small engines.

The linear and circular velocity are working under a pressure carrying the unbalanced slide valve, the load being approximately 1,200 pounds. The surface usually pressed by the eccentric would have a total surface of 28.27 inches, and, like the crank, only being one-half under duty, would be 14.13 inches in area. Therefore, the 1200 pounds must be carried by this surface, making the pressure and velocity per square inch considerable.

The two points on the eccentric travel at two velocities, P representing the lower, this being 12.57 inches in one revolution, or for the time in question 3771 inches or 314 feet; so it is clear that the lower velocity is something more than one-half that of the piston's movement, and the true working condition might be taken as an average between the extreme movements of the eccentric. The outside or extreme point of the eccentric is constructed as working in the path shown by the outer circle in Fig. 3.

The eccentric, in many cases, works under trying conditions, and carries much more load than the man in charge gives it credit for, and at a high velocity. This is one reason why the pinned crank pin for carrying the valve gear has worked so satisfactorily on the center-crank engine. There the load becomes that of the crank motion in the movement, not in actual load, but under the same conditions. As far as velocity is concerned, it can be much lowered below the design. The one fault has been that the designer reduced the surface too much as soon as he made the crank pin a substitute for the eccentric.

The velocity of the surface of the eccentric is somewhat changed, as to the conditions under which this pressure comes,

FIG. 1

FIG. 2

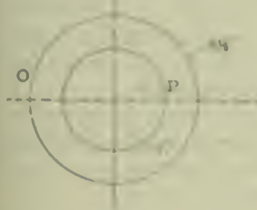


FIG. 3

FIG. 4

by the form of eccentric rod, and the length of the valve or eccentric rod has some effect on this. It can be clearly seen from Fig. 4 that the wearing condition of the eccentric strap having a rod as shown at N will be much more uniform on the eccentric than the one having a rod as shown at M, as the two velocities will blend better on the one having the long rod.

A Large Wood Pulley

The illustration shows a large wood split pulley which was furnished recently on a rush order by the Reeves Pulley Company, Columbus, Ind. It was 132 inches in diameter, 24 inches face, and had a $4\frac{15}{16}$-inch bore. The order was received at 9:40 a.m., and 28½ working hours later the pulley was loaded on a car and started to its destination.

This is the only firm, so far as we have knowledge, which builds such pulleys all wood. They have been building them for the past twelve years.

PULLEY 132 INCHES IN DIAMETER MADE IN TWENTY-EIGHT AND ONE-HALF HOURS

Catechism of Electricity

895. *How should the motor be shut down?*

Open the circuit breaker or main switch, allowing the machine to slow down of its own accord. Never stop a motor by releasing the lever of the starting rheostat, as this would burn the contacts on the box and might puncture the insulation of the field and armature coils.

896. *May the load now be placed on the motor?*

The motor, if new, should be allowed to run without load for a day or two so the bearings and brushes may have a chance to conform themselves to actual working conditions. When ready for the load, place the belt on the pulley and start the motor as before, closely watching the machine and everything connected with it so as to be ready to open the main switch or circuit breaker the instant there appears to be anything wrong.

When load is first thrown on a machine an ammeter should be in circuit for the purpose of ascertaining whether the machine is operating at its proper load, for if it is overloaded trouble may be experienced. The correct normal load in amperes is stamped on the nameplate mounted on the field frame.

897. *Mention any general precautions that should be observed after the load is placed on the motor.*

Inspect the motor frequently for the first few days, to guard against hot bearings, loose connections, etc. Keep all parts of the machine free from water, carbon dust and dirt of all kinds. Keep bearings properly filled with oil, and see that they do not leak or throw oil; also see that the oil does not overflow into the machine. Use every precaution to prevent oil from reaching the commutator or the armature windings. At first, the oil in the bearings should be changed once a week; later, two or three times a month.

Cleanliness is particularly essential, both inside and outside the machine. A hand bellows is convenient for blowing out dust, etc., from the inside of the machine, and an oily cloth for wiping dust, etc., from the outside. Cover the machine when not running, to protect it from dust.

898. *What troubles are most liable to arise in the operation of a direct-current motor?*

Sparking, heating, noise and abnormal speed.

899. *In which parts of the machine do the sparking and heating usually occur?*

Sparking at the commutator, heating at the commutator, brushes, armature, field magnets and bearings.

900. *What are the usual causes of sparking at the commutator?*

(1) The armature may be carrying too large a current, owing to an overload on the machine, or to friction such as that caused by the armature shaft not turning freely or the armature striking the pole pieces. A coil in the armature may be short-circuited or reversed, or there may be an open circuit in the armature. Too little resistance in the starting rheostat will cause sparking. If the armature or the pulley is not perfectly balanced, there will be vibrations of the machine which may produce sparking.

(2) The brushes may make poor contact with the commutator, they may have too high resistance, or they may not be at the neutral points.

(3) The commutator may be rough, not perfectly round, or may have some high bars in it.

(4) The field magnets may not be fully excited, or one pole may be stronger magnetically than another.

901. *How can one tell whether the sparking is caused by an overload on the armature?*

In case of a belted motor the tension side of the belt becomes very tight, and the belt sometimes squeaks owing to its slipping on the pulley. In either a belted or direct-connected motor an overload causes overheating of the armature, and this latter may be detected without stopping the machine; simply hold the hand in the current of air caused by the rotation of the armature and note the temperature by the sense of feeling.

To determine whether the overload is friction within the machine, stop the motor, and while turning the armature slowly by hand notice if it turns hard at a certain part of each revolution. If it turns hard there is some sort of mechanical obstruction within the machine; if it does not turn hard, the trouble, if an overload, is either a too tight belt or trying to accomplish too much work with the motor capacity available.

902. *What are the symptoms caused by a short-circuited coil in the armature?*

A short-circuited armature coil becomes much warmer than the others while the machine is in operation and is very liable to be burned out. The motor draws more current than usual and if the armature be felt when the machine is first shut down, the short-circuited coil can usually be located by reason of its higher temperature.

903. *How should trouble due to a short-circuited armature coil be remedied?*

By removing the short-circuit. A piece of metal between the commutator bars or between their connections with the armature winding is usually the cause, in which case it is easily remedied. If, however, the trouble is in the coil, the defective coil will probably have to be replaced by a new one.

Generally, the condition of a coil will readily indicate whether repairing or a removal is necessary. When a coil in a low-voltage machine has become injured through careless handling, it may be possible to repair the damage by separating the wires properly and applying a coat of shellac or some good insulating compound. Even in motors of higher voltage it is often possible in this manner to remove a small trouble without replacing the coil.

904. *Describe how to remove an armature coil.*

If a coil is entirely burned out, it may be easily removed by cutting it in two, but this should not be done unless it is certain that no part of it can be used again. Formed coils cannot be used a second time if a part of them is cut out. When, however, an accident happens to a hand-wound coil, the good wire in it may, by taking it off, be used again.

905. *Is it not advisable to keep a supply of wire on hand in the station for replacing damaged coils?*

It is important always to have in the station the proper wire for such coils as may be wound by hand on the armature or on the field coils. A sufficient amount of it to wind at least one or two coils should be provided. When a motor is built up of formed coils, there should always be within reach several coils of the different kinds that may be needed. Besides these should also be provided the shellac, oil, tape and whatever other materials may be necessary in repairing any particular machine.

906. *Explain how to replace an armature coil.*

The manner of replacing coils depends altogether on their construction and the type of the machine in question. When a coil is to be wound on by hand, care must be taken to notice how the old coil was wound on and connected, and the new one must be put on in the same manner.

A common type of formed coils used on direct-current machines, and the manner of applying them, is illustrated in Fig. 279. Such coils when supplied for repairs are usually already bent or formed, as the two shown at *a* and *c*. When this is not the case, as with the coil shown at *d*, they must be shaped to conform with the rest of the coils. When properly bent

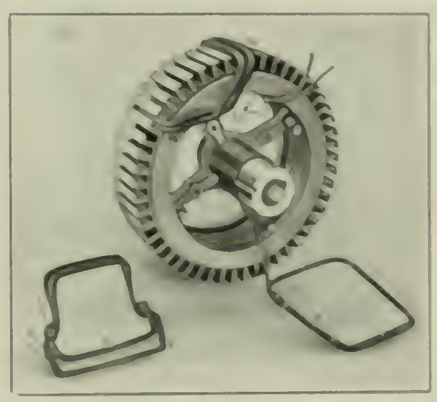


FIG. 279. FORMED COILS AND METHOD OF PLACING THEM IN POSITION ON THE ARMATURE CORE

they can be slipped in the slotted armature core as shown at *m* and *n*, their extremities being connected to the commutator bars in the usual manner.

907. *What are the symptoms of a reversed coil in the armature?*

The motor draws more current than usual, but the coil itself is no warmer than the other coils. If current be applied in the same direction to each coil separately by way of the commutator bars and a magnetic needle be held near the excited coil, the needle when applied to the reversed coil will point in the opposite direction to that when applied to the other coils.

908. *State how trouble due to a reversed armature coil should be remedied.*

By changing the terminal connections of the reversed coil so that they correspond to those of the other coils.

909. *How is it possible to know whether sparking is caused by too little resistance in the starting rheostat?*

If there is sparking from this cause it will occur only in starting up the motor. The motor will also start suddenly.

910. *What should be done to determine whether a motor has a poorly balanced armature or pulley?*

A poorly balanced armature or pulley usually causes vibrations of a stronger and more thoroughly distributed nature than those due to other causes and the vibrations increase with the speed of rotation, so that the trouble may be recognized in this way. If the indications point to the armature, the pulley, or both armature and pulley being unbalanced, they should be removed from the machine and tested separately.

The armature should be tested by placing it so that its shaft is supported at the ends upon two knife edges parallel to each other. Then, if the armature is poorly balanced, the heavy side will cause a rotation except when this side happens to be downward. By placing the armature at rest on the knife edges at different points around the shaft, the weighty side may be easily found. By providing a shaft for the pulley it also may be tested in the same way.

911. *How can a poorly balanced armature or pulley be remedied?*

Either by firmly fastening some lead on the lighter side of the core or by boring holes in, or filing off, the heavy side.

912. *If it is important that the motor be not shut down, can sparking due to vibrations of the machine be reduced temporarily?*

It can be partially overcome by giving more tension to the brushes so they press more firmly upon the commutator. This, however, is liable to develop considerable heat, both in the brushes and commutator, and should be resorted to only in cases of emergency. It may be found that the vibrations are due to an unstable base or foundation, in which case the trouble may be overcome without much difficulty.

913. *Is there not always some sparking at the commutator of direct-current motors?*

There is usually some sparking in all machines provided with commutators, but it is nevertheless a feature to be carefully watched and reduced to a minimum, inasmuch as it tends to destroy the brushes and commutator, causes trouble in the regulation of the machine and produces heat in the parts at which it occurs. A motor in perfect working condition should run without any sparking.

During the past few months the coal beds in the vicinity of Raton, New Mexico, have been investigated. The deposits have been found [illegible] 15 miles wide, extending from Johnson's Mesa westward to the mountains. Careful investigations, carried on by the United States Geological Survey, indicate that most of the coal contained in this field is a high-grade bituminous and of coking quality.

POWER
AND THE ENGINEER

DEVOTED TO THE GENERATION AND TRANSMISSION OF POWER

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Contents

For the Good of the Order

The opportunities for self-improvement afforded by meetings of engineers are often sacrificed or minimized by lack of sufficient preparation. Instead of having a definite program arranged for each evening, a subject selected for presentation and discussion and somebody prepared to elucidate and intelligently discuss it, a chance is taken that something will come up which will make the meeting worth while The inquiry "Has anybody anything to offer for the good of the order?" often meets with a barren response, and this part of the meeting, to which the routine business should be merely incidental, is often made a very subordinate feature. As a result the members disperse without having added anything to their stock of knowledge, without having had their interest excited, and really in a condition seriously to wonder if it is all worth while.

There are thousands of subjects any one of which will afford the material for an evening's consideration to the profit of the participants. The man who goes to a meeting and engages in the discussion and mastery of a subject which has been a mystery to him, who goes away with new ideas and an awakened interest, is likely to return and to become a valuable member and a better-informed engineer: to derive the real benefit from the association which its prospectus holds out. Many a man owes his success to the circumstance which impelled him to grasp some particular problem connected with his vocation and wrestle with it until he mastered its intricacies and made it a part of his equipment. The knowledge which the real engineer possesses has to be dug out by work and application. He cannot buy a handbook or library and sit with his feet on the desk and his pipe in his mouth and look at it and imbibe an engineering education. He cannot master principles and absorb the value of precedents by reading "easy" articles which do not make him get out his pad and pencil and think. One article which it takes a whole evening or a week of evenings to read and understand may, when mastered, be worth pages and volumes of discursive reading which has cost no effort.

The association affords an opportunity for a collective attack upon an article of this kind. Take for example the article by Mr. Jeter in our issue of January 5. This article describes a new and ingenious way of determining, by a glance at one of the charts accompanying it, whether a riveted joint in a plate of given thickness and with a given pitch of rivets will fail by tearing the plate, crushing the plate or shearing the rivets. The article while somewhat forbidding from its length and the formulas involved is very simple when one gets into it, and the instructor of any association can easily master it or refer it to somebody who can, and present it in abstract to the association, explaining knotty points and helping all the members to a thorough understanding of the subject. In order to encourage this use of the article we will be glad to loan, at no charge, lantern slides of the illustrations and charts accompanying the article to any association which desires to use them in this way.

High Boiler Efficiency

The boiler user is constantly reminded by the manufacturers of boiler compounds and tube cleaners of the inefficient results due to scaled boiler surfaces, a fixed ratio of loss to thickness of scale often being given. It has been pointed out by various authorities that such a ratio could not possibly exist, as it is a well known fact that the quality of the scale is generally of considerable more importance than its quantity. However, it is impossible to place too much stress on the necessity of keeping the inside of the heating surface clean, as not only efficiency but, what is of far more general importance, the safety of the boiler are dependent upon this condition.

When it is desired to keep the efficiency of a boiler to the highest point, the condition of the exterior portions of the heating surface is generally of more moment than the condition of the interior, particularly in the case of water-tube boilers. A thin layer of soot or ashes is a very effective nonconductor of heat and often portions of the heating surface are allowed to become banked up with soot and ashes until the effectiveness of the surface is almost totally destroyed. If similar conditions were the result of scale accumulations on the interior surfaces the metal would be at once destroyed, but in the case of external dirt no effect is produced except a rise in the temperature of the escaping gases, and hard steaming. The result is that often the cleaning of the external portions of the heating surface is neglected and the economy suffers. In many plants the periods between blowing off the external portions of the heating surface range from three days to a week. This is very much too long for economical operation where bituminous fuel is used, and in most plants once a day is hardly often enough if the highest economy is desired. The largest dividend payer in the boiler room, next to a skilled fireman, is a cleaning gang to keep the heating surfaces as nearly perfectly clean as possible. In selecting boilers the importance of this cleaning should be borne in mind, and the facilities offered by various forms of boiler or setting to accomplish proper cleaning should receive due weight in determining the kind to be selected.

Gas Power for Marine Service

The possibility of applying gas power to the propulsion of ships is becoming more and more a live question, nothwithstanding the fact that land practice has not yet attained what might be called stability. Of course the chief object in considering the internal-combustion engine for marine purposes is the saving in fuel consumption, which would reduce the cubic feet of fuel storage and thereby increase the freight space. The saving in the cost of the fuel is also a consideration, but space economy is the chief attraction. In view of the much greater space occupied by a four-stroke gas engine as compared with either a steam engine or a turbine, it would seem that the net result might not be a reduction in total plant and fuel space after all. Of course, the duration of the unbroken voyage would be a controlling factor. For a coastwise schedule, the saving in fuel space might be much less than the excess in engine space, as compared with steam.

In any event, the high value of space on a vessel of any commercial type undoubtedly points to the use of a two-stroke engine in the solution of the marine gas power problem. It is unnecessary to explain in detail the enormous space economy of the two stroke engine over the four-stroke type; everyone who is familiar with the subject knows all the points.

Provision of adequate means for going ahead or reversing suddenly and vigorously is recognized as being another serious problem. A flywheel on a large marine engine would be an anomaly, and the only other expedient for quickly applying the full power of a gas engine to its load is the combination of three or more double-acting two-stroke cylinders, or their equivalent, with a flexible transmission, such as electrical apparatus, between the engine and the load. With electrical transmission the quick application of full power in either direction would be easy, but what would become of the precious space reduction, not to mention weight and cost of apparatus?

All theorizing aside, there is much more work to be done on both the gas engine and the producer—especially the latter—before we will be prepared to tackle "long distance" marine service.

Loops in Noncondensing Compounds

With a compound engine running noncondensing the indicator diagram from the low pressure cylinder showed that expansion was carried below the atmospheric line, and all attempts on the part of the engineer to remove the negative loop by changing the length of the cutoff were futile.

Advice was sought from a consulting engineer, who thoughtlessly stated that the removal of the loop was a matter of easy accomplishment and who attempted to remove the loop from the diagram by the same means that the engineer had used in vain.

Failure to accomplish the desired result of course attended every effort in this direction and the consulting engineer finally advised a change of cylinder ratio by changing the diameter of the high-pressure cylinder. The change being made, an indicator diagram was taken and, as should have been expected, but much to the surprise of all interested, the negative loop was still in evidence and as large as ever.

It is not understood why any great difference in the terminal pressure of the low pressure diagram should be expected to result from a change in the diameter of the high-pressure cylinder. To do the work a certain amount of steam was required per stroke. This amount of steam, cut off by the cutoff of the high-pressure cylinder, fell to a pressure below that of the atmosphere when expanded to the volume of the low pressure cylinder. No change in the volume required per stroke could be made by altering the size of the high pressure cylinder, and the only way the loop could be avoided, with the same initial pressure, was by reducing the number of times the steam was expanded, i.e., by reducing the volume of the low pressure cylinder which each charge of steam eventually comes to fill. Indicator diagrams taken before the change of high pressure cylinder diameter showed that the engine was too large for the work under the conditions of operation. If the operating conditions were right, then the change to be made was a change in the size or power of the engine, and this could only be done by a change in the size of the low pressure cylinder, for it is the low pressure-cylinder diameter that is referred to in determining the power of a compound engine.

Valves for Superheated Steam

The American engineer visiting European power plants is usually surprised at the large number of globe valves used in the high-pressure steam lines, as well as the common absence of gate valves. This is perhaps more noticeable in the British isles than on the Continent, and is usually considered as a sign of the excessive conservatism of the European engineer. It may be well, however, to examine the conditions and the reasons given for this difference of practice.

A French engineer, who had long charge of one of the transatlantic liners, says:

"We use globe valves because they can be maintained tight without the use of machinery and at little expense. The discs are always ground tight to the seat under steam pressure and the shapes of the valve body and seat are better adapted to resist the destroying action of pressure and temperature than are the through or gate valves."

A well-known marine engineer from Glasgow said:

"It is vastly easier and cheaper to keep one disk and one seat tight than to keep two."

The loss from the constricted passage and the two right-angled bends in opposite directions is considered negligible in these and apparently American engineers hold the same opinion regarding throttle valves, as fully ninety-nine per cent. of the throttle valves in use are of either the globe or double-poppet design.

For line work in America the gate valve is almost universally used. Formerly the only type used for high-pressure steam was the solid wedge. This type was early preferred for steam, the double wedge being used for water only. With the advent of higher steam pressures the double-wedge and double-disk parallel-seat valves became popular and threatened to drive the solid-wedge type out of use. The introduction of superheat brought a new factor into the problem, in dealing with which the solid-wedge type appears to have an advantage. It is interesting to note that there are at least two manufacturers of globe valves for use in high-pressure superheated steam lines in this country.

It is, perhaps, superfluous to prophesy as to the valve of the future. Pressures have risen to 200 and 300 pounds gage, and it seems improbable that they will be increased. Superheat is from 100 to 200 degrees Fahrenheit, the temperature at which iron appears dull red in the dark, is certainly at the upper limit, and the signs of the times point to the more moderate temperatures of 450 to 500 degrees Fahrenheit.

Floating Central Stations Proposed

On December 29 William T. Donnelly spoke before the Modern Science Club of Brooklyn, N. Y., on the use of electricity from a floating central station for the purpose of marine transportation and the propulsion of vessels. As described by Mr. Donnelly, the proposition is that in the majority of cases marine transportation of freight can be more economically accomplished in barges, lighters, canal boats and similar vessels by motor-driven propellers supplied with current from a floating central power station than by towing.

It was argued that the same amount of power distributed to several boats by means of electric cables with proper connection around tunnels transports more freight a given distance than if all expended by a single towboat.

Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

The Detroit Return Trap

An improved and modified form of the tilting return trap is illustrated herewith. It is known as the Detroit trap, and consists of a galvanized-steel tank, held in a horizontal position by a weighted arm, as shown in Fig. 1, and supported in two stuffing-box bearings located in lugs in the cast-iron base of the trap.

Both steam and water connections are situated in the base, where expansion and contraction of the pipes cannot in any way distort the adjustment of the trap and render it inoperative.

Condensed steam enters by pressure or gravity at *A*, Fig. 1, and fills the tank through the bottom connection at the left. The vent valve *B* communicates with the top of the tank inside and has a flexible connection, as shown, leading to the sewer. This valve remains open as long as the tank is in a horizontal position and serves to let out the air as the tank fills.

When enough condensation has been collected to disturb the equilibrium, the trap tilts over on the buffer spring *C*, closing the vent valve and opening the steam connection at *D*. This puts boiler pressure on top of the contents of the tank and, by means of suitable check valves in the intake pipe, allows the trap to deliver to the heater, receiver, or wherever required.

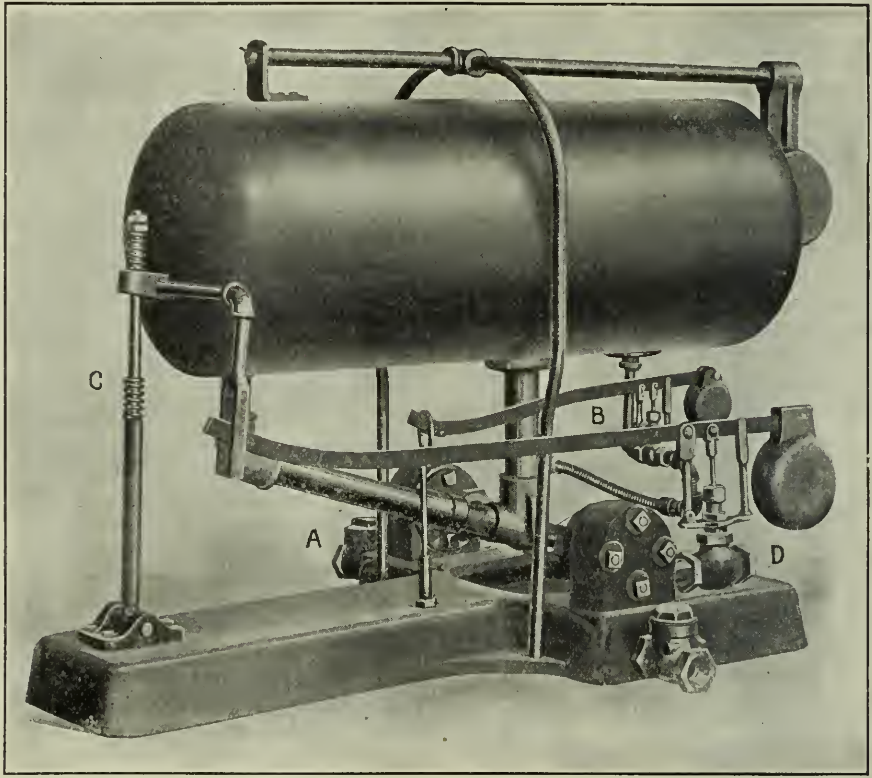


FIG. 1. THE DETROIT RETURN TRAP

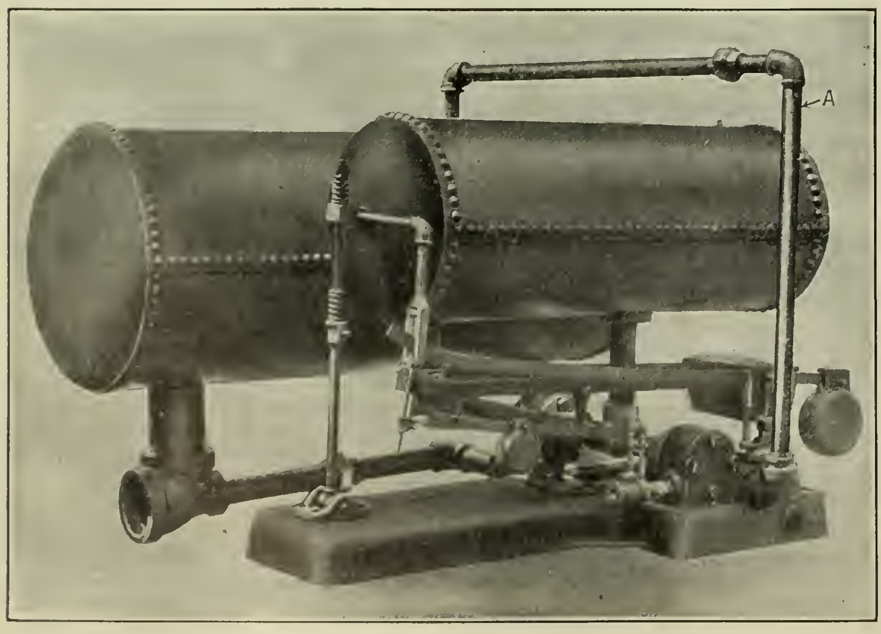


FIG. 2. SPECIAL APPLICATION OF THE DETROIT RETURN TRAP

To use as a boiler feeder, it is only necessary to place the trap at a convenient point above the water level so that, when discharging, the contents will flow to the boiler by gravity. With condensation at a very low pressure, another trap is used to deliver to the one feeding the boiler, in which case the installation is known as a double-trap system. Properly modified, these traps are successful in draining systems in which a vacuum is carried.

A special application of this trap is shown in Fig. 2. This consists of an auxiliary tank arrangement for use in places where large quantities of condensation must be taken care of.

The illustration shows an outfit designed to handle 50 gallons of condensation per minute. The trap itself has a volume of 8 gallons, and the auxiliary tank 50 gallons. A 4-inch connection leads to the large tank, the connection to the trap proper being of such size that both will

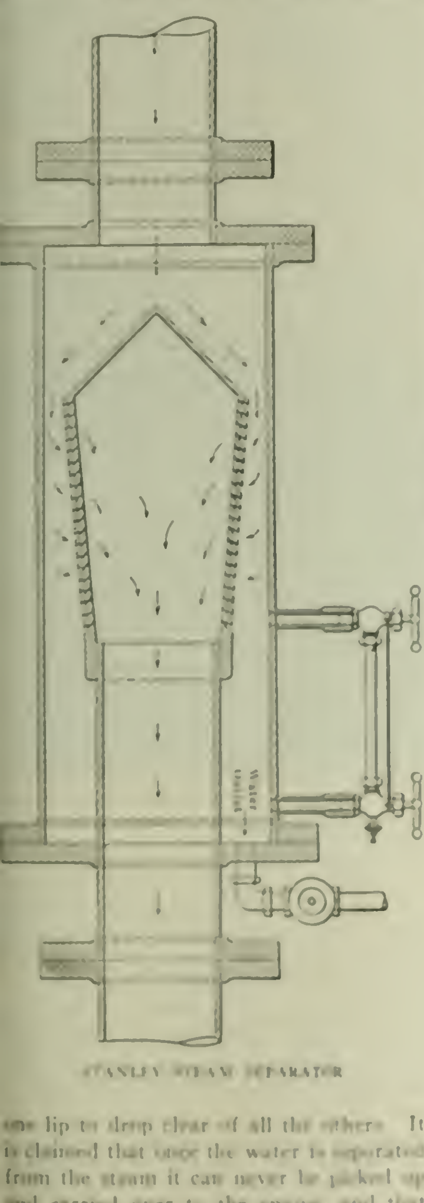
ill at the same rate. When full, the tilting of the trap turns steam at boiler pressure into both tanks, using the auxiliary connection *A* for the larger one, and the discharge in each takes place at the same time.

With this arrangement, a relatively small trap can take care of large volumes of water, it being only necessary to proportion the areas of the two water-supply pipes so the tanks will fill and empty at the same rate, the trap acting merely as a pilot valve on the system.

These traps are manufactured by the American Blower Company, Detroit, Mich.

Stanley Steam Separator

One of the advantages of this separator is the conical taper-shaped head, which is grooved or lipped so that the lips overhang each other, as shown in the illustration. This permits the water from any



STANLEY STEAM SEPARATOR

one lip to drop clear of all the others. It is claimed that once the water is separated from the steam it can never be picked up and carried over to the engine, and that the water, after being separated from the steam, does not come in contact with any metal surface that surrounds the dry steam, thus preventing condensation in the dry-steam chamber after separation.

The design is such that the large volume of steam passing through the separator is broken up into many small volumes by changing the direction of flow into an acute angle, thus permitting the water to drop freely to the bottom of the receiving chamber, whence it is immediately removed.

This separator has no baffles, funnels, pockets, troughs or vertical surface for water to lie in or cling to, and it is designed for a separator and receiver. It is manufactured by W. E. Stanley, Louisville, Ky.

"Union-Cinch" Pipe Fittings

The "Union-Cinch" pipe fittings, a type of which is shown in Fig. 1, are made in sizes corresponding to standard iron pipe up to 1 inch, and are especially designed for use in connection with oil pumps and oilers. They are manufactured by the Sight Feed Oil Pump Company, Milwaukee, Wis.

It is possible to use ordinary rough pipe with these fittings, if care is exercised in filing the ends of the pipe round and

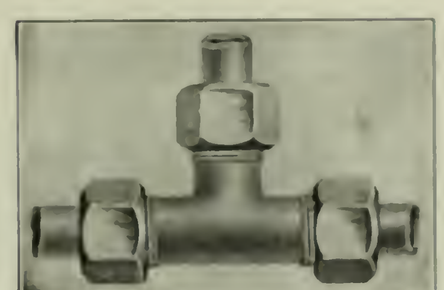


FIG. 1. "UNION-CINCH" PIPE FITTING

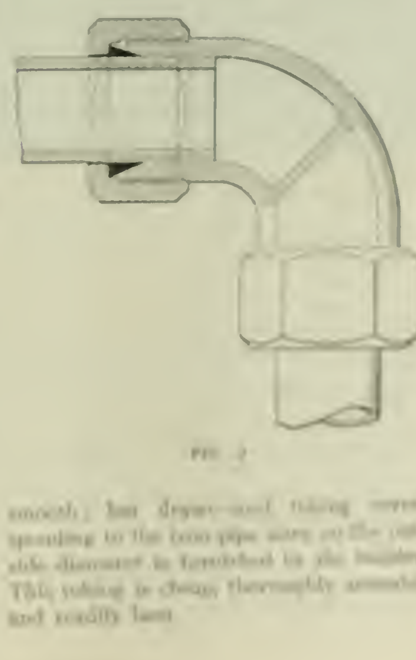


FIG. 2

smooth; but drawn-steel tubing corresponding to the iron pipe sizes in the outside diameter is furnished by the builder. This tubing is cheap, thoroughly annealed and readily bent.

Each fitting is a union, and the piping may be taken down at any point where a fitting is inserted. The joint is made by screwing down the outside nut, which presses a thin, tapered shell into the annular cavity around the pipe, between it and the fitting, as shown in Fig. 2. These nuts may be pulled up hard and the soft cone shell will make a tight joint around the tubing, which, it is stated, is good for [illegible] pounds pressure per square inch; or, in fact, is absolutely tight under any pressure that the tubing will stand. This type of joint may be taken down and made up again any number of times without trouble.

"Standard" Independent Steam Gage Movement

The accompanying illustration shows a gage movement that is distinctive in character in that a liberal air space separates the movement from the back of the case, preventing unequal thermal expansion of metal in movement and case. Considerable advantage is also gained by supporting the movement by the [illegible], as twisting of the case cannot change the relative position of the working parts, which would happen if fastened to the back and the case was accidentally strained out of position. [illegible] not affect its accuracy [illegible]. The pinion and segments are made of special [illegible], a composition selected for its perfect adaptability to conditions of wear and exposure to which it is subjected; [illegible] and others are of german silver.

"STANDARD" GAGE MOVEMENT

The gage movement is manufactured by the Standard Gauge Manufacturing Company, Foxboro, Mass.

Presentation to an Engineer

Arthur S. Vincent, for more than twenty-one years in the employ of the *New York Tribune*, first as machinists' helper and latterly mechanical superintendent of the Tribune building, recently resigned to go with the Belnord Construction Company, of New York, as mechanical superintendent. In view of his pending change, a number of friends assembled at the Tribune building Saturday afternoon, January 2, to give him a "send-off," and at the same time to present him a silver tea service. There were present the members of the engineers' and building departments of the *Tribune* and a number of invited guests, including James P. Holland, business agent of Eccentric Firemen's local union No. 56, who made the presentation, and D. A. Mason, who will succeed Mr. Vincent. The committee in charge of the occasion, which was most felicitous, comprised John Smith, Christopher Hatfield, William Funk, "Gus" Hedin and John Healy.

Business Items

F. E. Myers & Brother, of Ashland, Ohio, are distributing their annual calendar poster for 1909.

The Ashton Valve Company, 271 Franklin street, Boston, Mass., is sending out an attractive calendar for the new year.

The Minneapolis Steel and Machinery Company will remove its Dallas (Texas) office to the Praetorian building. J. P. Greenwood is the company's representative in that section.

The Ohio Blower Company, Cleveland, Ohio, reports recent sales of eight steam separators, one oil separator, eleven cast-iron exhaust heads and twenty-one gravity-closing ventilators.

R. A. Zoeller, manufacturers' agent of Tarboro, N. C., would like to hear from manufacturers of steam specialties, with a view of handling their goods in his section of the country.

The American Steam Gauge and Valve Manufacturing Company announces that after January 1, John B. Guthrie will be its sole representative in the Pittsburg district, with offices in the Columbia Bank building, corner of Fourth avenue and Wood street, Pittsburg, Penn.

The Nelson Valve Company, of Philadelphia, recently established two branch offices in the middle West to keep pace with its rapidly expanding business, one in Detroit, in the Penobscot building, the other in Cleveland, in the Perry Payne building. John M. Bulkley has been appointed sales manager for the territory of Ohio and Michigan.

D. D. Pendleton, who was connected with the Westinghouse Electric and Manufacturing Company, of Pittsburg, for some 15 years, recently opened an office as district sales manager of the American Boiler Economy Company, manufacturer of the Copes feed-water regulator, and the Copes pump governor. Mr. Pendleton's offices are located in the Frick building annex, Pittsburg, Penn.

The Commercial Testing and Engineering Company, recently opened offices and laboratories in the Old Colony building, Chicago, where it will specialize along the lines of boiler-room economies, coal analysis, heat-value method of purchasing fuel and coal washing and preparation for operators. The officers are: Edward H. Taylor, president; Harry W. Weeks, vice-president; W. D. Stuckenberg, treasurer; B. J. Maynes, secretary.

The Buffalo Steam Pump Company, of Buffalo, N. Y., has contracted with the city of Grand Rapids, Mich., to furnish ten sewage pumps having a total capacity under maximum conditions of over 250,000 gallons per minute. The pumps are to be placed in four stations, one station to contain two 18-inch pumps, one to contain two 24-inch pumps, one to contain two 24-inch pumps, and the fourth station four 40-inch pumps. The ten pumps together, without motors, will weigh approximately 200,000 pounds. Westinghouse electric motors will be used to operate them.

The Buckeye Boiler Skimmer Company, South End, Toledo, Ohio, is in receipt of a communication from the general foreman of the El Paso-Northeastern System, Alamogerdo, N. M., in which he says: "The skimmer arrived O.K. and we at once applied it to our No. 2 boiler. We were eight hours putting it on, and that same night we began operating it. To our surprise the boiler doesn't prime over any more. Fifty gallons of lime and magnesia have been skimmed off in sixty days, and we have also experienced a decided saving in fuel. After the second week we cleaned the boiler and found at least half a wagon load of old scale, which I consider very fine. We wash our boiler only once in two weeks now, where previously we washed it twice in one week. Mr. Martin, general manager of the E. P. & N. E. railroad system, who is authority in this section on bad water and treating appliances, claims this device the best he ever saw, and has ordered three more to be put on as soon as we can conveniently get to it."

New Equipment

Dr. J. I. Coleman, Hurdle Mills, N. C., is in the market for a 100-light dynamo.

The Escondido (Cal.) Mutual Water Company will install an electric lighting and power plant to cost $30,000.

It is reported that about $10,000 will be spent in improving water-works and electric-light plant at Marlow, Okla.

The Portland (Ore.) Railway Light and Power Company has had plans prepared for a new power station.

The Waurika (Okla.) Ice and Electric Company will build a 30-ton ice plant in connection with electric-light plant.

It is said that plans are being prepared for a power station at Garden City, Kans., for the Kansas-Colorado Railroad.

The City Council, Waukegan, Ill., is said to be considering the purchase of a 5,000,000-gallon water-works pump.

The citizens of Cherokee, Okla., are said to have voted to issue $65,000 bonds for watreworks and sewerage system.

The city of Thomaston, Ga., voted $10,000 bonds for the purpose of enlarging and improving electric-light plant.

The City Council, Wooster, Ohio, is said to be considering the question of establishng a municipal electric-light plant.

The city of Thomaston, Ga., contemplates doubling the municipal electric-light plant. W. C. Hartman, superintendent.

The Union Central Light and Ice Company, Hubbard City, Texas, will make additions and improvements to cost about $10,000.

Bids will be received until 11 a.m. December 22 by Capt. O. W. Bell, Jefferson Barracks, Mo., for a complete electric-lighting system.

The question of constructing an electric light plant at Bellefonte, Penn., is said to be under consideration. W. Kelly, borough clerk.

The citizens of North Arlington, N. J., have voted to issue $25,000 bonds to install water-supply system. H. C. Bayliss, borough clerk.

The Rochester (N. Y.) Railway and Light Company is having plans prepared for a vertical retort gas plant, which will cost about $150,000.

The Waurika (Okla.) Ice and Electric Company has been incorporated. Capital, $50,000. Incorporators, T. B. Martin, E. W. Gautt and others.

The Las Cruces (N. M.) Electric Light and Ice Company has applied for franchise to construct electric-light plant and water works.

Church E. Gates & Co., Fourth avenue and 138th street, New York, have filed plans for the construction of a power house to cost about $50,000.

The City Council, Linton, Ind., will enlarge and re-equip the municipal electric-light plant. It is said about $15,000 will be spent on new equipment.

The Brattleboro & Vernon Railroad Co. has been incorporated to construct an electric railway. Incorporators, C. R. Crosby, G. L. Dunham, of Brattleboro, and others.

The city of Marlow, Okla., will make improvements to electric-light plant and water works to cost about $10,000. T. T. Eason, chairman, purchasing committee.

Bids will be received about December 20 for construction of water-works at Hays, Kan. Cost, about $18,000. Orr Engineering Company, Kansas City, Mo., engineers.

The Lake Superior Power Company, Sault Ste. Marie, Ont., is said to be making plans for a new hydroelectric plant to cost about $110,000. L. H. Davis, chief engineer.

The Booneville (Ark.) Light and Power Company has been incorporated to construct and operate electric-light and power plant and water-works system. J. T. Thayer, president.

The Freeport (Ill.) Interurban Railway Company has been incorporated to construct an interurban electric railway. Owen T. Smith, W. A. Hance and Edward Courtney, incorporators.

Plans are being made for additions and improvements to the municipal electric-light plant and water works at Macon, Mo., to cost about $18,000. E. S. Bennett, superintendent.

The Acme Hosiery Mills, Asheboro, N. C., recently incorporated with $100,000 capital, is ready to buy equipment including 40-horsepower engine and 70-horsepower boiler. O. R. Cox, secretary.

The Grand Junction (Colo.) Electric Railway Company has completed plans for construction of new electric railway, which is to cost over $2,000,000. A power plant will be constructed at Debeque.

The Vernon Light and Power Company, Vernon, Texas, will buy in the next thirty days, 150-horsepower engine, 100 kilowatt alternator, boiler feed pumps, lubricators, etc. About $5000 will be expended.

The De Kalb (Ill.) Midland Railway Company has been incorporated to construct an electric railway from DeKalb to Sandwich. Capital, $150,000. Incorporators, J. W. McQueen, W. G. Wilcox, Elgin, Ill., and others.

L. W. Trumbull, Van Vleck, Texas, is interested in an electric and refrigerating plant to supply a town of about five thousand and would like to hear from manufacturers of electrical equipment and refrigerating machinery.

Hampton Power Plant of the D., L. & W. R. R.

The Largest of Its Kind in the Anthracite Region, Employing Both Steam and Electric Apparatus of the Most Modern Type

BY WARREN O. ROGERS

A central power station at the mines, the ideal condition to which mechanical engineers have given more or less attention, is found in the Hampton power plant of the Delaware, Lackawanna & Western Railroad Company, Scranton, Penn.

In the mining of coal, three kinds of power are available: steam, compressed air and electricity. These mediums are utilized in operating all kinds of mine hoisting, pumping, ventilating, drilling and machine operation. The mining of coal is, therefore, to a large extent, a mechanical proposition, and the best means which will not only insure reliable operation but the cheapest power, all things considered, should be selected.

The central station idea has proved economical in other phases of power transmission, and recent installations of electrically driven machinery at mines have demonstrated that the central power plant at the mines is productive of economy and efficiency. In the instance of large coal-producing companies this idea is all the more feasible because they operate numerous collieries which permit of distributing a large amount of current to them at minimum cost. Under the modern methods of wiring mines from a central station, the transmission losses which enter into the question of economies are very low. Where steam is used, the loss from condensation due to long steam pipes is considerable; the pipes in some instances being more than 3000 feet long.

Among the first to experiment with electrically operated breakers was the Lackawanna company, which has been experimenting for several years, with most favorable results. This was also one of the first of the anthracite companies to adopt the electric locomotive for mine haulage, thus doing away with steam and compressed-air locomotives.

Owing to the successful outcome of these and other electrical experiments, the Hampton power plant, the largest of its kind in the anthracite region, was installed. This station, which has a boiler capacity of more than 8500 normal horsepower, and an electrical output of 4500 kilowatts, supplies steam to five collieries and electricity to 18 additional mines. The nearest mine is only 1200 feet distant from the station; the farthest three miles away.

FIG. 1. GENERAL VIEW OF THE SITE OF THE HAMPTON POWER STATION

The power plant is situated in a basin formed by ranges of hills, a general view of the site being shown in Fig. 1. This location has several advantages. It is centrally located, is near its source of coal supply and obtains its boiler-feed water from the West hill section nearby. The water flows by gravity from a 700,000-gallon reservoir, shown at the left of Fig. 1, and is of excellent quality.

The buildings are constructed of brick, concrete, iron and steel. The roofs are of concrete, and no wood, with the exception of window casings and doors, is used in their construction. This feature is also observed in the construction of the oil house and work house, in which are shower baths, tubs and lockers.

Boilers

The original boiler plant consisted of fifteen 313-horsepower Babcock & Wilcox water-tube boilers, shown in Fig. 4, which are equipped with McClave stokers. A number of changes have been made in the arrangement of the furnaces, however, due to the fact that barley anthracite is used as fuel. Three factors were found of paramount importance in the plant for the successful burning of barley fuel; sufficient grate area, furnace arches, necessary to maintain a high furnace temperature, and a combination of forced draft and superheated steam.

The present arrangement of the furnaces of these boilers is shown in Fig. [illegible]. A steam conduit runs under the boilers, with branches extending to each furnace. The steam is superheated in order to reduce the moisture. Steam and air enter the furnace above the grates through a number of ... pipes set in the back wall, the supply being regulated by hand from the front of the boiler. This method, when properly handled, reduces the CO from about [illegible] per cent. to a trace and increases the CO_2 to about [illegible] per cent. As a result of this increase-ment, the fuel consumption has been reduced about 20 tons per day, with the same load.

The changes made in the stoker to meet the conditions of burning a very fine fuel, were to prevent the movement of the grate bars more than necessary to produce the proper amount of feed. The bottom end of the grate on each boiler has been equipped with a cleaning plate to facilitate dumping the ashes. The grates have an air space of 20 per cent.

Forced and induced drafts are used in all the boiler installations, the pressure in the furnace being almost balanced with a slight vacuum. The blowers were furnished by the American Blower Company and are driven by engines of suitable size built by the same company. The blower system is in duplicate, there being two 12-foot induced-draft fans, and two 10-foot forced-draft fans. The speed of the engines and fans is regulated, as the steam pressure raises or falls, by a Foster reducing valve.

The stacks are simply for the purpose

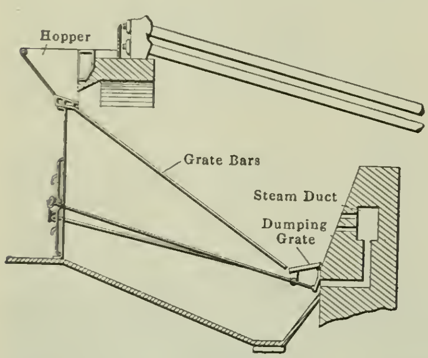


FIG. 2. ARRANGEMENT OF AIR AND STEAM DUCTS

of carrying away the gases, and are not depended on to create a draft. They are of iron, the tops being 60 feet above the surface of the grates. Two Green economizers are used with the old boilers, the gases passing through them to the induced-draft fans. The stack temperature averages 550 degrees after leaving the economizers.

The new section of the boiler room consists of six 2-drum Stirling boilers, each of 625 horsepower, the ratio of heating surface to grate area being 30 to 1. The new boilers are equipped with the Parsons system of forced draft without economizers. They are hand-fired, and the furnaces are equipped with stationary grates having an air space of 10 per cent. These furnaces are constructed with arches to assist the furnace temperature, also doors at both ends of the grates. Ash-dumping plates are also arranged to facilitate cleaning the fires.

The boilers are equipped with Murray, Williams and Vigilant boiler feed-water regulators.

As shown in Fig. 4, the coal is de-

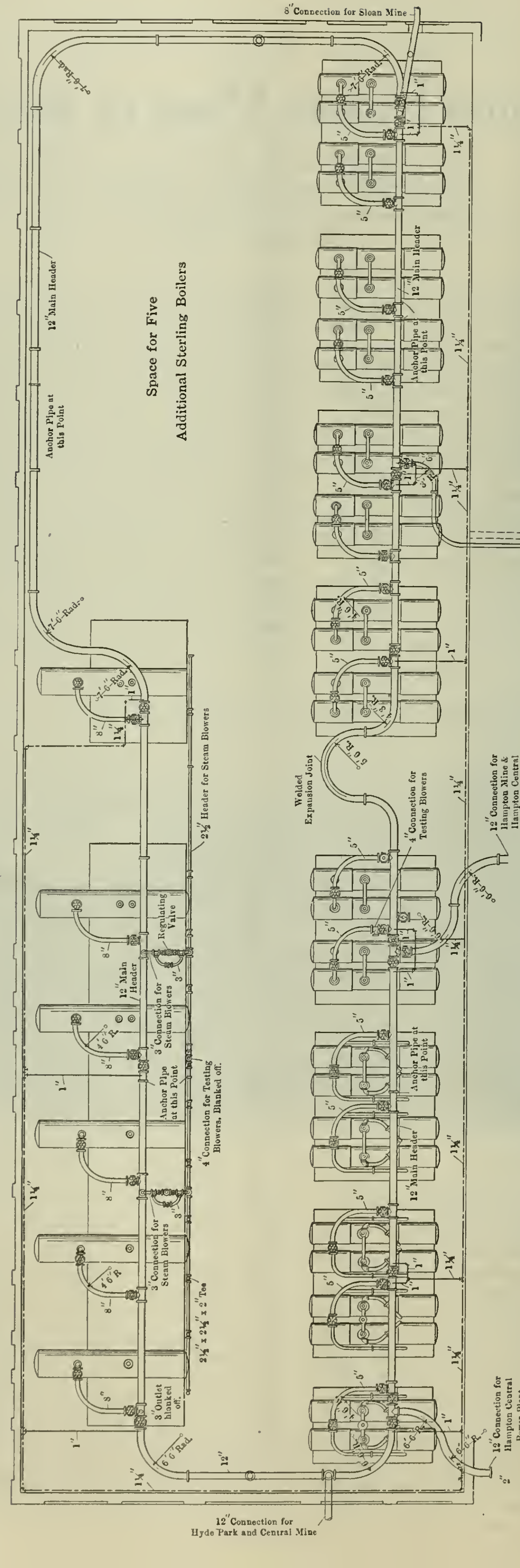


FIG. 3. PLAN OF THE BOILER-ROOM LAYOUT AT THE HAMPTON PLANT

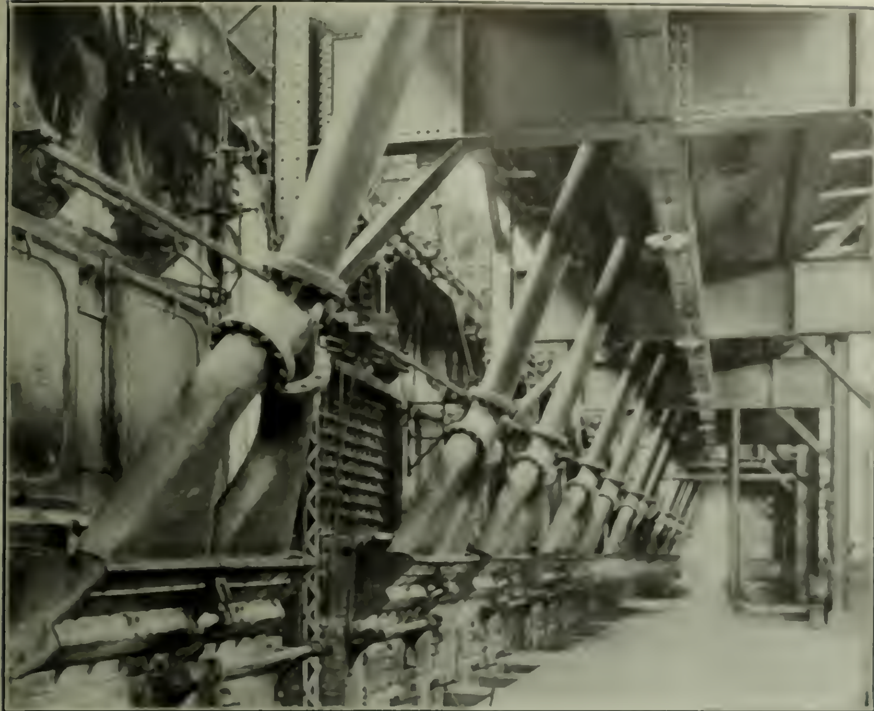


FIG. 4. VIEW IN THE BOILER ROOM

livered to the hopper in the case of the Babcock & Wilcox boilers by means of chutes from the storage bin located above and between the two rows of boilers. In the case of the new installation, the fuel is delivered on the floor in front of the boiler.

In Figs. 3 and 5 are shown a plan and elevation of the boiler-room layout. As will be seen, the Babcock & Wilcox boilers are arranged in seven batteries of two boilers and one of one boiler. The Stirling boilers are arranged in one battery of five boilers, the sixth boiler being set so that it will be the first of a second battery of six boilers, space being provided for five additional boilers, as shown. Each boiler is equipped with a superheater which superheats the steam 150 degrees. The boiler pressure carried is 150 pounds per square inch.

Piping and Valves

Each boiler is connected to a 12-inch main header of the loop construction. By this method, if one of the boilers should suffer a severe accident or a section of the header become defective, the remaining boilers and section of uninjured steam main may be operated, thus preventing the suspension of the mines depending on the station for steam and power.

The connection between each boiler and header is of 5-inch pipe, made with bends, having a radius of 4 feet 6 inches in the case of the Babcock & Wilcox boilers, and 8-inch pipes bent at the same radius in the Stirling boiler connection. The 12-inch header is bent at a radius of 6 feet 6 inches at one end of the plant and 7 feet 6 inches at the other.

From the 12-inch header the various pipe lines extend to the central power station, and to the various mines. These pipes vary in size and length, the pipes running to the turbine station being 12 inches in diameter. The steam mains leading to the mines are as follows: One 8-inch line, 1450 feet long; one 8-inch line, 1700 feet long; one 8-inch line, 1900 feet long; one 8-inch line, 3450 feet long; one 12-inch line, 1200 feet long.

Special steel piping with flanged ends and the improved Van Stone joints is used. This joint forms an ideal method of joining high-pressure steam pipes.

The advantages of doing away with as many joints as possible on the high-pressure steam mains was the reason for the use of welded pipes where possible. This has resulted in a saving in maintenance, there being fewer joints, and a saving in first cost because there are fewer flanges to make and cover. The advantage of welded mains is self-evident. In such instances of expansion bends or where the large high-pressure pipes make a bend of such magnitude that more than

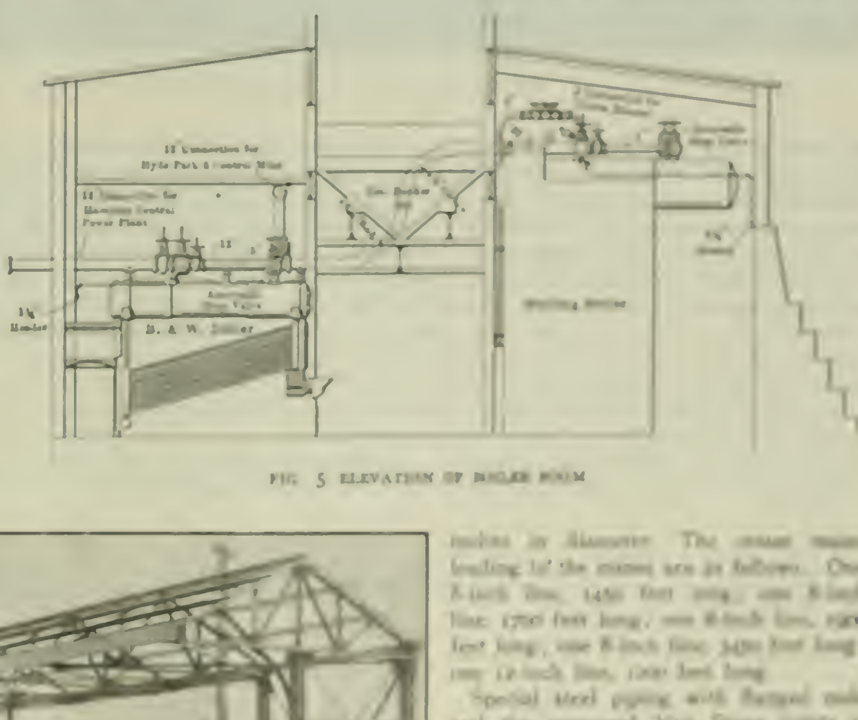


FIG. 5 ELEVATION OF BOILER ROOM

FIG. 6 SHOWING THE COAL CONVEYER INSTALLATION

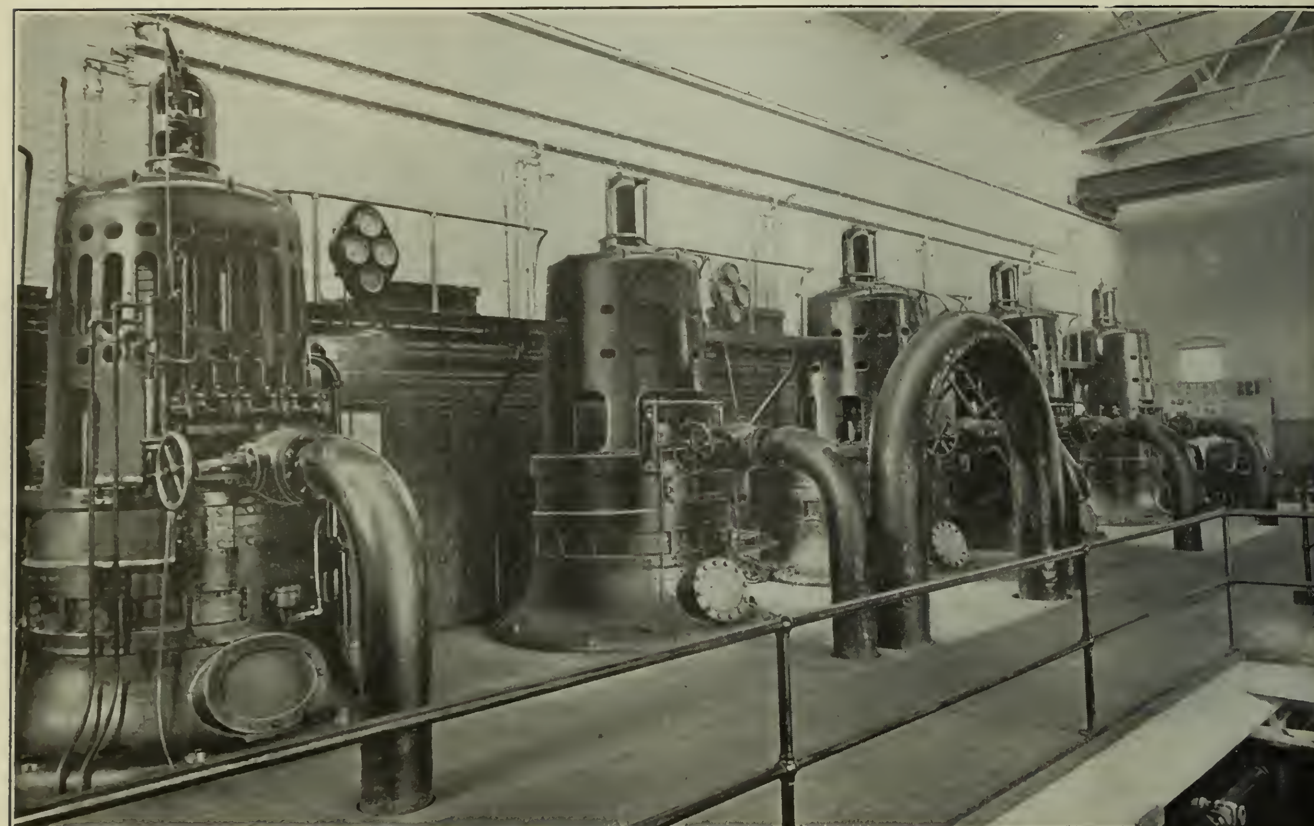


FIG. 7. VIEW IN THE TURBINE ROOM OF THE HAMPTON PLANT

one ordinary length of pipe is required. Other applications of the welded pipe are in the pipe connection between the boiler and the main steam header and the header and the prime mover. The piping system was furnished by the M. W. Kellogg Company, which also makes the improved Van Stone joint.

Another feature in the welding art is that of the welded separator placed in the 12-inch steam line leading to the turbine house. This separator is located on the outside of the building, but is protected by suitable covering, as are also the various steam pipes. It is constructed of open-hearth steel and has no joints whatever, with the exception of the inlet and outlet flanges and, in addition, even the supporting lugs at the bottom are welded to the cylinder of the separator. The body of the separator is welded together, and also to the top and bottom heads. The flanges, which are made of rolled steel, are also welded on. This separator was also furnished by the Kellogg company.

The valves throughout the plant are the product of the New Bedford Boiler and Machine Company. The globe valves are of the extra-heavy type for high-pressure service. They are designed for a working pressure of 300 pounds. The seats and disks are constructed of nickel bronze which, having the same coefficient of expansion as cast iron, makes a serviceable combination.

Disposal of Ash

A most unique method of disposing of the ash has been adopted, which not only eliminates all expense in the matter of cartage, but is turned to practical use.

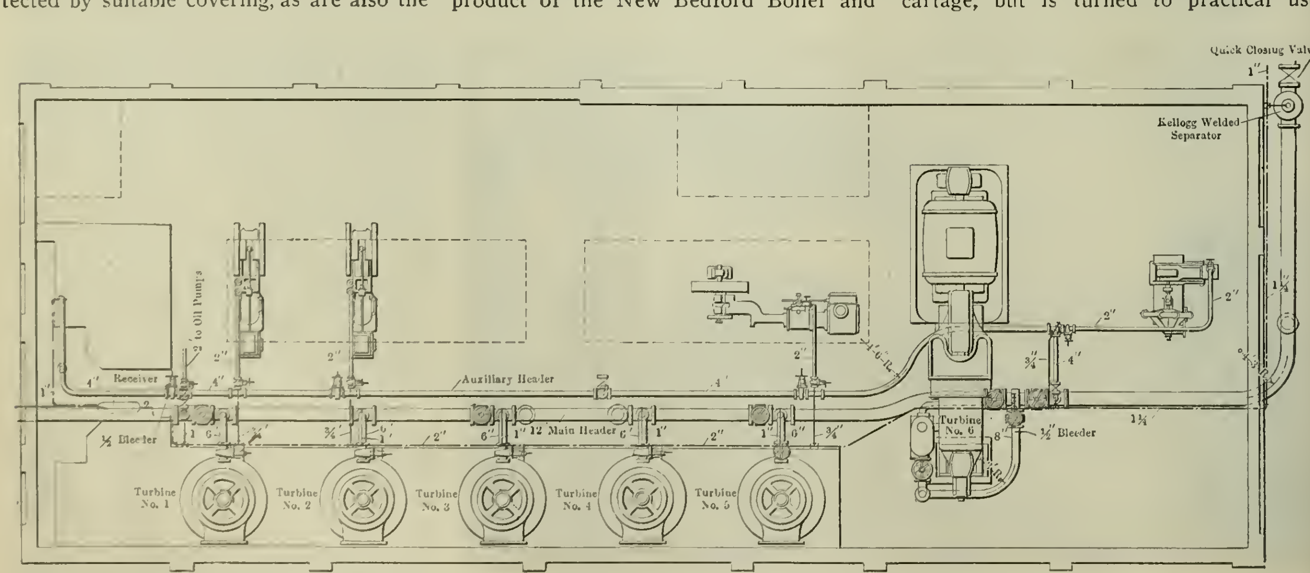


FIG. 8. SHOWING THE TURBINE LAYOUT AND DRY-VACUUM PUMPS

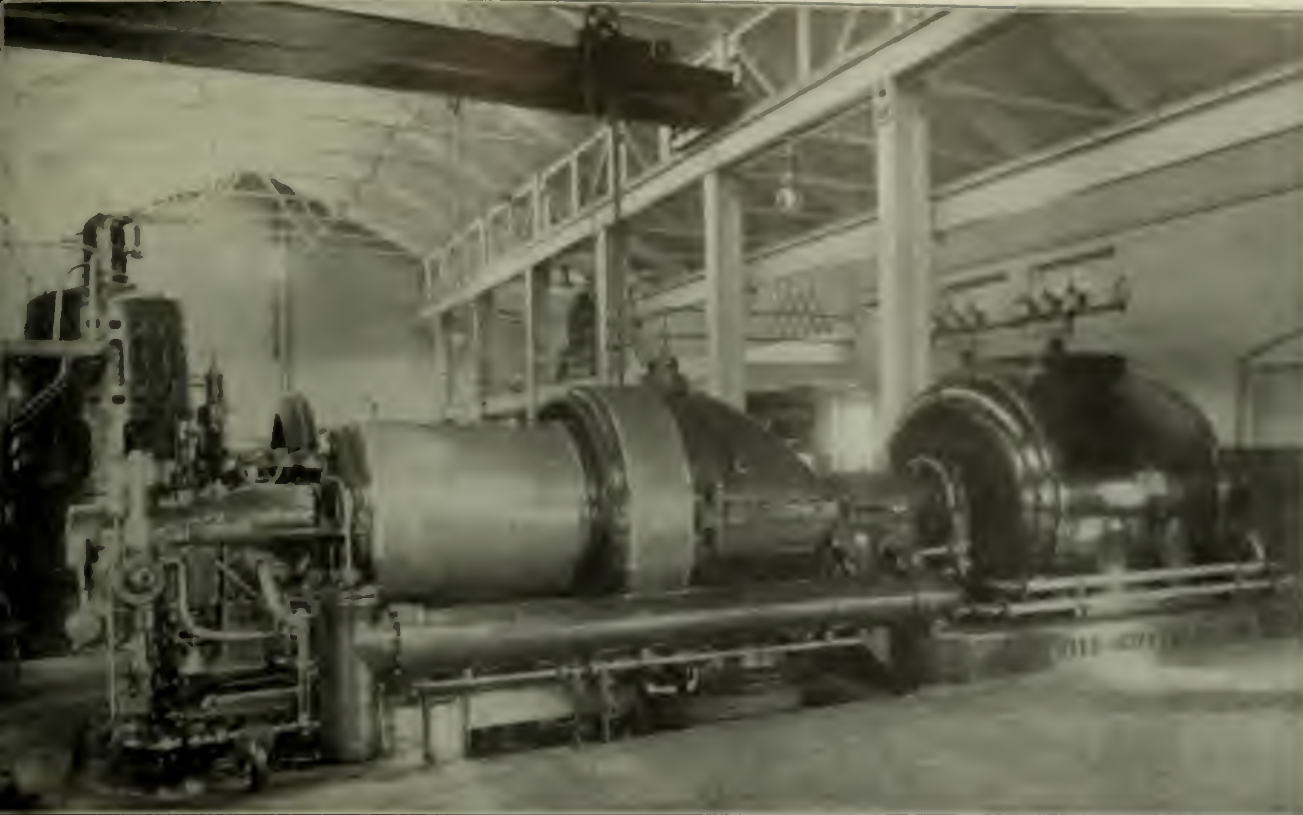


FIG. 9. ALLIS CHALMERS TURBINE AND BULLOCK ALTERNATOR

Under the ashpits of the Babcock & Wilcox boilers a tunnel has been constructed, and beneath the furnace doors of the new boiler another set of tunnels has been built. The ashes fall from the grate in the first instance, and pass into a tunnel which has a slope of ⅜ inch to the foot. In the case of the Stirling boilers the ashes are pulled out into the conveyer lines from both the furnace and the ashpits, the latter being cleaned but once a week. Pin hole grates are used; consequently, very little ash falls through into the ashpit. Water from the mines flushes the ash into a bore hole leading to abandoned mine chambers. It is estimated that about 50 tons of ash is flushed into these chambers from under the boilers each day. As the ashes in time harden sufficiently to support the roof of the mine, the solid-coal columns, which were left in place for this purpose can be removed.

Coal Conveyer

The barley-coal supply comes from the washeries in ordinary railroad cars. From these cars it is dumped into a concrete pit having a capacity of [illegible] tons, from which it passes onto an endless conveyer belt and is then conveyed up an incline and along an upper floor in the boiler house, Fig. 6. Along the path of the belt is an arrangement known as the tripper, which causes the coal to be emptied into a chute, through which it is carried down into the bunkers. The tripper moves slowly along the track made for it at just the proper speed to load the bunkers, and when it gets to the end starts back again.

The conveyer belt is [illegible] feet long and extends the entire length of the boiler room over the coal bunkers, from which the supply is delivered to the respective boilers. The coal bunker extends the entire length of the boiler room and has a capacity of [illegible] tons. It is covered with concrete on which the conveyer operates. The conveyer handles an average of [illegible] tons an hour and is in duplicate, as shown in Fig. 6, though when the photograph was taken the second belt was not in position. It will be seen that the building over the car, the concrete coal pit and the conveyer were unfinished at the time of photographing. The incline has the return-belt conveyer in support by concrete columns.

The conveyer, which was furnished by the [illegible] Works is operated by a [illegible]-horsepower Westinghouse [illegible] induction motor, running at [illegible] revolutions per minute.

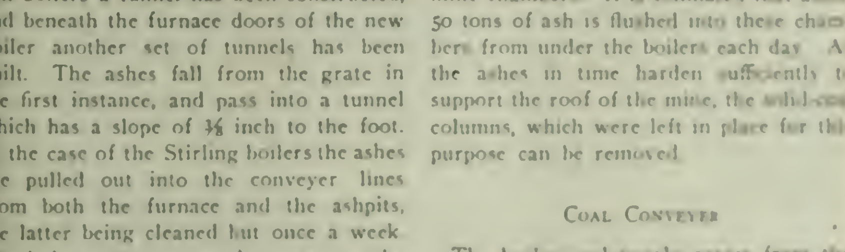


FIG. 10. ELEVATION OF CURTIS TURBINE SET, DRY-VACUUM PUMP AND ENGINE

Pumps

The pump room contains two of the Scranton Pump Company's 22 and 12 by 24-inch pumps of the outside-packed type, each equipped with a counter which acts as a check on the amount of water pumped. There is also one tandem duplex Epping-Carpenter pump, which is held as a reserve. In the pump room is also a Westinghouse air pump which compresses air for cleaning the tubes of the boilers.

The feed water for the boiler is taken from the reservoir already mentioned and is passed through a 6000-horsepower Cochrane feed-water heater.

Turbines

A section of the turbine room, which is about 25 feet from the boiler room, is shown in Fig. 7. The five Curtis turbines are located on one side of the room. They are of 500 kilowatts capacity and are direct-connected to alternators, generating a current of 2300 volts at a speed of 1800 revolutions per minute. In the right-hand corner is shown part of the air-pump pit.

The 12-inch steam header enters the basement and is tapped for a 6-inch pipe leading to each Curtis turbine. The arrangement of the piping is shown in Figs. 8 and 10, the former being a plan view of the turbine layout and dry-vacuum pumps.

In Fig. 9 is shown an Allis-Chalmers turbine direct-connected to a 2000-kilowatt Bullock three-phase 60-cycle alternator. It runs at a speed of 1800 revolutions per minute and generates a current of 2300 volts. This turbine has only been in operation a few months and represents the latest turbine design. Incidentally, it may be said that the Curtis turbine shown at the extreme end of the turbine room, Fig. 7, is one of the first, if not the first, turbines of 500 kilowatts manufactured by the General Electric Company, thus making the Delaware, Lackawanna & Western Railroad Company a pioneer in turbine practice.

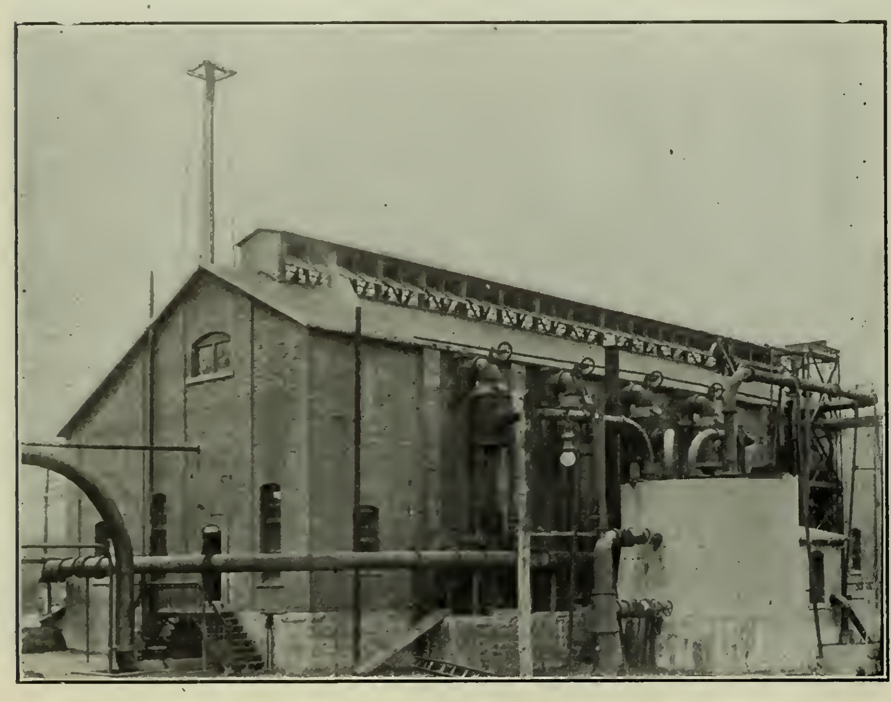


FIG. 11. SHOWING THE BAROMETRIC CONDENSERS

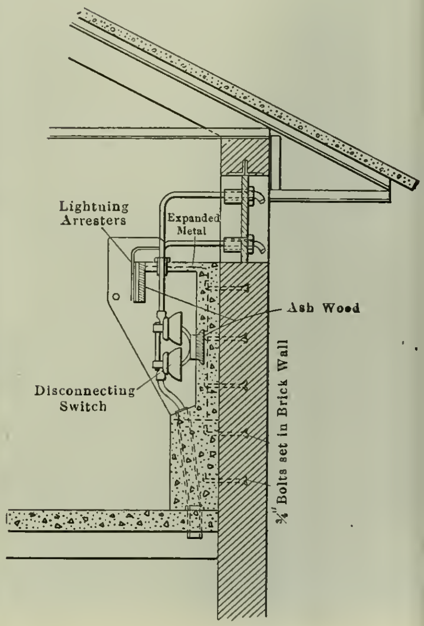


FIG. 15. ELEVATION OF LIGHTNING-ARRESTER ARRANGEMENT

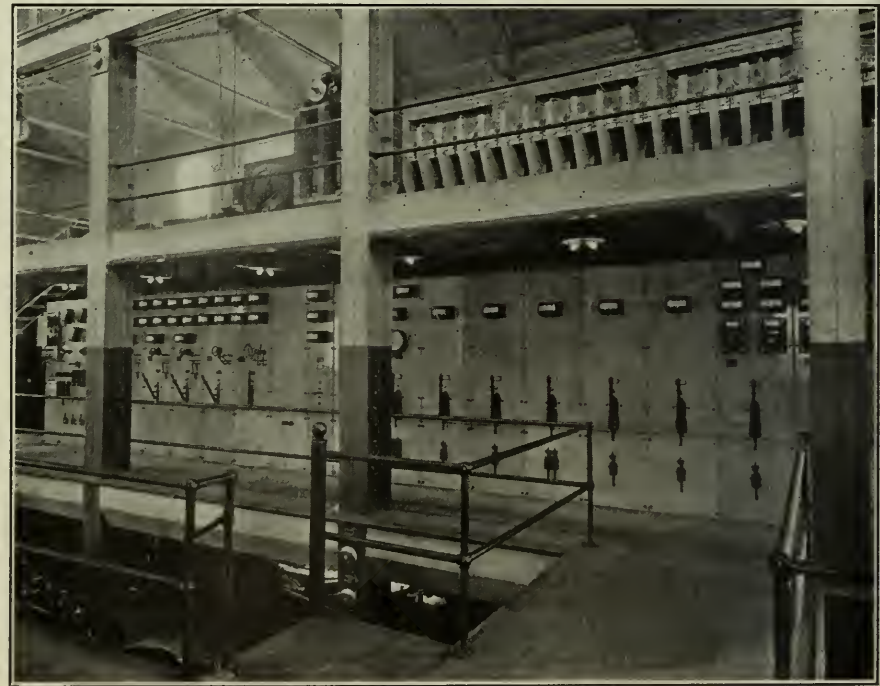


FIG. 13. GENERAL VIEW OF THE SWITCHBOARD

In the rear portion of Fig. 9 is shown the Curtis turbine, switchboard and one of the 10-ton cranes, the other being over the Allis-Chalmers turbine and used for handling the outer bearing, if necessary.

An elevation showing the arrangement and steam pipes of one of the Curtis turbine sets, dry-vacuum pump and exciter units is shown in Fig. 10.

Condensers

Four of the Curtis turbines are connected to Worthington barometric jet condensers and one is connected to a Worthington surface condenser. The Allis-Chalmers turbine is connected to a Tomlinson barometric jet condenser. The barometric condensers are placed on the outside of the turbine building, as shown in Fig. 11.

As is well known, mine water contains more or less sulphuric acid; therefore, considerable trouble has been encountered with the condensers, as mine water is used for condensing purposes in the jet condensers. In this case the water contains 39 grains of free sulphuric acid per gallon of water.

FIG. 12. THE EXCITER UNITS

The condenser heads were attacked as a matter of course, and to obviate this they were lined with lead as a protection. Here a difficulty was encountered, as air would get between the lining and the shell when the condensers were not in use, consequently, when a vacuum was again formed the air, due to expansion, would push the lead lining inward, reducing the area of the condenser heads and requiring more water to produce the same vacuum. Wood linings were next tried and have given fair satisfaction, and if the condensers could be operated continuously there would be but little, if any, trouble encountered. The alternate wetting and drying, however, tend to loosen the wood casing. Water-supply pipes lead the condenser heads from the concrete tank shown in Fig. 11. The water flows to the tank by gravity through concrete pipe.

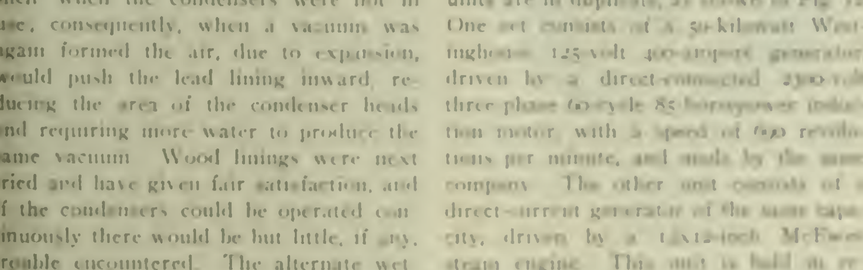


FIG. 14. PLAN OF LIGHTNING-ARRESTER LAYOUT

The surface condenser obtains its water from the reservoir containing the feed water. The course of the water is through the condenser to the circulating pump, and then through the heater, the surplus, if any, returning to the reservoir.

The vacuum is handled by two Worthington vacuum pumps which care for the Curtis turbines, one being a reserve. There is also a Union Steam Pump Company's vacuum pump for the new turbine. The layout of these units is shown in Fig. 8.

EXCITER SETS

As in all other apparatus, the exciter units are in duplicate, as shown in Fig. 12. One set consists of a 50-kilowatt Westinghouse 125-volt 400-ampere generator, driven by a direct-connected 2300-volt three-phase 60-cycle 85-horsepower induction motor, with a speed of 690 revolutions per minute, and made by the same company. The other unit consists of a direct-current generator of the same capacity, driven by a 12x12-inch McEwen steam engine. This unit is held in reserve and used in starting up in case the entire plant should be closed down for any cause. This unit runs at 280 revolutions per minute.

SWITCHBOARD

A general view of the switchboard is shown in Fig. 13. It consists of 12 panels of Vermont marble divided into six generator panels, the remainder being utilized for instruments and distributing panels, which are equipped with the necessary switches, recording instruments, etc. It is regrettable that a photograph of the rear of the switchboard could not be obtained, as it presents one of the most compact and yet systematic arrangements of switchboard wiring and feed-line distribution the writer has seen. All cables and wiring are incased in iron pipe and fiber conduits which are arranged in a systematic manner. The feed lines, incased in the fiber conduit, pass to the lightning arresters, which are arranged in a group on a platform above and back of the switchboard, as shown in Fig. 13. A plan and elevation of the lightning-arrester arrangement and wiring are shown in Figs. 14 and 15. The arresters are attached to a concrete backing secured to the brick sidewall of the station. Between each pair of arresters is a concrete slab 3 feet 2 inches high, 3 inches thick and 12 inches wide between the arresters. These slabs, which prevent arcing in case of lightning discharge, are removable. They are placed 9½ inches apart and are 24 in number. The outer feed lines pass out through the wall as shown.

The current generated by this plant is sent through overhead wires and lights the mines and breakers and operates the electric locomotives in the various mines. It also lights the passenger station and the railroad shops in Scranton. An arrangement is also made for switching current to the local electric company, if desired, and vice versa.

The writer is indebted to H. M. Warren, electrical engineer of the company, and Christopher Schillinger, engineer of the Hampton boiler plant, for data pertaining to this installation.

Effect of Superheated Steam on Mineral Cylinder Oils

According to G. W. Worrall and J. E. Southcombe, in a recent issue of the Journal of the Society of Chemical Industry, (1) no chemical change of a hydrocarbon cylinder oil takes place in a cylinder using steam which is not heated up to 700 degrees Fahrenheit; (2) the deposits consist chiefly of oxide of iron, which is formed independently of the oil; (3) the adherence of the iron-producing deposits depends upon the [illegible] constituent in the oil and the completeness of distillation; (4) the oil is carbonized by the steam, the shape of the cylinder and adjacent parts and the temperature influencing the quantity of sooty matter resulting hereby.—The London Practical Engineer.

A correspondent recommends the application of equal parts of lard, graphite and tallow oil, in equal parts, to the hot box of a journal, to reduce the heat.

Development of the High Speed Steam Engine

Why the Compound Single Valve Engine Is Preferable Where High Efficiency Is Necessary; the Angle Compound Engine; Inertia Thrusts

Tuesday evening, December 15, Frank H. Ball lectured before the Modern Science Club, of Brooklyn, N. Y., on "The Development of the High-speed Engine." Lantern-slide illustrations were freely used. The lecture hall was filled and the discussion which followed the lecture was pertinent and interesting. What Mr. Ball said was, in part, as follows:

It has been said that Charles T. Porter is the father of this type of engine, and it is true that he built and sent to the Paris Exposition of 1875 a remarkable engine which attracted great attention because it ran at much higher speed than was customary at that time; and it ran very smoothly and quietly. The performance of this engine was partly due to the design, which made it extremely rigid, and partly to the liberal size of the bearings and the perfect workmanship.

Mr. Porter embodied in this engine a pet theory of his regarding the use of heavy reciprocating parts for the purpose of absorbing the shock of the impact of steam on the piston during admission and giving off the stored-up energy to the crank pin during the latter part of the stroke, when these parts are being brought to rest. In other words, these heavy parts were to act as a flywheel in equalizing the effort on the crank pin throughout the stroke.

Those who have seen Mr. Porter's book on the Richards indicator will remember the elaborate tables given for calculating the effort on the crank pin as modified by the inertia of the reciprocating parts. These calculations are all very correct, and are theoretically beautiful, but experience has shown that this refinement is unnecessary and that heavy reciprocating parts are very difficult to counterbalance, and are, therefore, very destructive to foundations, so that extreme lightness of these parts is now considered desirable for high speed.

The Porter engine, although it ran at a high speed, did not belong to the class since called high-speed engines, because its valve gear was entirely different, and it did not use a shaft governor.

The chief characteristics of the modern high-speed engine are the shaft governor and generally a single valve. The first engines that came into general use with these distinguishing features were built by the Armington & Sims Company, of Providence, R. I.

Then followed the familiar straight-line engine of Professor Sweet, and another that will be called to your attention soon, and as the electrical business grew, the number of builders of these engines increased greatly.

At first the electric generators were all belt-driven machines of small capacity, and the engines were therefore small. Later the generators grew in size, and as the horsepower of the engines increased to correspond, the question of efficiency became more important. The Corliss engine was then, as it is now, the standard of efficiency, but the regulation was less satisfactory than with the shaft-governor engines, and it was inconvenient and cumbersome to belt from the slow-speed engine to the high-speed generator. Therefore it became a choice of evils between the inconvenience of the slow-speed engine and the less efficient performance of the high-speed engine, with the advantage clearly on the side of the shaft-governor engines for small powers, and the Corliss engine for large powers, but with the

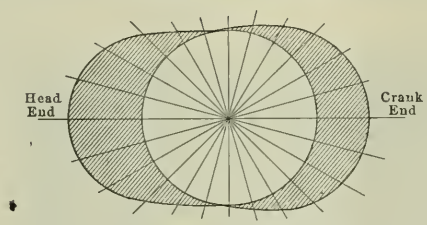


FIG. I. 160-HORSEPOWER SIMPLE ENGINE. UNBALANCED RADIAL FORCES WITH RECIPROCATING PARTS COUNTERBALANCED

boundary line of good practice not clearly defined. The tendency seemed to be to increase the field of the Corliss engine, and to limit the use of high-speed engines to still smaller powers, when it was found that single-valve engines were peculiarly adapted to compounding, and unlike the Corliss engine, these compound engines were very desirable for noncondensing service.

This changed the situation materially, for it was found that the high-speed compound engine was appreciably more efficient than the simple Corliss engine, so that the boundary line of good practice was moved up a long way into the field of larger powers, which had been held by the Corliss engine.

These compound engines first appeared as tandem engines, or as cross-compounds, but always with a shaft governor, and for many years the single valve was universally used. During all these years there was great similarity between the engines produced by the large number of builders of this class of machinery, but presently there began to be a divergence in the ideas of designers. Some sought to improve the efficiency of the single-valve engines by the use of complicated valve gears and an increased number of valves, while others claimed that the small gain in efficiency to be obtained by a multiplication of the valves and parts is more than offset by the increased cost of maintenance, and the greater liability of interrupted service, and that where high efficiency is desired a better plan is to use a compound engine of simple design and few parts.

The advocates of the multiple-valve high-speed engine answered this argument by proposing to compound the four-valve engine, while the opponents of the plan condemned it severely as being a wholly impracticable arrangement, because of the greatly increased number of parts and the rather appalling complication, which was held to be very objectionable for high speed.

Those who advocated the simpler valve gear for high-speed engines sought to realize the extreme of simplicity and fewness of parts. An illustration of the development in this line is found in the type known as duplex-compound. Comparing this with the compound engine just considered the difference in the valve gear is rather startling to the man who is expected to maintain these mechanisms.

Bear in mind that both these engines are compound engines. The engine wtih complicated valve gear gives slightly better efficiency, but the saving is unimportant. The following table of the number of parts in the valve gear of both engines makes an interesting showing:

	Eight-valve Compound.	Duplex Compound.
Number of eccentrics	2	0
Number of eccentric crank-pins	0	1
Number of eccentric rods	2	1
Number of connecting links	12	0
Number of rock arms	19	2
Number of rock-arm pins	26	2
Number of valves	8	1
Number of valve stems	8	1
Number of stuffing boxes	8	1
	85	9
Total number of working bearings	42	5
Total	127	14

The question naturally arises, what is the increased efficiency to be obtained by all this complication? The relative performance of the three classes of engine, the Corliss, the four-valve high-speed engine and the single-valve engine, may be best illustrated by comparing simple engines of these types. The Corliss engine has been so long known and so fully tested that its performance is well established as approximately 26 pounds of steam per horsepower per hour under usual conditions. The single-valve engine has been very definitely located at about 30 pounds per horsepower per hour, but the four-valve high-speed engine is newer and its efficiency is not so well known. Without regard to what may be finally considered a fair representation of the average performance of this engine, it must be evident that because it does not use the releasing valve gear, and because its clearance is necessarily greater than the Corliss engine, its efficiency must fall short of the standard efficiency of the releasing-gear engine, and its performance must therefore be between the Corliss and the single-valve types.

It has been abundantly demonstrated that the single-valve compound engine develops power on a consumption of from 22 to 24 pounds of water per horsepower per hour and therefore it is a more efficient engine than any type of simple engine.

It becomes, then, a question of the practicability of compounding the four-valve high-speed engine. Here again an interesting comparison may be made between the two types of valve gear, as follows:

NUMBER OF MOVING PARTS AND WORKING BEARINGS IN VALVE GEAR.

	Simple Engine	Compound Engine
Four-valve type	71	127
Single-valve type	14	14

From this table it appears that the single-valve engine may be compounded without increasing the number of parts of the valve gear, whereas the compounding of the four-valve engine increases the number of these parts 60 per cent.

The matter is summed up by the advocates of simplicity in high-speed engines as follows: Where the efficiency is not important the simple single-valve engine is desirable because it represents the smallest initial investment and the least cost of maintenance.

If high efficiency is necessary, then the compound single-valve engine is better than the simple four-valve engine, because it does not increase the number of parts of the valve gear and it is appreciably more efficient than any form of simple engine.

Leaving these comparisons and going back to the early days of the high-speed engine, you will remember the pioneer engine with shaft governor, known as the Armington & Sims engine. Then followed the straight-line engine of Professor Sweet and about the same time the engine which is to be followed in its development through all these intervening years.

The distinctive features of the high-speed engine are the shaft governor and the single valve, but we will not undertake to follow the development of these governors. A description of one of the latest designs may be interesting. The features of this construction are the gravity balance and the arrangement of the springs. During the whole period of the development of the engine the same form of the valve has been used continuously in the simple engine.

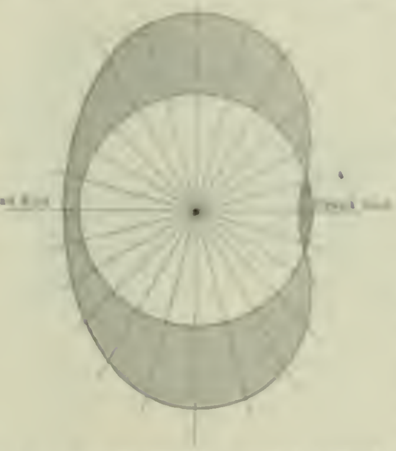


FIG. 2. 160-HORSEPOWER SIMPLE ENGINE. UNBALANCED RADIAL FORCES WITH RECIPROCATING PARTS COUNTER-BALANCED

Going on now to the compound engines as the next stage of development, the duplex-compound will be investigated as being along the line of extreme simplicity. The latest development along the line followed is a new type of compound engine that many of you have not seen.


FIG. 3. 160-HORSEPOWER ANGLE-COMPOUND ENGINE. UNBALANCED RADIAL FORCES WITH RECIPROCATING PARTS COUNTERBALANCED

This engine is called the "angle-compound" because the high-pressure and low-pressure elements are placed at an angle of 90 degrees in the plane of the crank's rotation, and both connecting rods engage the same crank pin, being placed side by side on a pin of double the usual length. This general arrangement is not new. It is the general plan of the mammoth engines installed in one of the large traction power houses in New York City, and has been very successful there and elsewhere.

Engineers do not seem to have realized, however, the peculiar advantages of this form of construction for small high-speed engines, where the counterbalance problem makes smooth running and freedom from vibration increasingly difficult as the speed is increased.

With even moderately high speed it has been found wholly impracticable to depend on ordinary foundations to resist the unbalanced inertia thrust of the reciprocating parts of horizontal engines, so a certain amount of counterbalance is therefore placed opposite the crank to neutralize these inertia thrusts.

The difficulty here encountered is that while it neutralizes horizontal thrusts, it also develops an unbalanced thrust in a vertical plane, so that, contrary to a very prevalent idea, the reciprocating parts of an engine cannot be counterbalanced by a rotating counterweight, and it becomes a matter of choice as to what part of this thrust shall be transferred from the plane of the engine to a plane at right angles to it. With horizontal engines it is common practice to use a counterweight to the extent of transferring the larger part of the inertia thrust to a vertical plane, because ordinary foundations resist vertical thrusts more successfully than horizontal thrusts. The magnitude of these thrusts increases as the square of the speed of rotation, so that at very high speeds they become very serious.

It has been positively demonstrated that the counterbalance in the driving wheel of a locomotive, necessary to prevent the engine from "nosing" badly at high speed, develops so much vertical thrust that the wheels, with the weight of the locomotive on them, actually lift clear of the rail at each revolution.

Keeping this all in mind it is evident that with the angle-compound engine the counterweight necessary fully to neutralize the inertia thrusts of the horizontal engine is just what is required to neutralize the inertia thrusts of the vertical reciprocating parts when the crank passes the line of centers. A practically perfect balance may therefore be obtained if both sets of reciprocating parts are made to weigh the same, and the counterbalance be made sufficient entirely to neutralize the inertia thrusts as the crank passes each of the four centers.

This is just what has been done in the angle-compound engine, with the result that remarkable smoothness of running is obtained even at very high speeds and the foundation problem becomes a very simple one. There are four small impulses on the crank pin of this engine at each revolution, instead of the two large ones ordinarily delivered to the crank pin of an engine. This is a more desirable condition for uniform rate of rotation without heavy flywheels and, because the shocks of impact are small on all these bearings, the wear is proportionately slight and the tendency to heat is reduced.

Among the many views shown on the screen were three showing the inertia thrusts of the reciprocating parts on the crank pin. These were graphic illustrations of the extent and direction of the force developed. Fig. 1 shows the direction and extent of the inertia force in an engine with unbalanced reciprocating parts; Fig. 2 shows the transference of force from the horizontal to the vertical plane when the reciprocating parts of the engine are as nearly balanced as may be by revolving weights; and in Fig. 3 is shown the inertia stress exerted in the angle-compound engine with the weight of both sets of reciprocating parts made to weigh the same, with the counterbalance sufficient to neutralize the inertia thrust at each center. There are thus four small inertia impulses at each revolution instead of the ordinary two large ones of the single engine.

Reserve Power for Auxiliaries

By W. H. Wakeman

There are many large and medium-sized plants in which the operation of the main engine depends on the action of auxiliary apparatus which is not equipped with reserve power of any kind for driving it, in case the regular means fails on account of an accident or the wearing out of some essential part.

For illustration, a certain mill that is run twenty-four hours per day is lighted by electricity supplied by a generator driven by a simple high-speed engine. If this engine is disabled by an accident the generator must stop, because no other method of driving it has been provided. This would leave the rooms in darkness, as the local electric-lighting company declined to supply current in case of such an emergency, and would not run wires into the plant for this purpose, as they wanted all of the job or none of it.

Again, a large power pump draws water for a certain manufacturing process. It must deliver water nearly every hour that the plant is in operation, or else the supply does not equal the demand; consequently, if it stops for any cause, the main engine must be shut down until the damage is repaired.

A certain plant which develops about 1000 horsepower is equipped with a stack sufficient for about 200. A fan is located between the boilers and this stack, and it is large enough to send the products of combustion to the low stack at a very rapid rate; but if the single engine which drives it is temporarily disabled no other means can be used to make it revolve, because none has been provided.

These illustrations show the advisability of providing more than one way to drive these important auxiliaries, especially when the comparatively small expense involved is considered.

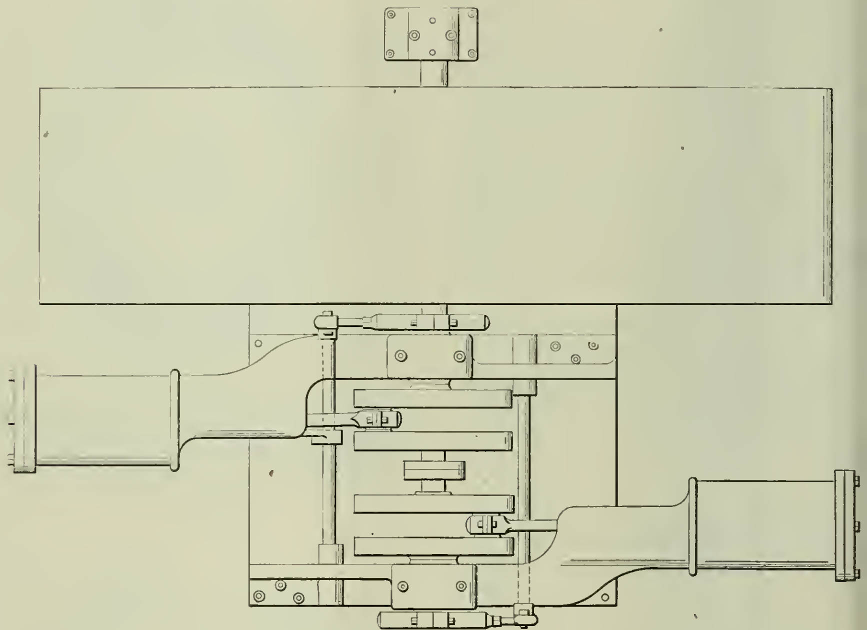


FIG. 1

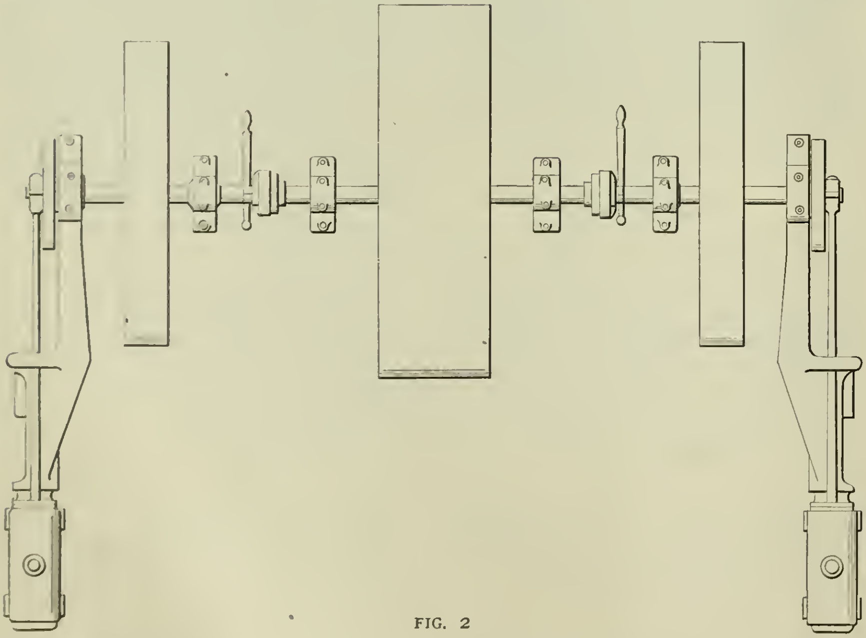


FIG. 2

Fig. 1 is a compact double engine which can be used as shown, or if one piston, cylinder, crosshead or connecting rod must be repaired, that part can be disconnected and the other used to drive part of the load, or carry the whole of it, if possible. Such an engine ought to be designed so that one cylinder will be large enough to do nearly all of the work; then, if both are used the liability of accident will be made less and the parts will prove durable. The engine as a whole will not show its greatest possible efficiency, but inasmuch as it develops only a small part of the power used this is of little consequence.

Fig. 2 occupies more space, but the design is excellent for several reasons. This shows two separate engines, with one flywheel that is common to both. It is not necessary to run one "over" and the other "under," as both must revolve in the same direction.

A substantial cutoff coupling is provided for each, with a suitable lever to operate it, by means of which either one or both of the engines can be disconnected with no delay whatever. They also make it practical to set the cranks in any desired position in relation to each other at pleasure as it is only necessary to shut off steam from both cylinders and set one crank on either center. Release the other coupling set this crank with the other, directly opposite to it, or at any point between these extremes. Throw in the lever and the cranks must remain in the given position.

A heavy balance wheel is provided for each engine for the following reason: The turning effect on the crank shaft in each case is not constant, but varies with the position of the crank pin, therefore the resulting strain on the cutoff coupling would be severe if it was not counteracted by the steady motion of the balance wheel. On this account a throttling, slide-valve engine, with a valve designed to cut off at seven-eighths stroke, is better than one of the automatic type, because its action is more nearly uniform in this respect.

Catechism of Electricity

914. If the sparking is due to the brushes, how should it be remedied?

If the brushes do not conform to the curvature of the commutator, or are not smooth, a strip of coarse sandpaper should be wrapped face upward once around the commutator, allowing it to lap a couple of inches over the first turn. By slowly turning the armature while the brushes are thus pressing on the sandpaper around the commutator, the contact surfaces of the brushes will be given the desired curvature. Then remove the coarse sandpaper and give each brush the necessary smoothness by drawing back and forth under it a short strip of fine sandpaper, keeping the back of the sandpaper throughout its length close against the surface of the commutator. Use a bellows to blow out the carbon dust from the commutator, brushes and brush holders and adjust the tension spring of the brush holders so the brushes are given the proper pressure upon the commutator as explained in 890.

Oil is sometimes applied to the commutator for the purpose of reducing the noise or chattering of the brushes and when much of it has been applied the brushes become sticky and readily collect dirt on their contact surfaces, producing sparking. They should then be cleaned by a cloth moistened in oil or benzine.

915. Is there any simple way of ascertaining whether sparking is caused by brushes of too high resistance?

Yes, this may be detected by the abnormally high temperature of the brushes. Such brushes should be replaced by others having a lower resistance.

916. How is one to know if the brushes are at the neutral points?

If there is sparking, and by shifting the brushes slightly around the commutator by means of the rocker arm the sparking is decreased, it proves that the brushes were not at the neutral points. In case, however, the brushes are not spaced as explained in 892, no amount of shifting will place them at the neutral points. They must then be readjusted before satisfactory results can be secured.

917. What causes the commutator to become rough or worn?

Unless there is some end play in the armature shaft, allowing it to move backward and forward in accordance with the motion imparted to it by the belt, the

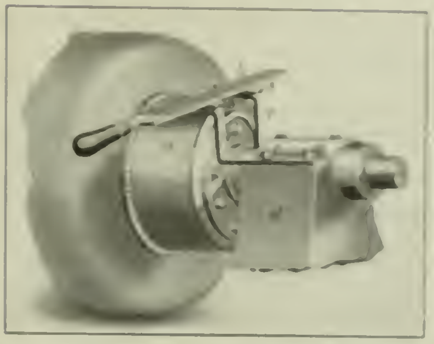


FIG. 285. A CONVENIENT FORM OF FILE REST FOR SMOOTHING THE COMMUTATOR

brushes will bear continuously on the same portion of the commutator and will in time cause it to become grooved and roughened. Hard particles in the carbon brushes will scratch the commutator. And it may be that the commutator has been turned out of the shop in a rough state.

Sometimes a bar in the commutator is of softer metal than the others and, by wearing, more rapidly causes the commutator to become flattened or eccentric. There will then be a gap between the brushes and the commutator at this point, resulting in sparking.

A high bar in the commutator, or a projecting strip of mica between the bars, which on account of its hardness does not wear down as quickly as the bars, will throw the brushes off the surface of the commutator during the rotation of the latter, and this will cause sparking.

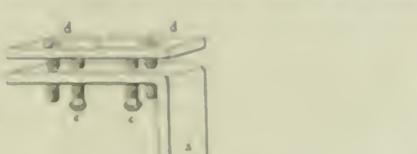


FIG. 286. DETAIL OF THE FILE REST SHOWN IN FIG. 285

918. What is the best guide with reference to the condition of the commutator and brushes?

The appearance of the commutator. If there is perfect contact between the brushes and commutator, the surface of the latter will take on a glossy brown or bronze appearance. A rough commutator, however, will generally overcome itself by lowering the brushes so make a chattering noise; this is particularly the case in high-speed motors. With an uneven commutator there will be a considerable rising and falling of the brushes when the armature is rotating slowly.

919. What precautions should be observed to keep the commutator in good condition?

Wipe its surface occasionally with a soft cloth or piece of waste to remove accumulations of dust. Dust is a direct cause of poor contact between brushes and commutator; it is therefore responsible for much of the sparking, roughness and heating of a commutator. After removing the dust from the commutator, it is advisable to place a few drops of good machine oil or vaseline on a clean portion of the wiping cloth, and while the commutator is in motion, move the cloth slowly across it so the oil will spread lightly over its entire surface.

920. If the commutator is rough, how should it be smoothed?

Place a piece of fine sandpaper on a block of wood which has been hollowed out to fit the curvature of the commutator and press it against the commutator while the armature is in motion. If the commutator is very rough or unevenly worn, sandpaper does very little good. It is then necessary to use a file.

921. Explain how to use a file in smoothing the commutator.

The grade of the file used should depend on the work to be done, but it must be one that is least liable to be clogged by the copper. Oil must be used freely to avoid heating and clogging, and to make the file cut well. The commutator must not revolve too rapidly and the file must be held properly. The hand which holds the file from slipping should be in a position where the commutator tends to pull rather than push the file. Failure to observe this rule may result in serious injury to the hand, or in a piece gouged out of the commutator.

To make a file safer and more serviceable for this work, a file rest should be provided. Without a file rest it is impossible to file the commutator surface level from end to end, and the flat places will not be taken out but made larger. There is also danger and difficulty in doing the work. Where there are several motors (one size), one file rest may be used for all of them.

922. What kind of a file rest should be used and how should it be fastened in place?

A convenient form of a file rest, bolted in place, is shown in Fig. 285. It consists of two pieces of iron, a and b, each provided at one end with an adjustable point c. Each of the pieces a and b is attached to one side of the bearing d, and is held in position by the cap bolts e and c. A bar f is laid across the pieces a and b, which are so adjusted that the file will just touch the commutator *a*.

The separate parts of the file rest are more clearly illustrated in Fig. 281, where *a* represents one of the pieces of iron, provided with slots *b*, etc., for the reception of the cap bolts. The other end is made adjustable by being provided with an extra piece *c*, whose hight is regulated by the screws *e*, etc. The piece *c* after having thus been raised to the proper hight is held in position by the screws *d*, etc. The part *c*, consequently, rests on the screws *e* and *e* and is held on them by the screws *d* and *d*. The latter screws are countersunk so that they will not be in the way of the file. The bar *a* should be of such dimensions that the pressure on the file will not cause it to move.

Driving up Bags in Steam Boilers

By M. Kennett

Among the many defects to which steam boilers are subject, there is none more common than that which is usually called a bag. These are sometimes called blisters, although a blister, or lamination, which is the correct name, is an entirely different phenomenon. In the days of iron boiler plates, laminations were quite common, but they are seldom found in modern steel plates, although occasionally met with, and the writer has noticed that they appear to be more common in the heavy plates which have recently been coming into more general use, than in the lighter ones.

A bag is caused by the sheet becoming overheated from some cause and forced out by the pressure. This overheating is usually caused by an accumulation of scale or sediment on the fire sheet, or it sometimes occurs around the blowoff at the rear. There are two methods of repairing a bag: one is to drive the metal back to its original position, and the other is to cut out the affected portion and put on a patch. Generally speaking, it is a great mistake to patch a boiler on this account unless the bag is unusually deep or very large. A patch is objectionable for several reasons. If it is of considerable size it weakens the shell, unless provided with the same design of riveted seam with which the longitudinal joints are provided, and this is usually impractical unless a half sheet or two-thirds sheet is put in. Owing to the difficulty of doing the work under unfavorable circumstances, the rivet holes often do not come fair when the patch is to be riveted-up, and the drift pin is resorted to, with the result that the rivet holes soon crack out, forming what are known as fire cracks and causing a great deal of annoyance from the resulting leakage and corrosion of the sheets. Furthermore, it is much more expensive to put on a patch than it is to drive up a bag, even of considerable size.

The process of driving up a bag is so simple that there is little excuse for an engineer calling in a boilermaker to do it, yet frequently bags are allowed to remain in boilers for months at a time because the engineer dislikes to call in the boilermaker. It is not good practice to allow a bag to remain in a boiler, as it forms a pocket which is apt to collect more sediment and serious results are liable to follow.

To drive up a bag, the plate must be heated to a dull cherry red, and with a short-handled sledge hammer light enough to be handled easily and quickly it should be driven back. Care must be exercised to start around the outer edge and gradually work in toward the center, for if the work is started in the center, the plate is certain to be buckled and cannot be straightened without probably removing some of the tubes and driving it back from the inside. When a bag forms in a boiler, the metal is stretched and, of course, is reduced somewhat in thickness, and in driving it back the metal must be made to flow back to its original position. In order to do this it is plain that work must be started on the outer edge, gradually proceeding in toward the center as the metal is forced in ahead of the hammer. In the case of a very deep bag it is sometimes impossible to cause the metal to flow back sufficiently to prevent buckling and in this case it is a good plan to drill about a 1-inch hole in the center of the bag, so that the surplus metal will flow into this space, almost completely closing it by the time the sheet is straightened, after which it should be reamed out and fitted with a rivet.

The essential apparatus is a forge of some kind for heating the plate and a hammer. This forge must be such that it may be easily pushed aside out of the way when the required heat has been reached, for the thin sheet will cool quickly and no time can be lost. A style of forge which the writer has used to good advantage is made of a common galvanized-iron water pail as follows: About 3 or 4 inches from the bottom a number of holes are cut and into these pieces of 3/8- or 1/2-inch pipe are slipped to serve as grate bars. Below the grates another hole is cut and a short piece of 1/2-inch pipe inserted, to which a hose leading to a small bellows is attached for the blast. This will be found to be an excellent forge for the purpose, being inexpensive and so light that it is easily removed.

When ready to proceed with the work, remove the boiler grate bars, with the exception of one on either side, and lay a couple of boards across these to set the forge on. Fill the forge with charcoal and set it on the boards close up against the boiler shell and directly under the bag, and by means of the blast from the bellows bring the metal to a dull red heat. A small pile of charcoal placed in the bag inside the boiler will assist in this somewhat. Do not hurry the heating, and when the desired temperature is reached, remove the forge as quickly as possible and with the hammer begin driving up the sheet, working around the outer edge. Work until the metal is almost black and then heat it again, working in toward the center all the time and taking care not to drive the sheet up too far. It is better, if anything, not to drive it up quite far enough rather than too far, as the finishing may be done with a flatter as a final touch, using a straight edge to make sure there is no depression remaining in the plate. Of course this cannot all be done in one heat, and if the bag is very deep or large, a great many may be required. In one case a large bag required 80 heats, although not all in one spot.

Some engineers are of the opinion that if a sheet has once bagged and been driven back, it is apt to bag again. There is no good reason to suppose that this is the case, however, and the experience of a good many years in this line of work does not justify it. The metal is practically the original thickness, and unless scale or sediment of some kind is allowed to accumulate, there is no reason why the sheet should come down again.

A small amount of oil or grease will produce a serious bag and one difficult to repair, because it extends over a great area, and for this reason, as a rule, cannot be driven back. Furthermore, the patch required is so large that the usual single-riveted seam would seriously weaken the shell, and a joint similar to that in the longitudinal seams must be used. These are not practical where exposed to the fire, and the consequence is that half or two-thirds of a sheet must be put in to bring these joints above the fire line.

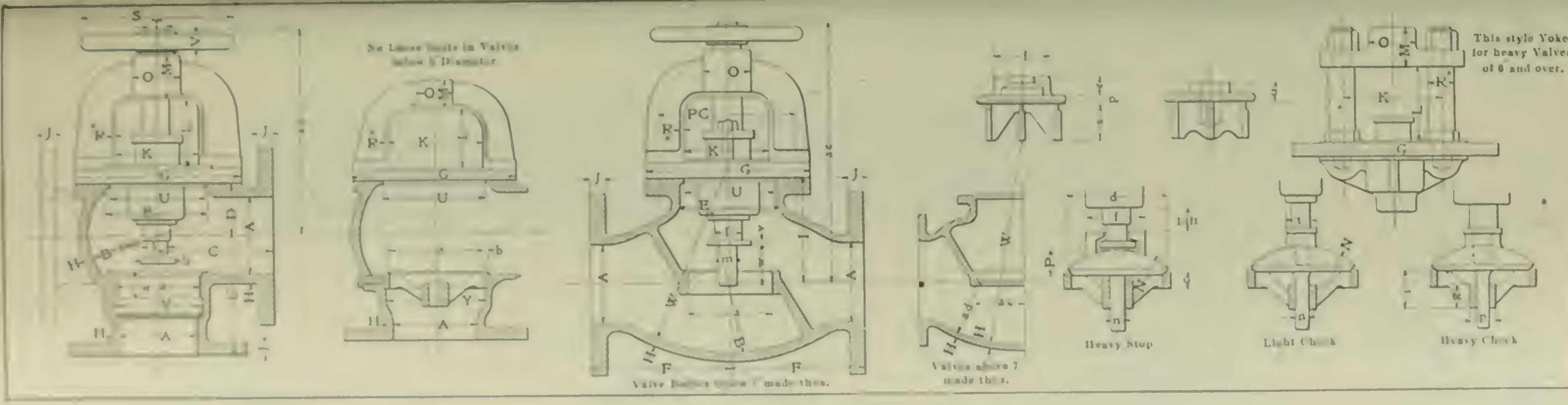
Dimensions of Valve Parts

By O. James

The table on the opposite page gives values which will facilitate the design of composition valves for pressures up to 200 pounds per square inch and for sizes from 1-inch to 9 1/2-inch, with additional 11 1/2-inch and 13-inch heavy sizes.

This table is excellent for those who have to design valves, as each figure or size has been carefully checked by drawing the valve either to full or half scale.

The angle, cross and globe valves, with the different combinations of stop and check valves, for both light and heavy pressure, have been carefully treated, as will be seen from the different sketches above the table. Provision has also been made for loose seats in all the valves above 5 inches in diameter.



A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	R	S	T	U	V	W	Y	a	b	c	d	e	f	g	h	i	k	l	m	n	p	r	s	t	u	v	w	x	Lift	Studs: In Bonnet	Studs: Size in Bonnet	Studs: No. in Yoke	ab	ac	Per Cent. of Bolts in Bonnet
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DIMENSIONS OF VALVE PARTS—SEE PAGE 152

The Plunger Hydraulic Elevator

Different Designs of the Lower Casting in "Standard" Plunger Elevators Described, with Illustrations of Piping Connections

BY WILLIAM BAXTER, JR.

Construction of Plunger Lower Casting

The lower casting *F* of the plunger is arranged to carry the guide brushes *H* that hold the plunger in the center of the cylinder. The construction of this casting and the way in which the brushes are held in place may be fully understood by the aid of the two horizontal sections, Figs. 295 and 296, taken on lines *N N* and *M M*, Fig. 291, and the vertical elevation, Fig. 297. The two sectional views also show a section of the cylinder *C*, to present more clearly the relative positions of the several parts. In Fig. 295 it will be seen that the brushes are held in grooves cast lengthwise of the casting *F*, and that these grooves are provided with flanges *a* along their inner edges, to prevent forcing the brushes too far in toward the center, and other short flanges *F′* to lock them in position. The brush back is made with short flanges *H′* that slide in back of the flanges *F′*. In putting the brush in position it is raised to the top of the groove and then pressed in until the flanges *H′* can be forced down back of the flanges *F′*, then the brush is driven down and a key *I*, Fig. 291, is put in above the brush to prevent it from jumping up. The brush is forced down until the back rests hard against the bottom *F″* of the side grooves in casting *F*. The keys *I* are not driven in endwise but sidewise, that is, toward the center of the casting

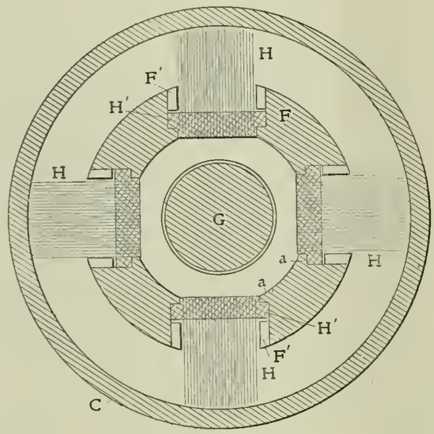


FIG. 295

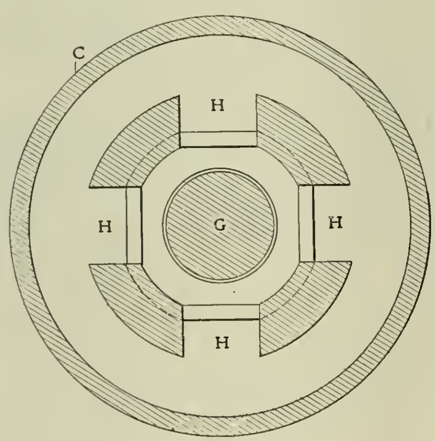


FIG. 296

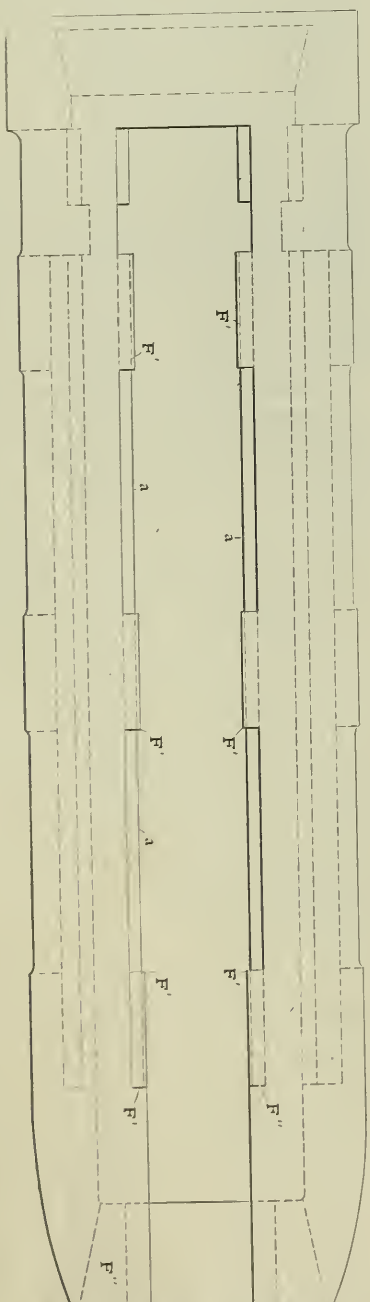


FIG. 297

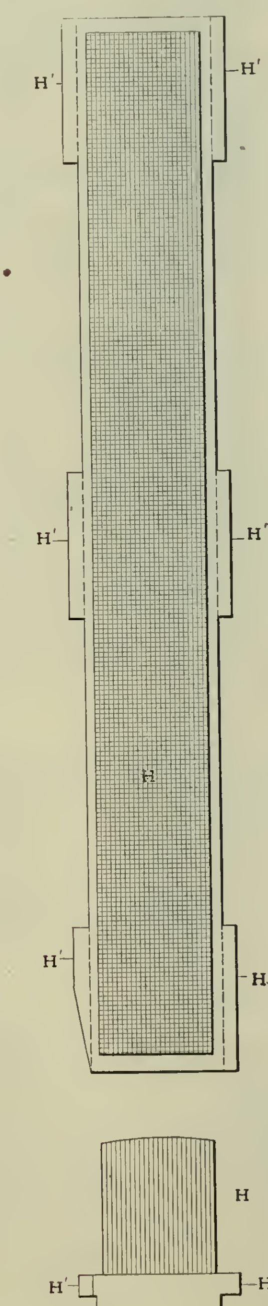


FIG. 298

and, when in position, are clinched so they cannot work out.

The shape of the brush is more fully shown by the aid of Fig. 298, which is a view looking at the face of the brush. The positions of the short flanges H' are clearly shown, there being six of them arranged in pairs. At the lower end the brush back is tapered off so as to facilitate getting it in the groove back of the flanges F' of the casting F. The space above the flanges F' is greater than the length of the brush flanges H', so there may be no difficulty in pushing the brush into the proper position. The brushes are made of hard spring-brass wire, about No. 22 gage. The back is of babbitt metal and is cast around the wires to hold them firmly in position. The grooves in the casting F, into which the brush backs fit, are not machined, but are simply carefully cast, and the burs well cleaned off. As the brush back is soft, there is no difficulty in forcing it into place. If it should fit too tightly, it can be easily shaved off where it binds. When the brushes are in place in the casting F the water in the cylinder can reach the central space through the openings above and below the brushes and also through the joints between the brush back and the casting, as these are not tight fits.

Another Design of Plunger End

Another design of plunger end made by the Standard company is shown in Fig. 299, which is a vertical elevation in section, showing the plunger at its highest position, that is, in the position it reaches when the car is even with the upper floor of the building. The brushes in this case are held by the bolts B. A horizontal section through the lower end of the casting F is shown in Fig. 300, from which it will be seen that there are only three brushes. The design, Fig. 291, can also be made with three brushes, but Fig. 299 cannot be made with four, unless they are made considerably narrower and the bolts B are set farther away from the center. This design is simpler than that of Fig. 291, but it is not as perfect. In the latter if the car overruns the upper limit of travel the holes B' in the piece B will pass above the stuffing box and let the water in the cylinder flow out before the brushes reach the packing, but in Fig. 299 it can be seen that for the water to escape the plunger must run up until the part F of the casting passes above the gland E, and this will carry the upper end of the brushes up into the stuffing. If the latter is of the cup type it may not be damaged to any extent, but if it is hemp it is liable to be pulled out of place. This plunger end cannot be used with the cylinder top shown in Fig. 289, unless there is so much head room above the elevator car, when even with the top floor, as to permit running it several feet higher before the casting F is high enough to permit the water to escape.

If with this cylinder top the plunger should run normally as high as it is drawn in Fig. 299, the brushes would be carried up into the brass lining D and, by being bent back and forth at every trip, would soon become useless. The cylinder top in Fig. 299 is very much shorter, so the plunger can run just as high as the plunger in Fig. 299 can run in the top in Fig. 289, without running the brushes up into the bore of the casting.

FIG. 299

FIG. 300

Piping Connections

The pipe connections between the pump, tanks and lifting cylinder of a plunger-elevator system are generally very simple, but in some of the higher-grade passenger-elevator installations they are very elaborate. The arrangement most commonly used is shown in Fig. 301. In this diagram A represents the lower portion of the elevator car, B the plunger, C the cylinder and D D spring buffers provided for the car to rest on when at the lower floor. The main valve is shown at F, and is represented as of the simple rack-and-single-gear type. The discharge tank is at G, and H is the pressure tank. The water in the lifting cylinder C is discharged into the tank G through the pipe L, and from this tank the pump draws its supply through the suction pipe M. The discharge pipe N of the pump leads to the pressure tank H, and from the latter the water is carried to the lifting cylinder through the pipe O. In order to keep the necessary quantity of air in the pressure tank H means must be provided for forcing air into it from time to time, to replenish that which will inevitably escape in one way or another. In large installations, where several pumps and possibly tanks are provided, a small air pump is installed to furnish the compressed-air supply, but in smaller plants the pump K is arranged so as to be [illegible] necessary. The pressure tank H is provided with a glass water gage to show the height of water in it and also with a pressure gage. In addition, a pressure regulator is used to stop the pump when the pressure in H rises to the maximum, and to start it when the pressure falls below the minimum.

Fig. 301 shows a system provided with a full complement of hand valves, three of these being marked I, I' and I''. There are two more, one in the pump suction and one in the pump-delivery pipe N. When all these valves are placed in the pipe lines the inspection of the several parts of the apparatus may be done with very little trouble. If it is desired to examine or renew the cylinder packing, all that is necessary is to run the car down to the lower floor and then close valve I'. If the main valve is to be taken apart, the valves I, I' and I'' are closed. To inspect the pressure tank H, the valve I'' and the one in pipe N are closed. If repairs or inspection of the pump are required the valves in pipes M and N are closed. Thus with all the valves closed it is not necessary to drain water from any part of the system, as has been found in previous accidents in which it was assumed that a [illegible]. If the discharge tank is at a lower level than the cylinder pipe O the valve I' may be [illegible] pensed with without impairing the system, and we may also add that the balanced main valve *F* can be replaced by one of the unbalanced type, such as shown in Fig. 287. The valve in the suction pipe *M* may also be discarded.

The Nature of the Volatile Matter of Coal*

By Horace C. Porter and F. K. Ovitz

In connection with the fuel investigations being conducted by the Technologic Branch of the United States Geological Survey, a special effort is being made to determine the chemical and physical structure of coal. The chemical investigation is being pursued along three special lines: (1) The chemistry of combustion in the furnace, that is, determining the chemical composition of the hydrocarbons given off during the process of combustion; (2) the hydrocarbons which are given off at different temperatures, starting with a normal temperature and determining the nature of the hydrocarbons given off at each of a series of successively higher temperatures from the normal to the temperature of the ordinary furnace, and (3) the hydrocarbons existing in the coal at normal temperatures to be determined by solution and subsequent analytical methods.

A paper presented by Dr. Horace C. Porter at the June meeting of the American Chemical Society, of which the present statement is an abstract, relates to the second of these three lines of investigation. Dr. Porter is in charge of the chemistry of the distillates of coal under the United States Geological Survey. The statement is in part as follows:

It is a familiar fact to retort-coke-oven and gas-works operators that the volatile products of coal are largely affected, both in quantity and character, by the conditions of temperature and rapidity of the rise of temperature in the coal, and by the conditions to which the products are subjected after leaving the coal. The usual laboratory determination of volatile matter serves almost universally as a more or less valuable indication of the coal's adaptability to industrial uses either for combustion, destructive distillation or gasification. The method for this determination is, however, an arbitrary one and does not duplicate closely that of any industrial operation, nor is the character of the volatile matter produced by the laboratory method known with any degree of certainty. Furthermore, the results by the laboratory method are very sensitive to varying conditions, and the influence of such variation on the character of the volatile products has not heretofore been the subject of extended study.

The importance of the role played by the volatile matter in all industrial applications of fuel is generally recognized. There are more heat units in the volatile matter in proportion to its weight than in the fixed residue. Pittsburg coal, of 30 per cent. volatile matter and 7 per cent. ash, has 36 per cent. of its heat value in its volatile matter, as shown by comparing the heat values of coal and coke. When coal is fired under a boiler, either by hand or mechanically, it first undergoes a process of distillation, and both the quantity and quality of the volatile products and the relative ease of their liberation are concerned very largely in the boiler efficiency and the production of smoke. It is reasonable to suppose that coals of different origin may yield volatile gases carrying different percentages of tarry vapors and heavy hydrocarbons and may on that account differ in smoke-producing tendencies. A knowledge of the chemical reasons why coals smoke in varying degrees, and why high volatile coals are hard to burn with maximum efficiency, is a necessary preliminary to the taking of intelligent steps toward improvement in these respects.

The gas producer for bituminous and low-grade fuels is coming more and more into favor. Here also the volatile matter in the fuel plays a very important role, since at the top of the fuel bed a process of distillation is continually going on. A certain proposed new type of producer will utilize high volatile fuels, such as bituminous coal, lignite, peat and wood, by passing the hot gases from the producer through the raw fuel in a series of preliminary chambers, thus distilling the valuable hydrocarbon gases, as well as ammonia, out of the fuel before it is charged into the producer itself.

Attention need hardly be called to the preëminent importance of the volatile matter of coal in the illuminating-gas and by-product coke-oven industries. It is of interest to note, however, the increasing favor accorded by the gas industry to the

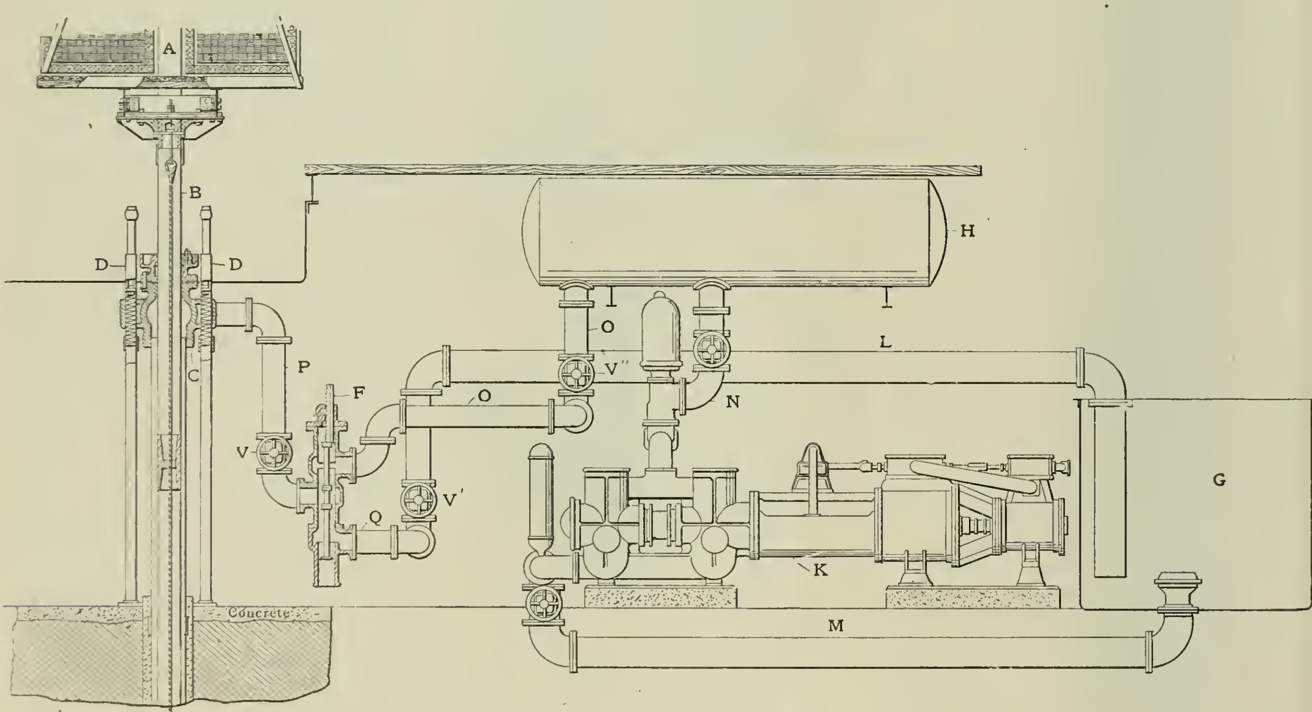


FIG. 301

*Presented with the permission of the director, U. S. Geological Survey.

vertical gas retort, as most successfully operated by the Bueb system at Dessau, Germany, and to explain that one advantage of this process lies in avoiding decomposition of certain valuable gases in passing over heated surface, as occurs in the ordinary processes, although at the same time a higher gas yield is obtained by using higher temperatures in the retort itself

Purpose of the Investigation

The purpose of the investigation described in this paper has been: (1) To throw light on the nature of the volatile products from coal, and on the manner in which they are affected by the conditions prevailing during their formation, or to which they are subjected after formation; (2) to contribute, in the interests of smoke abatement, some data on the comparative amount and character of the gases and vapors distilled from different coals at low temperatures, a subject intimately concerned in the production of smoke; (3) to prove experimentally that the volatile product of coal is to some extent incombustible, and that the proportion of inert volatile varies in different coals; and, finally, (4) to show that the oxygen of coal is in many cases evolved in the volatile matter very largely in combination with carbon as CO and CO_2 as well as with hydrogen as water, thereby explaining in great degree the discrepancy found in these cases between the determined calorific value and that calculated by Du Long's formula

Deterioration in Heating Value at Ordinary Temperatures

In connection with a series of experiments not yet completed, on the deterioration in heat value of various coals during storage under different conditions, a liberation of gas in remarkably large quantities was found in certain cases. About 25 pounds of bituminous coal of nut-wheat size was stored in a 5-gallon glass bottle closed with a rubber stopper, which was provided with glass tubes for removing gas samples. The bottles stood in the laboratory at a temperature ranging from 20 to 25 degrees. In some of the bottles the coal was immersed in distilled water and the interstices well filled with water by attaching a partial vacuum for about one hour. About 400 cubic centimeters of air remained above the surface of the water.

The gas liberated during these experiments consisted almost entirely of methane, with a very slight amount of CO_2 and no more than doubtful traces of CO and heavy hydrocarbons. No hydrogen could be detected by the palladium fractional combustion method. Whether this gas may properly be considered as volatile matter due to decomposition of the coal, or whether it is held in the coal as such by occlusion or absorption, cannot be decided without further study. The fact that the oxygen of the air surrounding the coal was rapidly absorbed without forming CO_2 indicates a change of composition in the coal. It is reasonable to suppose that a larger quantity of gas escaped between the mining of the coal and the starting of the experiments than was measured during the experiments. The measurement of quantity of gas formed is therefore of little value. The gas pressure in the case of one coal measured, reached at one time 7 inches of mercury.

TABLE 1. ANALYSIS OF COAL USED IN EXPERIMENTS

	Moisture	V. M.	F. C.	Ash
Connellsville, Pa	1.10	30.87	[illegible]	7.[illegible]
Ziegler, Ill	7.67	[illegible]	54.22	7.[illegible]
Sheridan, Wyo	[illegible].15	[illegible]	[illegible]	[illegible]
Pocahontas, W. Va	[illegible].35	[illegible]	7[illegible].51	[illegible]

TABLE 2. AVERAGE RESULTS OF 10 GRAMS AIR-DRIED COAL

(10 Minutes Heating.)

Coal	Heating Temp. in Coal	Tar	Water	Gas (c.c.)	Gas Composition (Calculated to nonsmoking gas): CO_2	Illuminants	CO	CH_4	C_2H_6 (a)	H_2	N_2
10 minutes heating at 500°											
Connellsville, Pa	[illegible]			8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ziegler, Ill	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10 minutes heating at 600°											
Connellsville, Pa	441	4.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ziegler, Ill	440	6.8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10 minutes at 700°											
Connellsville, Pa	[illegible]	11.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ziegler, Ill	[illegible]	7.8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sheridan, Wyo	[illegible]	8.2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Pocahontas, W. Va	[illegible]	4.2	1.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10 minutes at 800°											
Connellsville, Pa	687	12.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ziegler, Ill	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sheridan, Wyo		7.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Pocahontas, W. Va		6.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

(a) Includes all higher paraffin hydrocarbons calculated as C_2H_6.
(b) Includes small amount of air

TABLE 3. ABSOLUTE QUANTITIES OF SMOKING AND NONSMOKING PRODUCTS*

(10 Minutes Heating.)

Designation of Coal	Temperature: Furnace	Temperature: Coal	Smoking Products: Tar Per Cent	Gas (c.c.): Illum.	Gas (c.c.): Ethane etc.	Gas (c.c.): Total	Nonsmoking Gases (c.c.): CO_2	CO	CH_4	H_2	Total
Connellsville, Pa	500	335		0	0.6	0.6	2.4	[illegible]	[illegible]	[illegible]	[illegible]
Ziegler, Ill	500	325		0	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Connellsville, Pa	600	441	4.9	16	46	61	12	11	[illegible]	[illegible]	[illegible]
Ziegler, Ill	600	440	6.8	12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Connellsville, Pa	700	[illegible]	11.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ziegler, Ill	700	[illegible]	7.8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sheridan, Wyo	700	[illegible]	8.2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Pocahontas, W. Va	700	[illegible]	4.2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Connellsville, Pa	800	687	12.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ziegler, Ill	800	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sheridan, Wyo	800		7.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Pocahontas, W. Va	800		6.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

*10 grams of coal.

Volatile Matter at 105 Degrees Centigrade

A series of experiments, conducted primarily for direct weighing of moisture driven off from coal at 105 degrees, yielded results incidentally which showed the amount of the loss of substances other than moisture, generally CO_2 in small percentages.

Volatile Matter at 500 to 1100 Degrees Centigrade

In studying the nature of the volatile matter at the medium and higher temperatures, 500 to 1100 degrees Centigrade, two sets of experiments were run, using a different apparatus in each. In one a 10-gram sample was heated in a platinum retort suspended in an electric resistance furnace maintained constant at the desired temperature, the gases evolved being collected by displacement of water in a bottle. No attempt was made in this set of experiments to duplicate the methods of industrial practice. The apparatus was designed with the idea of maintaining definite and controllable conditions which would yield results comparable with each other in experiments on different scale. The other set of experiments was run on a somewhat larger scale, heating 400 grams of coal in a cast-iron retort resting in a cylindrical electric resistance furnace, the tar, water, ammonia, CO_2, H_2S, and gas being collected in appropriate absorption apparatus and measured. Owing to the heavy nature of the retort and the large sample of coal the temperature in the coal could not be varied as easily in these experiments as in those using the platinum retort. Accordingly one set of conditions was adopted approximating as nearly as possible those of industrial by-product coke-oven practice, and a number of typical coals compared under these conditions. The object was rather to compare the different coals with each other under this set of conditions, than to determine absolutely the industrial by-product yields; and further, to determine the composition of the volatile matter from different coals under these conditions.

Series of Tests of 10 Grams of Coal

The series of tests on 10 grams of coal in a platinum retort, at various temperatures, is not yet completed, but has yielded sufficient results to show their approximate agreement with those obtained on 400 grams of coal, and also to indicate the composition of the gas produced from different coals in the early stages of heating at low temperatures. A thermocouple was inserted in the retort to determine the temperature under the surface of the coal itself. The tests were run in an atmosphere of nitrogen, which was passed through the retort until the exit gases contained less than 1 per cent. oxygen. The tar was collected in two 6-inch tubes of absorbent cotton heated to 100 degrees Centigrade and also weighed on the neck of the retort. The water was collected in a 5-inch $CaCl_2$ U-tube, and always contained a slight amount of light oil, driven over from the tar, causing an error of 1 per cent., or less.

Smoke Formation and the Composition of Low Temperature Gases

From the results given in Table 2 and in different form in Table 3, it may be seen that the low-temperature gases are high in illuminants and the higher homologues of methane, and low in hydrogen. Comparing the four coals at 700 degrees, where the gas begins to be formed in considerable amount, the Connellsville is the richest of the four coals in illuminants and heavy hydrocarbons and the Pocahontas the highest in hydrogen. The high CO_2 and CO from the Illinois and Wyoming coals accords with other experiments on these coals. The tar at 700 degrees is greater also in the Connellsville coal. The smokeless character of the Pocahontas coal may be connected more or less with the presence of considerable hydrogen in its gas at low temperatures, since the low-ignition point of hydrogen tends to assist in the burning of other gases present.

From the tables the bearing of these results on smoke formation may be seen. The smoke-producing constituents of the volatile matter are here considered as including tar, and the heavier hydrocarbon gases: benzine, ethylene and homologues of methune, calculated as C_2H_6. While at 440 degrees, in the coal, the Illinois coal, and probably also the Wyoming, has produced more smoky gases than the Eastern coals; at 565 degrees and higher the Connellsville produces much more. This accords with the finding in practice of greater difficulty in burning coals of the Connellsville type without smoke.

Conclusions Drawn from Experiments Made

1. Some coals liberate gas during storage, of a composition similar to that of natural gas, and some coals rapidly absorb oxygen from the air during storage without forming CO_2.

2. During drying in air at 105 degrees Centigrade, some coals lose appreciable amounts of CO_2, and most coals take up oxygen to a considerable extent, but none of those tested showed any considerable formation of combustible gases.

3. The nature of the volatile products, distilled from several coals at low temperatures in the early stages of heating, vary in different coals in accordance with their smoke-producing tendencies.

4. The volatile matter of coal comprises a considerable proportion of noncombustible matter, varying with the typ of coal.

5. A modification is suggested of Du long's heat-value calculation for coal based on experimental results showing th distribution of oxygen between hydrogen and carbon.

Steel Belts for Power Transmission*

Steel belts, or metal belts, are by no means unknown, yet they are not generally used and are considered as particularly unadapted for heavy duty. Thus the development of steel belts for heavy power-transmission service in Germany is of more than passing interest. The subject of this article is the steel-belt development of the Eloesser-Kraftband-Gesellschaft, of Berlin.

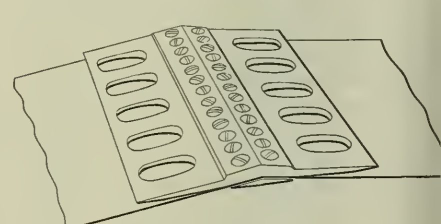


FIG. 1. JOINT OF A GERMAN STEEL BELT

As would naturally be expected, the joint or splice of a steel belt is one of the critical features. The joint construction used by this German firm is illustrated by Fig. 1. It consists of two steel plates, an under and an upper, between which the ends of the belts are joined. These plates taper from a thickened section at the center to comparatively thin edges. In the size illustrated, the upper plate is made with a series of holes in order to lighten it. Each of these plates is shaped to a circular arc, whose radius is equal to the radius of the smallest pulley on which the joint is to be used. Thus, for a given joint there is a minimum limiting diameter of pulley on which it can run, but no similar maximum limiting diameter; for a given joint can be used on pulleys of any diameter larger than the one to which the plates are particularly fitted.

COMPARISON OF ROPE, LEATHER-BELT AND STEEL-BELT DRIVE.

Item.	Rope Drive.	Leather-belt Drive.	Steel-belt Drive.
Breadth of belt space	6 ropes 45 mm. in diameter	500 m.	100 mm.
Breadth of pulley	380 mm.	500 mm.	110 mm.
Weight of pulley	1000 kg.	520 kg.	270 kg.
Weight of rope or belt	240 kg.	140 kg.	13 kg.
Total weight of drive	1240 kg.	660 kg.	283 kg.
Cost of pulleys	720 marks	400 marks	250 marks
Cost of ropes or belts	600 marks	1300 marks	750 marks
Total cost	1340 marks	1700 marks	1000 marks
Power lost in per cent	13 %	6 %	0.5%
Power lost in horsepower	13 h.p.	6 h.p.	0.5 h.p.

*Condensed translation.

The belt itself is made of a uniform quality of steel of an even thickness and is tempered. The ends are carefully brought together, fitted and soldered with a special solder that flows at a comparatively low temperature. This joining is then placed between the two plates that we have described, and these plates are fastened together by means of screws, as shown in the illustration, Fig. 1.

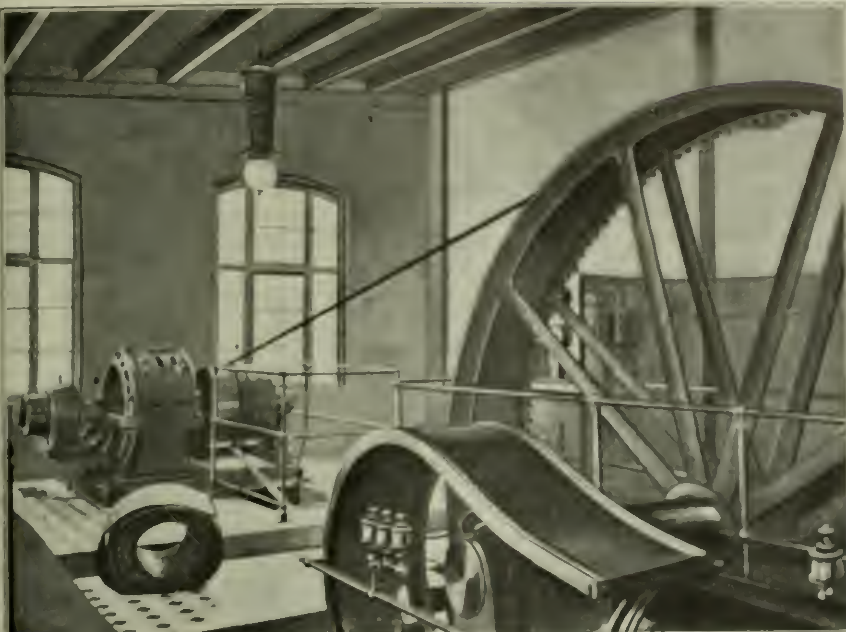


FIG. 2. A 250-HORSEPOWER STEEL-BELT DRIVE

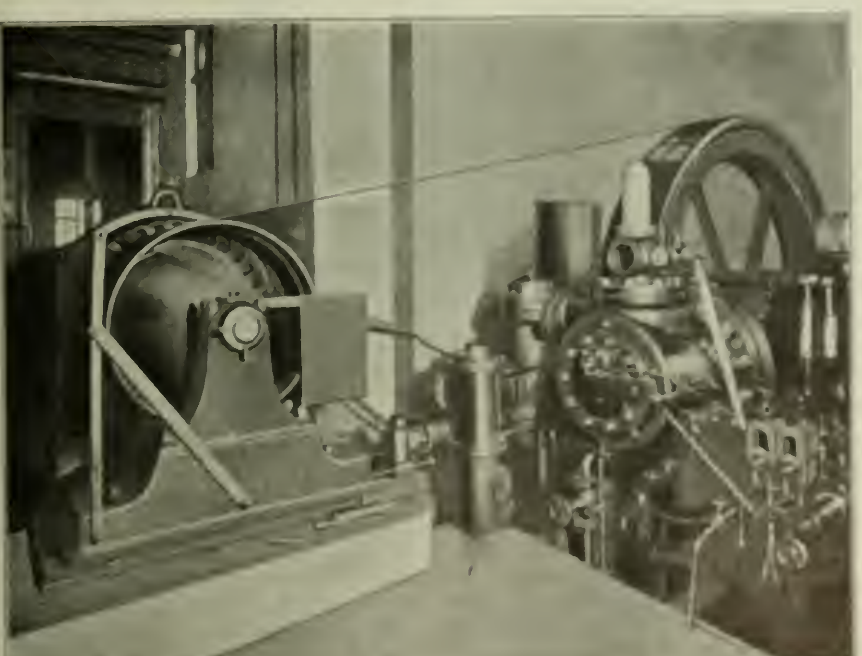


FIG. 3. A 160-HORSEPOWER STEEL-BELT DRIVE

ADVANTAGES

A number of interesting claims are made for these belts. Three of the most striking are: The small amount of slipping of the belt on the pulley, given in figures as less than 1/10 of one per cent.; the narrow width of the belt compared with leather belts, the proportion being about 1 to 5; and the great speed at which these belts can be run, given as 100 meters per second, or say 19,000 feet per minute. This latter figure is striking if we compare it with the figure usually given for leather belting at 5000 feet per minute. It is very common to run these steel belts at a speed of 50 meters per second or, roughly, 10,000 feet per minute.

Other minor advantages which are really dependent upon the three major ones that we have pointed out are: A narrower and lighter pulley for given service, a lighter and smaller shaft, a reduction of the strains upon bearings (thereby a reduction of the size of bearings and in many cases—especially on electrical machinery—the elimination of outboard bearings), a saving of room through a reduction of the general dimensions of machinery, avoidance of temperature and humidity effects (thereby a lessening of the required attendance) and, in case the belt is applied to existing pulleys, the possibility of using the pulley face for other belts. This last feature is particularly true of portable engines.

Because of the high permissible speed these belts have been adapted in many cases to electrical machinery, both generators and motors, and to gas engines. They have also been used for driving belts in machine shops and other manufacturing establishments. The table gives comparative data between a rope drive, a leather-belt drive and steel-belt drive for 100 horsepower, transmitted by pulleys 10 meters, 30 feet apart, at a speed of 200 revolutions per minute and a diameter of 1 meter, 3 feet. The metric measurements in the table are not translated into English measurements because the table is of comparative interest only.

REPRESENTATIVE INSTALLATIONS

Referring to the half-tone illustrations, Fig. 2 shows a drive on a steam engine at the plant of Ludwig Stollwerk & Company, Berlin, from a 250-horsepower steam engine to an electric generator. The width of the steel belt is 100 millimeters, or say 4 inches; the width of the leather belt which was removed, and which is seen lying on the floor, is 600 millimeters, or say 24 inches. The striking feature of this illustration is the narrowness of the belt.

Fig. 3 shows a drive in the plant of the Berliner Elektricitäts-Lieferungs-Gesellschaft, Berlin. It transmits 160 horsepower, and the breadth of the belt is 100 millimeters, or say 4 inches. The leather belt that it replaced was 480 millimeters wide, or about 19 inches.

The American consul at Naples states that steam engines and boilers are being built in Italy, and the demand for the latter from abroad has almost disappeared. Steam engines are still imported from Switzerland and Great Britain. The introduction of suction-gas engines has of late diminished the use of steam engines and locomobiles in industrial enterprises. Centrifugal engines are built by a few large firms in Italy, but they are also imported from Great Britain, Switzerland and Germany. Dynamos and electric motors are imported from Great Britain, United States, Germany, but only in small quantities as yet, the demand being, however, increased as a result of the reduction of duty on petroleum. Steam pumps are imported from Great Britain and Germany.

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Extraneous Supervision of Power Plants

I trust that you will give me space for a self-discussion of your editorial on "Extraneous Supervision of Power Plants":

First—Let me state that I recognize the fairness of your presentation of the subject, but I do not agree with your conclusions.

Second—I wish to call attention to the fact that I purposely modified, in the same paper in which the original matter was published, viz., the *Record and Guide*, my remarks about graft in the engine room. By this I mean that I publicly stated that there were a great many high-class engineers who recognized the evils of the graft system and the system of receiving commissions on supplies and repairs as fully as I did, and they further recognized the fact that an honest engineer who would not take graft was placed at a serious disadvantage when applying for a position, because other engineers who were not honest and who expected to take graft and commissions were able to offer to take the position at a very much less salary.

It is, of course, a matter of common knowledge and of individual knowledge that in a great many plants in this city, the purchasing agents, whether they be engineers or others, exact commissions on purchases. It is not the amount of these commissions that is the serious drawback, but it is the fact that a fair judgment as to quality of the supplies is absolutely precluded. It is also a fact that in many instances repairs are undertaken, which would not otherwise be necessary, merely for the purpose of obtaining commissions; and in such cases the employer not only pays the commission made by the repairman to the engineer, but he spends probably nine times the amount of this commission in an unnecessary repair. How can an honest engineer, expecting to receive nothing more than his salary, compete with an engineer who counts on these commissions and graft as part of his salary; and is it any wonder that where such conditions do exist the Edison company is able to come in and shut down a plant?

It is my honest opinion that with a properly and honestly managed plant, whether operated under engineering supervision or not, there is no chance at all of shutting the plant down after it is once installed, but with dishonest or incompetent management the shutting down of a plant is a foregone conclusion.

Now as to your conclusion; your idea is that the engineer of the plant becomes an automaton, a mechanical automaton you say, whose strings are pulled by the engineering supervision office. *This conception of the relations between the supervision company and the operating or chief engineer is entirely erroneous.* It must be evident to anyone who is familiar with the operation of the modern complex plant that any attempt to operate this plant without a high-grade trained engineer on the premises would be disastrous. It is the writer's opinion, and one that he has stated frequently, that unless the chief engineer worked in sympathy with the supervising engineer, no good results can be accomplished; and the chief engineer of the plant is, in my estimation, one of the most important members of the organization of the supervision company, and I see no reason why there should be any more conflict between the chief operating engineer and the advisory consulting operating engineer than there is between the architect of a building and the builder. The supervising advisory engineering office has functions to perform requiring a whole office staff consisting of draftsmen, engineers, stenographers, auditors, etc., which cannot be properly performed by a single chief engineer no matter how good; and on the other hand, a chief engineer has duties to perform which could not be performed by any organization unless located directly on the premises operated.

A large plant has its advisory consulting engineer, and if the small plant is to compete with service from the central station, it must have at its disposal engineering services and purchasing services equal to those available to the central stations.

You speak of contracting engineering companies; the supervision company is not a contracting company. I have always objected to a contracting engineering company, as I think it essential that the interests of the employer and of the advisory engineer be identical and not opposed, as they are to a certain extent where a contract for operation is entered into. That is, the supervising engineering company should be paid for its services the same as the architect is paid, and the plant should be operated to the best interests of all concerned.

Another point of importance in connection with the relations between a supervision company and the operating engineer is that efforts to effect improvements are noted, and the capable, honest engineer is sure of advancement as well as steady employment. As examples of this, may be noted the chief engineer of the Langham, who started as assistant engineer; the chief of the Weil & Mayer buildings, who has been promoted from one plant to another paying better, inside of one year; the chiefs of Reisenweber's, Acker, Merrall & Condit's, Langsdorf's, Saks & Co., all promoted from assistant engineers to their present positions; in fact nine-tenths of our chief engineers have graduated from assistants.

P. R. Moses.

Engineering Supervision Company. New York City.

Multiple Feed Lubricator

Several months ago I constructed a lubricator, a sketch and description of which are herewith submitted.

The reservoir, Fig. 1, is made of 5-inch iron pipe, 15 inches long, capped at both ends. The sight feed is attached directly on the pipe. There are two sight feeds for lubricating two different steam cylinders, but any number of sight feeds may be attached. There is a gage glass to denote the hight of oil; *C* is a ¾-inch cross valve connecting the bottom of the reservoir with the pressure pipe *M*, which can be connected to any steam pipe; it is preferable, however, to connect this pipe direct from the main steam pipe so that pressure is always available. The valves *D D* are for feed regulation. The valves *E E* must be kept closed at all times while in operation, as they are ordinary gage valves. At *F F* are oil-feed pipes leading to the cylinders; at *G* is a ½-inch filling valve, on top of which is a funnel *H* containing a brass-wire screen for a strainer; the top of this funnel is closed with a leather cup to keep out dust and dirt. At *I* is a ¼-inch air vent to be opened when filling and also when draining out the water. Valves *J* and *K K* are to drain the body and sight feeds; all drains are piped together. At *L L* are sight-feed glasses. The part *M* acts as a ¾-inch condenser and pressure pipe. The highest point is 6 feet above the top of the oil reservoir. At $N N$ are ⅛-inch pipes on the inside of the reservoir, which extend to the top of the body of the lubricator; they connect to the feed-regulating valves D, the shanks of which are tapped out, and a short nipple and elbow screwed in and the long vertical pipe screwed into the elbow. To fill, after once in operation, it is only necessary to close the valve C and the feed valves D. The valves $E E$ serve another purpose beside holding the gage glass and, as mentioned, must be kept closed, as the pressure would immediately force the oil through them to the oil-feed pipes and empty the lubricator.

Where the steam cylinders are quite a distance from the lubricator, it would be better to run the oil-feed pipe from the top of the reservoir directly to the cylinder and place the regulating valve as in Fig. 2. It is also well to have the oil-feed pipes covered, especially if exposed to a cold draft, or where the pipe is rather long, as it may cause trouble by clogging with cold oil. When placing the independent sight feed, Fig. 2, directly on the cylinder or steam pipe, the same advantage of forcing any amount of oil directly into the cylinder in case of necessity is had but in a different way.

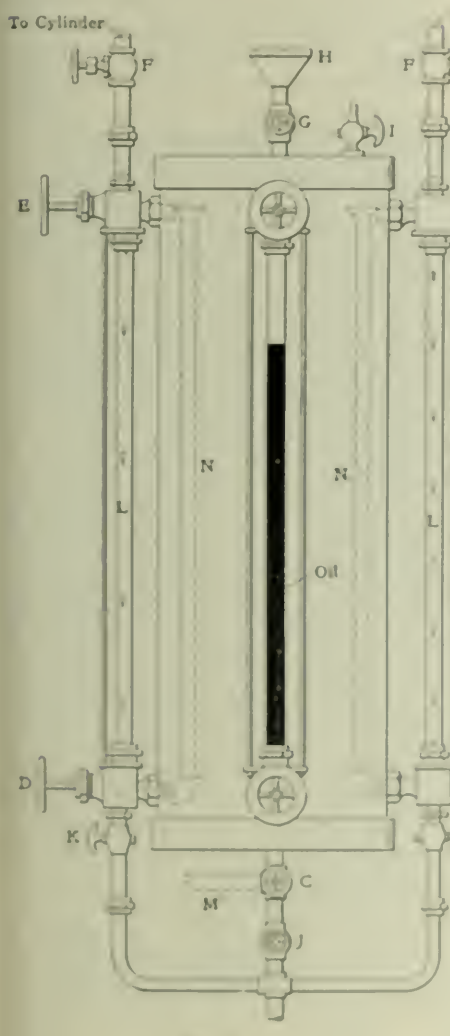


FIG. 1

FIG. 2

MULTIPLE-FEED LUBRICATOR

This action, however, is taken advantage of when first starting the engine or pump; or, in case a cylinder becomes dry for want of oil, any amount of oil can immediately be forced to any cylinder by opening the valve E for a few moments and then closing it again.

Another advantage of this lubricator is that any pipe, glass or drain can be blown out without interfering with any other part, as long as there is steam pressure.

In Fig. 2, is seen a steam pipe leading to the engine or pump; B is a valve placed in the oil-pipe line F, and is of any convenient size.

To operate, close the valve B and slowly open the top valve so as to fill the glass with water and leave it open. Then open the regulating valve D and adjust the oil feed. To flood the cylinder with oil, open the valve B for a moment.

A. J. Stone.

Cincinnati, O.

Mr. Sheehan's Motor Trouble

The cause of the trouble reported by Thomas Sheehan on page 1013 of the December 15 number may be readily explained by the fact that the motor in question had a compound winding on its field magnet. Such a motor has two field windings, one a shunt winding connected across the line, and the other a series winding which carries the entire armature current. It is customary to connect these two field windings so that they assist each other in building up the magnetic field. In this case, however, the series winding must be connected so as to oppose the shunt winding.

What happened was this: When the workman started the beater the clutch on the shaft was not thrown out quickly enough to prevent the motor from shutting down. It stopped, as stated by Mr. Sheehan, while still connected to the line. That would cause the motor to take a very heavy current through the armature and the series field winding, and the result would be that the voltage of the generator would drop off to a very low value. The motor at a standstill put almost a short circuit on the generator, and under these conditions the generator could not hold its voltage. The low voltage greatly decreased the strength of the current in the shunt field winding of the motor, while the current in the series winding was much stronger than normal; consequently, the series field winding was the stronger and reversed the polarity of the field magnet, causing the motor to run backward as soon as the clutch on the shaft was thrown out. The reversed direction and the heavy current would cause the motor to spark violently. The current would very speedily drop off as the motor gained speed, but the reversed direction of rotation would still account for the sparking, as the brushes were undoubtedly shifted backward somewhat for the correct direction of rotation.

The high speed was due to the fact that the motor was running as a series motor without load. It is to be further noted that the shunt field winding of the motor would gradually build up and as it opposed the series winding would still further weaken the magnetism of the poles. The voltage of the generator did not rise at once when the motor became unloaded because the field strength could not build up instantaneously.

If the attendant had allowed the motor to run a little longer it is possible that the voltage would have risen sufficiently for the shunt field winding to overpower the series field winding and cause the motor to stop and reverse again. But before doing so it would undoubtedly have reached a dangerous speed, so that the operator did the correct thing in opening the switches.

It is to be noted that this does not

count for the reversal of the meters, inasmuch as the large current would still flow in the usual direction as there was no action to reverse the generator. In fact, there seems to be no reason why the polarity of the meters should have been changed, unless the ammeter was of such a design as to become reversed by a large current. It is in fact very questionable whether the meters actually did reverse, for it is frequently reported that meters have become reversed when as a matter of fact the pointers are only stuck at one end or the other of the scale. I am not casting any reflection on the accuracy of Mr. Sheehan's statements, but merely suggest that an instrument may appear to be reversed when a more careful investigation will show that this has not happened. In the instance under discussion the voltmeter pointer would drop back practically to zero and might easily become caught at the lower end of the scale, due to the sudden swing, while the ammeter pointer would go off the scale at the upper end, and might stick there.

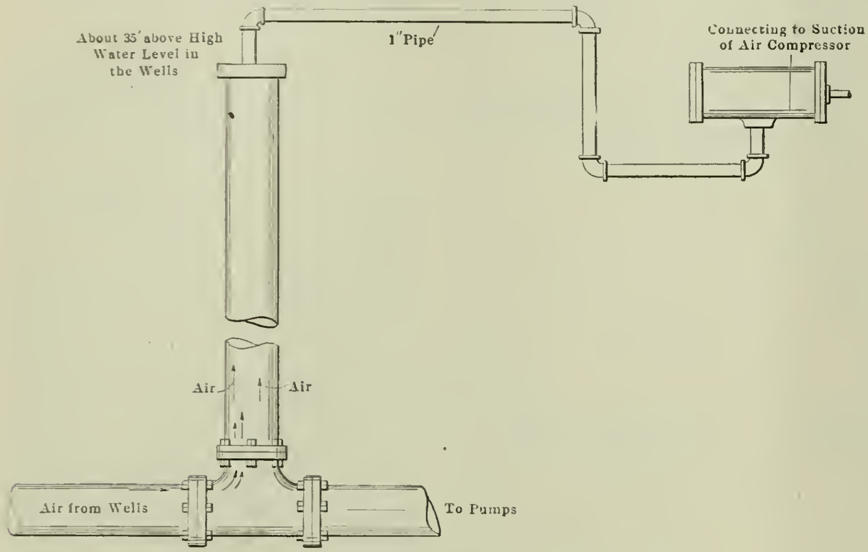
It might be of interest to Mr. Sheehan and the motor attendant to note that the connection of the series field winding as it now stands is not usually employed except where it is desired to maintain a very close speed regulation through all changes of load. The opposing influence of the series field winding causes decreased ability of the motor to carry a heavy load, and, just as has happened in this case, when the load becomes too heavy the motor will stop. By reversing the connections of the series field winding and making it assist the shunt winding the motor will be better able to stand up under severe load conditions and will also have better starting torque. The drop in speed from no load to full load will be greater than it now is, but in all probability this will not be objectionable.

S. A. Fletcher.

Wilkinsburg, Penn.

Air Pump Arrangement in a Pumping Station

While visiting a large pumping station recently, my attention was called to the arrangement shown herewith. The main suction line connects to 115 driven wells,



AIR-PUMP ARRANGEMENT IN A PUMPING STATION

the water level of which is ordinarily from 10 to 12 feet below the pumps, which are located in a circular pit about 25 feet below the level of the engine-room floor.

During the dry weather of last year the water level fell to such an extent that, on account of so many wells being connected, considerable air was drawn into the suction, causing the pumps to pound badly when any attempt was made to run them above half-speed.

Just outside the pump connections on the suction line was a tee having a vertical pipe 10 feet long capped on the end, which acted as an air chamber. This pipe was extended up level with the engine-room floor, making about 35 feet above the highest water level in the wells. The top cap was drilled for a 1-inch pipe to connect to the intake of a small steam-driven air compressor, which was not being used at the time. By running the compressor (or vacuum pump, as it was in this case) at a moderate speed, a 26-inch vacuum was maintained on the 1-inch line.

As all air coming from the well connections would naturally follow along the top of the suction line, it would pass up into the vacuum chamber and be removed through the compressor, leaving a solid body of water entering the pumps. Since making this arrangement no trouble has been experienced in operating the pumps at their full capacity.

S. Kirlin.

Fort Worth, Tex.

How to Set Brushes

There has been a discussion for some time relative to the proper way to set brushes on motors and generators. There seems to be a wide difference of opinion regarding this matter, which is probably due to the fact that each person in relating his experience has reference to the type of brush holder with which he is familiar, and as different types of holder require different treatment, there arises an apparent contradiction of one writer by another.

Some brush holders require brushes set *with* the direction of rotation of the commutator, and others require brushes set *against* the direction of rotation. In Fig. 1 is shown a brush holder of the first class, which must always be set as indicated by the arrow. If set in the opposite direction trouble will surely ensue, as an inspection of the figure will show, because the surface of the commutator and the brush would form a toggle joint, and the brush would tend to dig into the commutator and either break itself or bend the brush rigging.

In Fig. 2 is shown a brush holder of the other type which is used by one of the large manufacturing companies. This brush is set against the direction of rotation but an inspection of the cut will show that there is, in this case, no tendency for the brush to dig into the commutator surface.

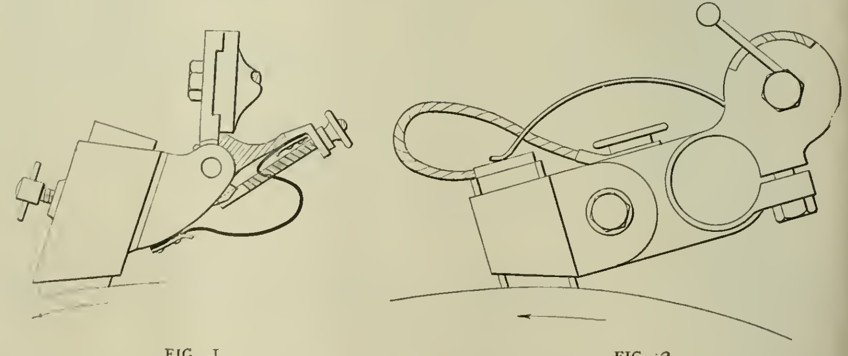


FIG. 1 FIG. 2

From the foregoing it is seen that no hard and fast rule for brush setting can be made, but each type of holder must be treated as recommended by the manufacturer of that particular type.

R. H. Fenkhausen.

San Francisco, Cal.

Capacity of Rectangular Tanks

By the use of the accompanying diagram the capacity of rectangular tanks may be found. Tables giving the cubic contents of this style of tank for 1 foot of depth will be found in many handbooks, but it is necessary to multiply this value by the hight of the tank to find the total capacity. The diagram also serves as a ready means for securing the dimensions of tanks of equal capacity.

The lines running upward from the lower left-hand corner to the right represent the width of the tank, and are so labeled. The lines running upward from right to left represent the hight of the tank. The lower margin gives the length of the tank in feet. The left-hand margin gives the capacity of the tank for 1 foot in depth, while the upper margin gives the total capacity.

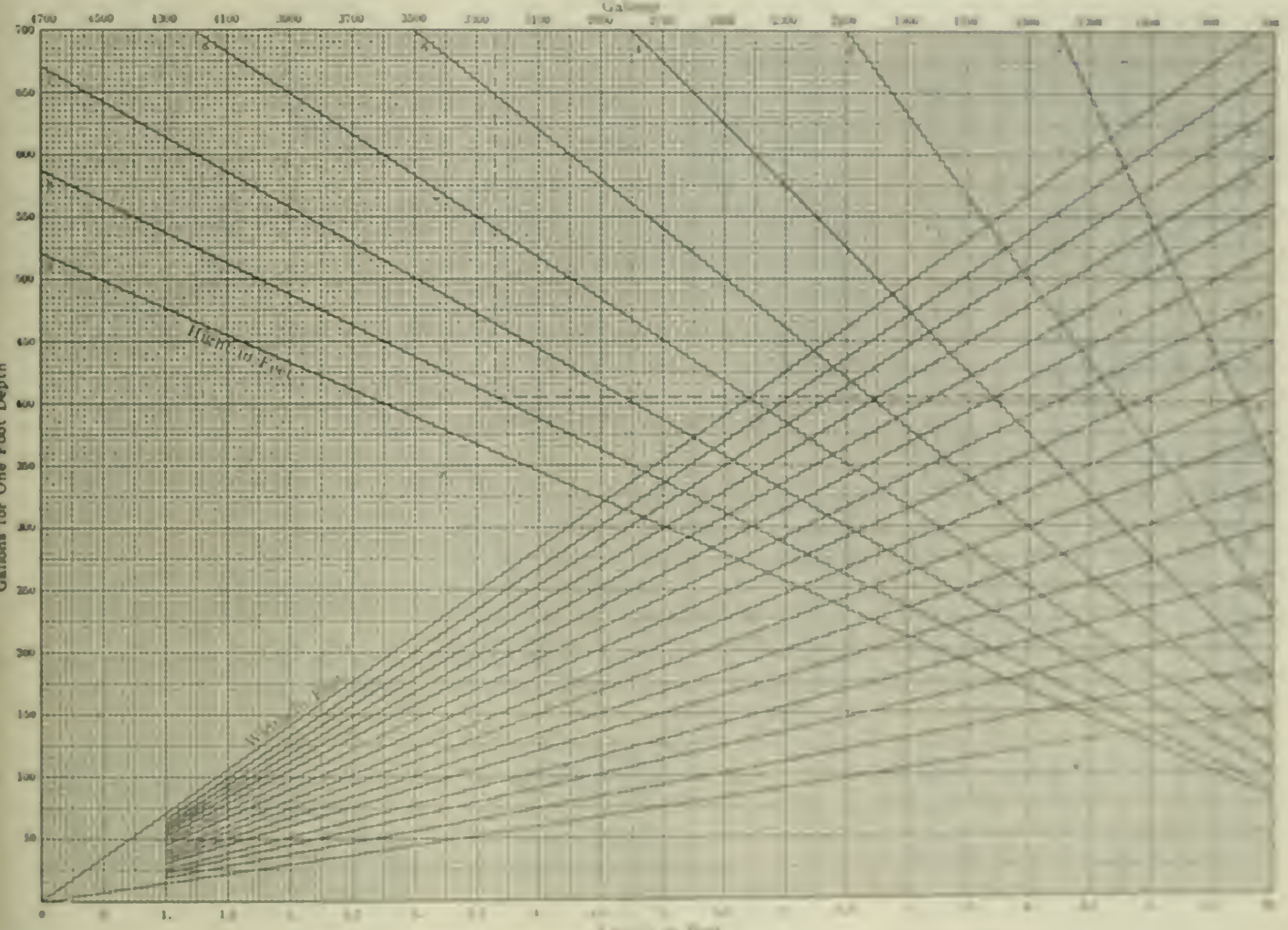


DIAGRAM GIVING THE NUMBER OF U. S. GALLONS IN RECTANGULAR TANKS

As an example, suppose the capacity of a 6x9x8-foot rectangular tank is required. The method of solving this problem is shown in dotted lines on the diagram. Starting with the length, 9 feet, project upward to the 6-foot line, across to the 8-foot line, then upward to the top margin, where the answer is found to be 3240 gallons.

The given capacity of a tank equals 3500 gallons, its hight is 7 feet and the width 7 feet; find the other dimension: Project down from 3500 on the top margin to the hight line, marked 7, across to the width line 7, and then downward to the lower margin, where the length is found to be 9.55 feet.

Suppose the capacity of a tank equals 3000 gallons, then the dimensions of tanks of this capacity are found by the chart to be 5x9.5x8.45 feet, 6x8x8.35 feet, etc.

John P. [illegible]

Aurora, Ill.

Cast Iron Crosshead Pins

F. L. Johnson stated, in an article in the December 8 issue, that "somehow it looks as if the whole family of engine makers has gone steel crazy and are using steel for everything under the sun, even where a moment's thought would show that for some purposes steel is the worst possible material that could be selected, and crosshead pins is one of these."

As the best engine builders use cast steel for pins, and steel pins can be worked at nearly double the pressure permissible with iron running at the same speed (Kent, page 801), I should like to ask Mr. Johnson to give his reasons for his statement, as I believe the same will be of interest to many engineers.

G. Hecklinger.

Portland, Ore.

[Mr. Hecklinger's letter was sent by Mr. Johnson to Mr. Sawyer, whose remarks were quoted in the article in question, and he commented as follows: "What I said about the use of steel referred entirely to crosshead pins, and my critic turns to Kent on crank pins, an entirely different matter, and the comparisons made there is between steel and wrought iron, and not between steel and cast iron. What I had in mind for crosshead pins was cast iron, which is not considered at all by the 'best engine builders' referred to by Mr. Hecklinger. These same engine builders make steel pins and bronze boxes for the crossheads, but in this [illegible] heavy [illegible]. These heavy pressures and the slow movements of the surfaces in the crosshead bearings. Lubrication is difficult and dangerous, and unless made of proper materials the wear is rapid. The coefficient of friction is greater between brass and steel than between any two metals used in machine construction, while with one of the [illegible] the coefficient of friction is low. Cast iron is more easily lubricated than any other metal, hence its amount of lubrication [illegible] is ample for a cast-iron pin may be, and usually is, insufficient for a steel pin. Not long ago I saw a cast-iron crosshead pin that had been in daily use for more than 25 years and the most careful measurements failed to detect any wear. I have never known of a hot or cut pin where cast iron was used, but have personally had several cut steel pins. I would use cast iron for crosshead pins because they run with less friction, are more easily lubricated, wear better and give less trouble than steel pins."—EDITORS.]

Engine Wreck Prevented by Quick Action

At our street-railway power station two cross-compound vertical engines are

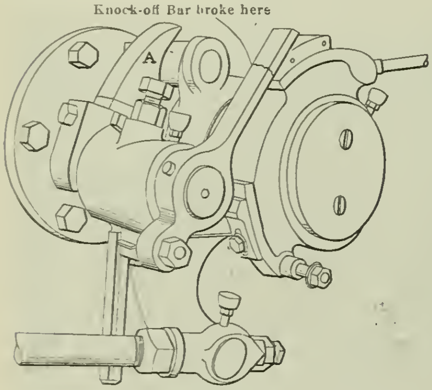


FIG. 1

equipped with the type of releasing gear shown in Fig. 1. Not long ago the knockoff bar broke, as shown in Fig. 1, and, dropping down, became wedged against the knockoff lever, as shown in Fig. 2, forcing the governor down to its lowest running position, when the engine would take steam at seven-eighths stroke.

The governor belt being intact, the idler pulley kept the lugs in contact with the

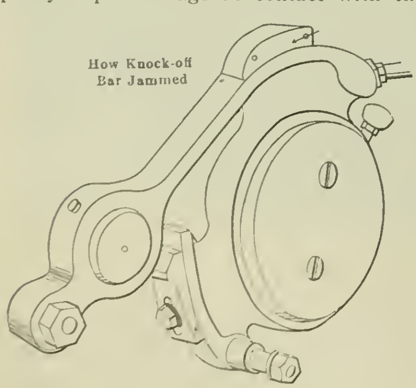


FIG. 2

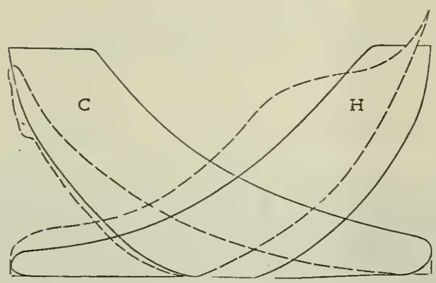
governor collar and prevented the governor from assuming its lowest position and bringing the safety cams into action. Of course, the engine started to race and only quick action prevented a wreck. The throttle-valve wheel is handled from the floor and the engineer was on the valve deck. Knowing that there was no time to come down in the ordinary way, he jumped from the upper deck to the floor and shut the throttle.

THOMAS SHEEHAN.

Pittsfield, Mass.

Faulty Indicator Diagrams

In a recent number, under the heading "Faulty Indicator Diagrams," a contributor asked what could be done to benefit the engine. The trouble is due to incorrect valve setting, and the only thing to do is to set the valves correctly.



CORRECT AND INCORRECT DIAGRAMS

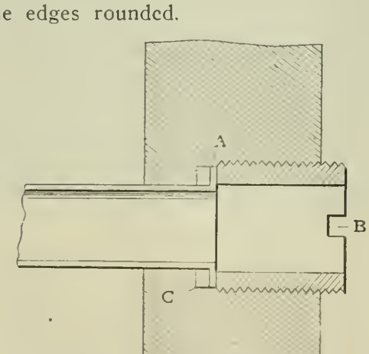
I believe the problem can be solved by plotting correct diagrams on the faulty ones to compare them. The illustration shows the full lines indicating the correct diagrams; the dotted lines the faulty ones.

E. J. FARKAS.

Detroit, Mich.

Condenser Tube Packing

The tubes of a surface condenser began to leak badly, and were repaired in the following manner: The tubes were annealed on one end and flanged over leaving a collar *A*. (See sketch.) The holes in the condenser head were bored and tapped with a radial drill press. Brass glands were made in the usual manner by the aid of an adjustable box tool, and the edges rounded.



REPAIR OF CONDENSER TUBE

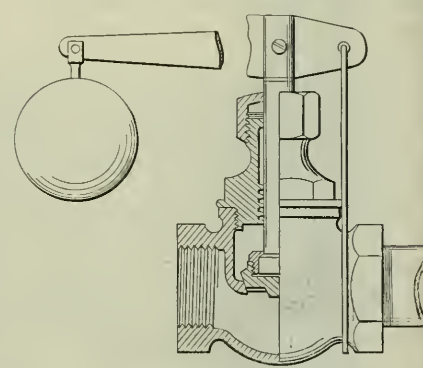
One end of each condenser tube was packed by placing a rubber gasket *C* underneath the collar of the tube, and the gland screwed down against the face of this collar. The other end of the tube was packed in the same manner as water-glass tubes, allowing the tube to pass through the gland, squeezing the rubber against the outside of the tube. This made an excellent job and for six years the condensers have not leaked.

SAMUEL KINSEY, JR.

Peoria, Ill.

A Homemade Relief Valve

Herewith is described the way I made a relief valve to put between a pump and a water motor. I got an old globe valve and, removing the stem, filed the threads off to make a smooth surface. A slot for the lever arm was then cut, and a hole drilled and tapped to receive a 5/32-inch button-head machine screw, as shown in the illustration. The lever was cut from a piece of 3/32-inch band iron and the



A HOMEMADE RELIEF VALVE

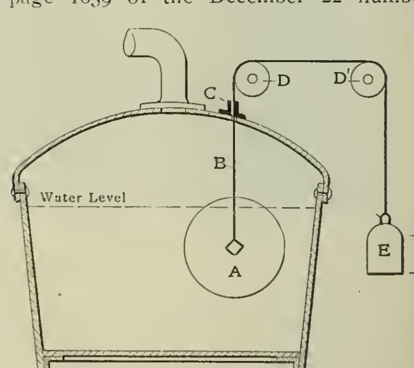
necessary holes drilled in it. The fulcrum was made from a piece of No. 8 wire, bending it in the middle where it passes through the lever, and securing it around the valve body, as shown.

A. C. GRANT.

Middlefield, O.

An Old Haystack Boiler

The article on the above subject on page 1039 of the December 22 number



A FLOAT-STONE WATER GAGE

interested me greatly. It seems a pity to let those old fellows rust but, of course, it is impossible to preserve all of them. The method of running the vertical seams straight instead of staggering each tier seems to me to be wrong. Mr. Maplethorpe says:

"There is no sign of gage cocks or water gage."

It is peculiar, for the only part of the half-tone which stands out by itself is probably all that is left, *outside* the boiler, of the water gage.

On top of the haystack boiler is an upright which supports a sheave. If this is what I take it to be then it is part of a water gage much used in the early days.

When Puffing Billy was used at Killingworth colliery in England, that is subsequent to 1813, these haystack boilers were used for raising steam for the winding engines. There was as a general thing either a platform or the brickwork built up around the boiler to near the hight of the water level. The engineer with his wooden-soled clogs would ascertain the level of the water by kicking the plate. The sound would tell him whether there was water or steam behind the part of the plate where he was tapping it with his foot. This was much the same as we tap a plastered ceiling or wall to find where the joists or studding are.

A later invention in the way of a water gage was evidently used on the haystack boiler referred to. It consisted of a piece of stone somewhat like a grindstone. Grindstones when worn small were often used for this purpose. These were called "float stones" and their application is shown in the accompanying cut in which *A* is the float stone and *B* is a copper wire, one end of which is secured to the float stone and the other end to the iron weight *E*. The wire passes up through the stuffing box *C* and over the two sheaves *D D*, *D* being the sheave shown in the half-tone. As the water "boiled down" the heavy float stone would lift the weight *F*. The relation of the weight *E* to the marks *X Y* showed the engineer where his water was.

If Mr. Maplethorpe will crawl inside that old boiler he will probably find an old float stone.

It is merely a question of specific gravity. In air the stone weighed more than the iron weight *F* but with the stone partly immersed in water the stone would balance the weight *F* in air.

C. A. Dunn.

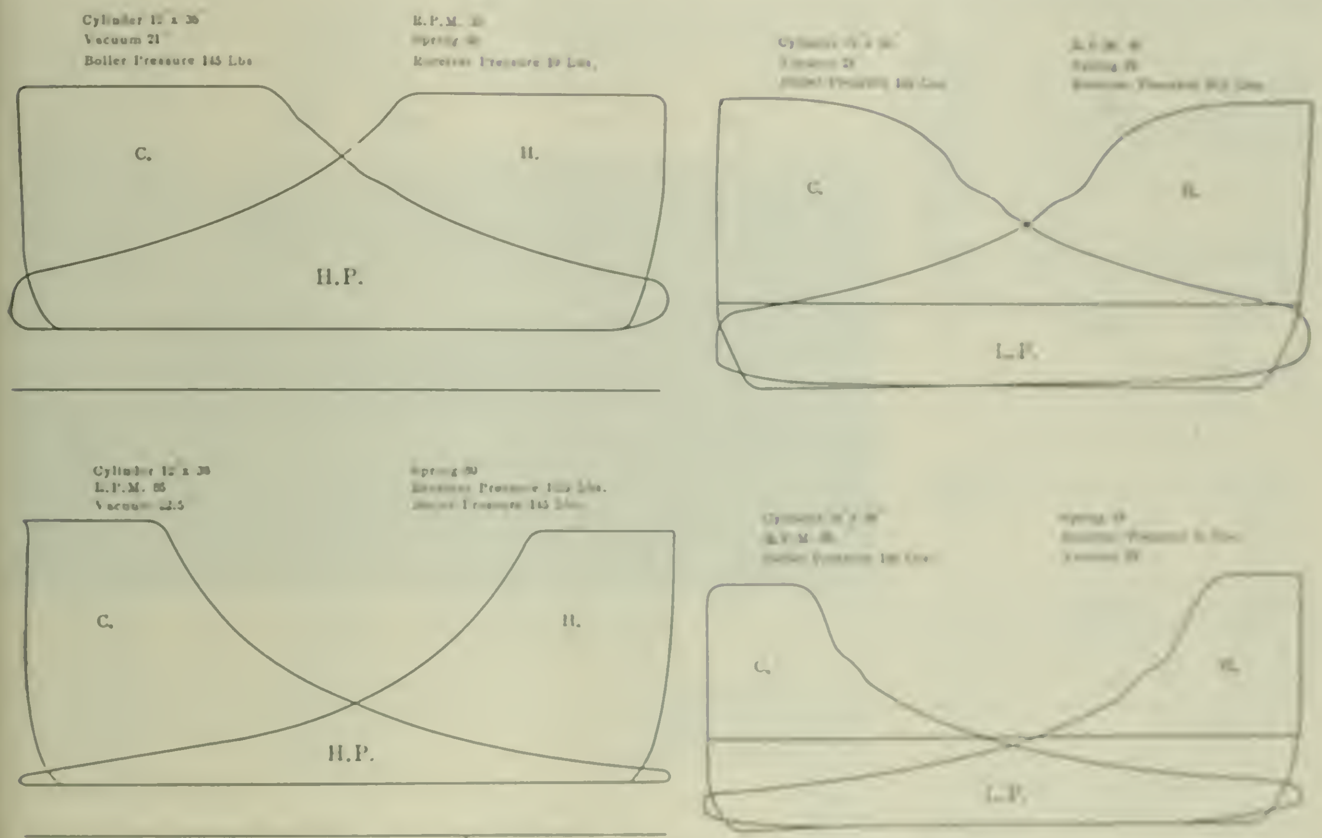
New York City.

that it can be done. I do hope Mr. Hall will not disregard such a question. I submit the accompanying diagrams from a Corliss 12 and 24 by 36-inch cross-compound condensing engine. While these diagrams do not figure quite the same horsepower on each side, I have taken diagrams where there was only a slight difference in the work done in both cylinders.

I should like to know the theory in putting a larger cylinder on an old engine frame when, by compounding, the steam is not only saved but the extra work is gratuitously done by the low-pressure cylinder for the same coal. It is true that by putting a larger cylinder on an old engine frame more power is obtained, but it will require more steam to do the extra work.

George W. Hanson.

Lexington, Neb.



DIAGRAMS FROM A 12 AND 24 BY 36-INCH CROSS-COMPOUND CONDENSING ENGINE

Compounding Engines

Recently in a letter entitled "Horsepower of Compound Engines," W. H. Wakeman says that some steam users think a compound engine develops twice the horsepower that a simple engine does, and that somebody ought to show them their mistake.

If it is not to increase the horsepower, why are engines compounded so as to do more work by using again the steam that has done work in the high-pressure cylinder?

Mr. Wakeman also challenges Mr. Hall to produce indicator diagrams to show

Gas and Boiler Explosions

Charcoal can absorb about forty times its own volume of "marsh damp gas" (the deadly agent in explosions). How can H. R. Cobb reconcile this fact with his theory for the explosion of his boiler, which was made of charcoal iron, as noted on page 1058 of the December 22 number?

J. E. Terrill.

New Haven, Conn.

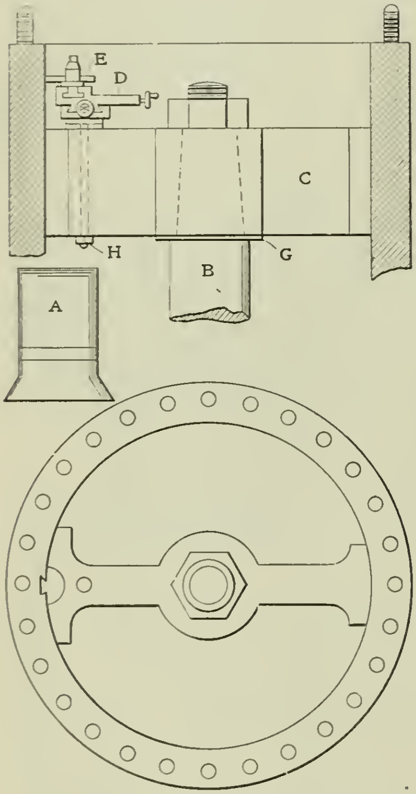
[illegible] "laughing gas" [illegible]

Pump Cylinder Repair

An accident happened to one of the high-pressure cylinders of a pumping engine, and as the pump was needed almost any moment, the owners looked for the quickest way to repair it.

The trouble was due to one of the sections of packing ring breaking and cutting a score the full length of the cylinder about ¾ inch wide and 5/16 inch deep.

Several machine-shop superintendents wanted to rebore the cylinder, but as this would necessitate a new piston, and



ILLUSTRATING A PUMP-CYLINDER REPAIR

considerable time, we gave up this idea and resorted to the following method:

An iron casting *C* was bored to fit the piston rod *B*, and turned to a nice sliding fit in the cylinder. A slide rest *D* was fitted to the top of this casting and held with the bolt *H*.

With this arrangement we planed a dovetailed slot in the cylinder, the full length, raising the piston rod by water pressure and lowering it by allowing the water to escape from the lower cylinder. The slot was planed as far down as could be with the slide rest on the top of the casting, and then we finished by placing the slide rest on the under side. Next a bronze strip was prepared the exact size of the slot and driven to the bottom of the cylinder. As this strip was rather slender and long it was soldered on a reinforcement at *A*. A washer *G* was placed under the casting *C*, so we could loosen the nut holding it, allowing it to turn without binding on the taper end of the rod.

By swinging this casting in a circular motion it was possible to plane off the excess metal to the same arc as the cylinder. This made an excellent job, and took but a short time to finish.

There was quite a discussion as to whether to cut the bronze strip off flush with the end of the cylinder or cut it off a little short, to allow for expansion, but finally it was decided that the best plan was to cut it off the same length as the cylinder and let the metal take up itself. This cylinder was opened again after running about one year and if the exact place where the strip was had not been known, it could not have been detected.

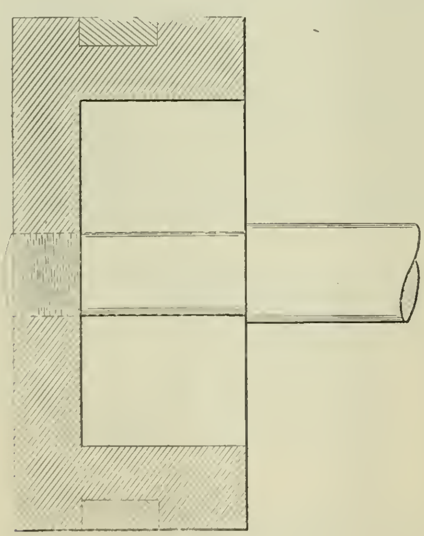
Samuel Kinsey, Jr.

Peoria, Ill.

What a Substitute Piston Did

A very dangerously designed piston rod which came to my notice recently partly wrecked a 26x51-inch Corliss engine, running 56 revoluions per minute.

The piston was 6 inches thick. The end of the piston rod was threaded for 1½ inches and engaged with a corresponding thread in the 1½-inch cast-iron follower plate, there being no thread in the piston spider. Instead of securing the rod with a nut, it was left flush with the follower plate. The strain on the cast-iron thread caused it to strip, allowing the piston to deliver a blow against the head, cracking it in several places, and as the momentum in the wheel forced the rod back it caught on the piston, breaking the



HOW THE PISTON ROD WAS PUT IN

crank. The cylinder was cracked by one of the thin steel packing springs being jarred out of place and wedging under the piston. A piece was broken out of the back side of the piston and was afterward found in one of the exhaust ports.

It may be said in favor of the engine builders that this piston and rod were not of their design. The original piston and rod having been put out of business by a dose of water, this freak piston was put in without the builders' knowledge.

R. F. Blanchard.

Fitchburg, Mass.

Indicator Stop Device

This device for taking indicator diagrams is somewhat unusual. It consists of a ½-inch board, 42 inches long and 6 inches wide. The upper end swings on a

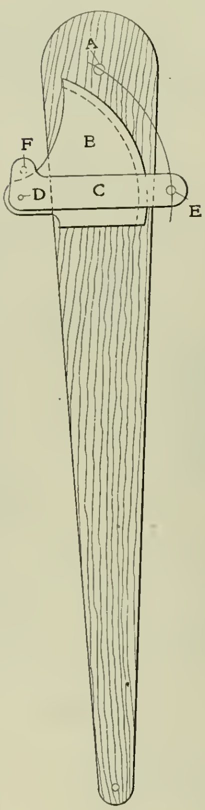


FIG. 1

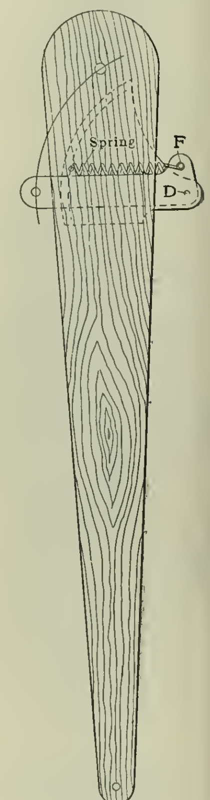


FIG. 2

pivot at *A*, Fig. 1; the lower end has a projection which swings in a block, sliding on a spindle fastened to the crosshead. A piece of iron *B* is placed over a ½-inch board of the same shape, but does not come quite to the edge at the curved part. Both are fastened to the main board. A lever *C* is attached at *D* with a joined spring at *F*, as shown in Fig. 2.

The indicator cord is attached to a projection at *E*.

When desiring to put a new cord on the indicator diagram, a string running to another projection back of *E* may be pulled through the groove left between the main board and the iron *B*, which will bring *E* in line with *A*, and all motion of the indicator will cease.

In making this device it is necessary to locate the point *E* down from *A* according to the length of diagram desired and to place *D* so that when *E* is pulled up it will come exactly over *A*.

Bert E. Evans.

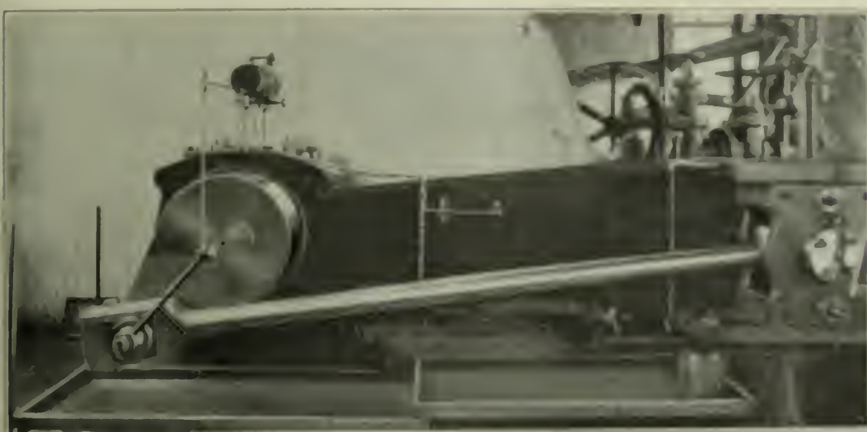
Springfield, Mass.

An Oiling Device

The accompanying photograph is of an oiling device attached to the frame of our engine. The oil tank above the main pillow block was originally a piece of 6-inch iron pipe. It has a head welded in at either end. A gage glass is attached to show the amount of oil in the tank. The front oil guard of the engine has been removed so as to give a better view of the arrangement.

The pump is fastened directly to the front side of the engine frame and connected to the rocker arm from which it derives its motion.

After the oil has lubricated the various bearings and drops into pans, as shown,



THE OILING DEVICE ATTACHED TO ENGINE FRAME

it runs into the filtering tank just below the pans, where all sediment is removed and the oil used over and over again.

F. H. JANNEY.

Minneapolis, Minn.

Calculation of Cooling Surface for Surface Condenser

The article by C. L. Hubbard, on condensers, in the December 22 issue, attracted my attention, and I wish to offer some comments on the calculation of cooling surfaces. Attention should be directed to the analysis of the formula

$$S = \frac{W\ L}{180\ (T - t)},$$

where L is the latent heat of the steam at condenser pressure. This, at the outset, assumes that the steam is saturated at the condenser pressure but, as will be shown, this is not so.

Assume an engine exhausting to the atmosphere against a back pressure of 2.3 pounds, gage, and also an engine using 30 pounds of steam per indicated horsepower at a pressure of 80.3 pounds, gage. The total heat for 30 pounds is, therefore,

$$30 \times 1180.7 = 35,421$$

B.t.u. One horsepower corresponds to 33,000 foot-pounds per minute, or

$$\frac{33,000 \times 60}{778} = 2542$$

B.t.u. per hour.

The heat in the exhaust equals the total heat taken in minus the heat transformed into work. Using the above figures, these

$$35,421 - 2542 = 32,879$$

B.t.u. above 32 degrees.

Looking in the steam table, it is seen that the total heat in the steam at 2.3 pounds gage pressure is 1148.9 B.t.u., and

$$1148.9 \times 30 = 34,467$$

B.t.u. The error is, therefore,

$$\frac{34,467 - 32,879}{34,467} = 0.046$$

or 4.6 per cent; and radiation would tend to increase it.

Taking the case of a high-economy engine using 11 pounds of steam per indicated horsepower at 175.1 pounds gage pressure and exhausting into a condenser at 28 inches vacuum, and applying the same method as before, the total heat equals

$$11 \times 1197 = 13,167$$

B.t.u. The heat left in the exhaust equals

$$13,167 - 2542 = 10,625$$

B.t.u. The heat corresponding to saturated steam at condenser pressure equals

$$11 \times 1114.4 = 12,258$$

B.t.u. The error amounts to

$$\frac{12,258 - 10,625}{12,258} = 0.133$$

or 13.3 per cent.

By using higher economy and lower condenser pressures the figure reaches above 15 per cent, as can be seen by working out the necessary example. This error is too large to be neglected in scientific investigation, and a rational formula should take this into account.

I also take a different view as to assuming the ratio of heating surface of the boiler to the cooling surface of the condenser. I think Professor Thurston was the first to express this ratio, but the idea is entirely too crude and inaccurate to be propagated.

The methods of computing the total heat as illustrated may be objectionable to some, on account of the uncertainty in the data on the transmission of heat through the plates. The experiments usually quoted are those of Joule and Isherwood. However, they are far from the actual conditions that exist in a condenser. The rapidity of the cooling water passing through the tubes affects the rate of absorption; the higher the velocity the higher the absorption.

To my mind the rational formula should be based on actual conditions, theoretically correct, and then multiplied by a factor expressing the efficiency as a cooler.

ALPHONSE A. ADLER.

Brooklyn, N. Y.

Method of Setting Gas Engine Valves

Nearly all directions for setting valves give certain crank angles at which the valves should open or close. The cams having fixed contours allows of adjustment only by varying the relative lead or lag and the amount of clearance or lost motion in the connections. It follows, then, that with a certain clearance the closing of a valve becomes fixed as soon as the opening is fixed, or vice versa. Too much clearance not being desirable, it is limited to a small amount, and the smaller the error limited in the adjustment.

The placing of the flywheel at definite crank angles requires measuring of angles, or the use of trams, which should have already been marked on the wheel. Why not give definite piston positions, and set the valves when the piston is at those positions? Marks may be made on the guides at the right places, or measurements may be taken from the piston to some fixed point. Then the inlet should close when the piston has moved back a certain distance, and the exhaust should open when the piston is at a certain distance from the end of its stroke. With the piston placed at a given position the inlet valve is set to close. It will open at the right time if the clearance is set right. With the piston in another position, at the proper stroke, the exhaust valve is set to open and will close at the correct time with the clearance set right.

R. W. [illegible]

Baltimore, Md.

What Knocked the Cylinder Head Out?

Some time ago both cylinder heads of an Atlas automatic cutoff engine were knocked out, the wrist strap pulled apart and the connecting rod badly bent.

The piston was fitted with rings, made in three sections with a lap joint and a brass bushing and a coiled spring under each joint. One of the sections began to rattle one day and an examination showed that the rivets had worked loose. We repaired them and replaced the rings.

As the engineer was putting the piston in place the "boss" came around and, noticing the way he was placing the rings, told him they were wrong, stating that the bushings and springs should be in the center of each section instead of at the joint. As one-half of the outer rings travel over the counterbore in this type of engine, it may account for the trouble.

The bushing being in the center of each section may have allowed the sections to rock, thus letting one end of a section extend out far enough to catch in the counterbore, when the velocity of the flywheel pulled the wrist strap apart, carrying the crank and connecting rod around, the connecting rod striking the crosshead, knocking it through the crank-end cylinder head and the piston out through the head-end cylinder head.

W. A. Hamlin.

Paola, Kan.

Firemen's Conditions Should Be Improved

While the many developments in boilers, engines and their accessories have placed greater responsibility on engineers, there has been, to a great extent, corresponding improvement in the status of the engineers themselves.

Passing over the question of salaries, the average engineer nowadays has privileges, and his comfort and convenience are consulted to an extent unthought of in the old times. These things had to come and will continue to come in the natural evolution of events.

But what of the fireman? Happening in a boiler room recently, just as watches were being changed, the engineer made the remark to me that "there are two dandy firemen." Yet as we talked these firemen were washing in a greasy pail, and their street clothes hung, exposed to ashes and dirt, on the bare wall.

In another plant, wagons deliver fuel directly from a driveway, along the whole front of the boiler room, which is practically wide open all the time. The fuel is dumped on the floor along the boiler fronts, leaving but a small space for the firemen to stand in while at work.

What, then, of the average stationary fireman? Is his life made any easier, does he get any more thought from employers than he did twenty years ago?

W. Auld.

Milwaukee, Wis.

An Unusual Crank Shaft Repair

The engine on which the herein described repair was made is a 600-horsepower, 18 and 36 by 36-inch, cross-compound condensing engine, side crank on the high-pressure side and center crank on the low-pressure side, direct-connected to an 8-inch line shaft on the low-pressure side. The rather unusual design of this engine, the first of its type put out by the builders, made it a subject of much interest and attention. It was prophesied that it would run warm on the low-pressure side, but the engine was on duty 150 continuous hours per week for more than a year, and after the first night evidenced no cause for uneasiness, running but a trifle warm after this hard service.

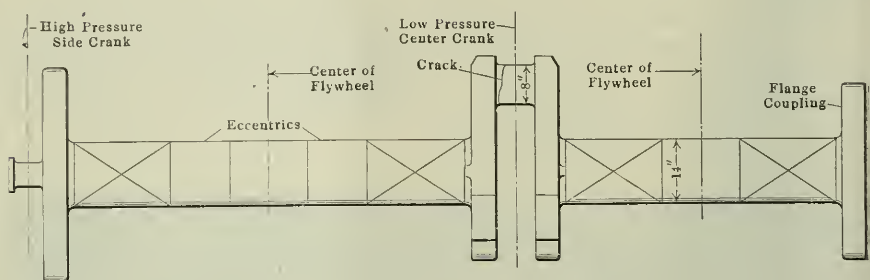


FIG. 1. SHOWING THE LOCATION OF THE CRACK

Needless to say, then, that after a little over a year's time the superintendent was astonished to find, upon taking out the center-crank connecting-rod brasses for examination, a small and almost imperceptible crack on the surface of the center-crank pin, running about ⅝ of the way around the pin, as shown in Fig. 1. The extent of this crack, after being drilled in for ½ inch or so, and examined by representatives of both the builders and the plant, was still only a matter of conjecture. The question to be solved was how to make the repair with the least possible interruption to service, and at the same time at a cost which should not be prohibitive. A new crank shaft being out of the question, and those in charge not knowing sufficiently well the staying qualities of thermit welding, it was decided to adopt the following method, which proved entirely satisfactory:

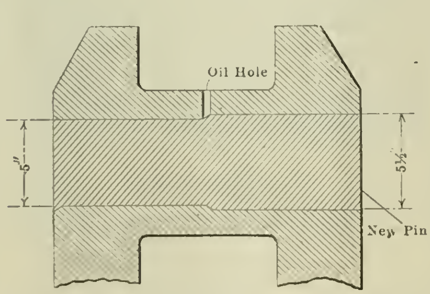


FIG. 2

The pin was drilled through as shown by Fig. 2, leaving the original pin as a shell. The bore was made 5½ inches on one end and 5 inches on the other, thus leaving a ¼-inch shoulder, so that when the pin was drawn in against the shoulder, the small end could be riveted into the countersink, flush with the cheek of the crank, thus preventing side motion on the part of the pin, and at the same time serving to draw the crack together. The shoulder was made to come midway the length of the pin, so that the confined air would not cushion against the shoulder, but would escape through the original oil hole. It was a drive fit, the crank cheeks being warmed and the pin pulled in with a stud at the small end and driven in at the large end at the same time.

The method of boring out is also of interest. A timber superstructure was built up above the crank shaft, the ends being supported by the flywheel on either side and an old lathe head, rigged up with a self-feed, was inverted and bolted to the timber work. The distance between the crank cheek and flywheel did not permit the headstock being set upright in the usual position, as the feed works interfered with the hub of the flywheel, hence the necessity of inverting it.

The first drill was made with an 1¼-inch twist drill and after being redrilled to 2½ inches a regular boring bar was used in the usual manner. A small 1½-horsepower vertical engine was used to drive the lathe head. More than six months have passed and everything seems to indicate the entire success of the repair.

L. C. Blake.

St. Louis, Mo.

The fourteenth entertainment and ball of the Eccentric Firemen's local union No. 56, I. B. of S. F., of New York City, will be held at the Grand Central Palace, Saturday evening, January 23. Aside from the entertainment program, as usually provided by the best professional talent, there will be a special four-hand reel exhibition and exhibition drill by the Eccentric Firemen's Fife and Drum Corps. The proceeds of the occasion will be turned into the death-burial fund.

Transmission of Power by Leather Belting*

A Diagram Giving, without Calculation, the Size, Speed, Capacity, etc., of Belts, Including Effects of Slip and Centrifugal Force

BY CARL G. BARTH

The common assumption that the sum of the tensions on the tight and slack sides of a belt remains constant was shown to be a fallacy by Wilfred Lewis in 1886.** The coefficient of friction between the belt and the pulley varies greatly with the velocity of slip, and the centrifugal force of the belt has a great deal of effect. The accurate calculation of the size or capacity of a belt is, therefore, a much more complicated matter than the allowance of so many feet per minute of belt to the horsepower, even when the latter calculation is modified to allow for angle of contact.

Mr. Barth has evolved formulas covering all of the variables and enabling him to construct the diagram shown on pages 170 and 171, the nature and use of which can best be described and illustrated by working out a couple of examples.

EXAMPLE 1. The maximum cone step on the countershaft of a lathe is 22 inches in diameter and wide enough to carry a 5-inch double belt. The speed of the shaft is to be 300 revolutions per minute. Assuming the thickness of a 5-inch double belt to be [illegible] of an inch, and the arc of contact of the belt to be 180 degrees: (a) What pull can the belt be counted on to exert, and what horsepower will it transmit with this pull? (b) Under what initial tension will the belt have to be put up and retightened from time to time? (c) And what minimum initial tension must it not be allowed to fall below to insure the above-determined pull without undue slip?

Solution. To get the answer to question (a), we first turn to the small bottom portion of the diagram plate, and on its right-hand side note the point reading 300 revolutions per minute. From this we pass horizontally to the left until we intersect the vertical line from the point reading 22 inches on the scale of pulley diameters at the bottom line of the diagram. From the point of intersection we follow the diagonal line upward to the bottom line of the main portion of the diagram, and there read the velocity of the belt to be about 1700 feet per minute. The points of intersection referred to have been indicated upon the diagram by small circles.

We now note the point that corresponds to this belt speed of 1700 feet per minute in that scale on this same bottom line of the main diagram which is marked "Velocity for Pull of Machine Belt" and interpolate a vertical line extending upward from this point. (The circle between 1600 feet and 2000 feet, about the middle of the left-hand diagram is at the bottom of this line.) Then leaving this for the time being, we turn to the extreme left-hand portion of the diagram and there note the point corresponding to the belt thickness [illegible] inch on the vertical scale to the extreme left, and also the point marked 5 inches on the scale of belt widths at the bottom of the diagram. Following from these two points, respectively horizontally to the right and vertically upward, until they intersect, we now follow the diagonal from this point of intersection, until it terminates against the

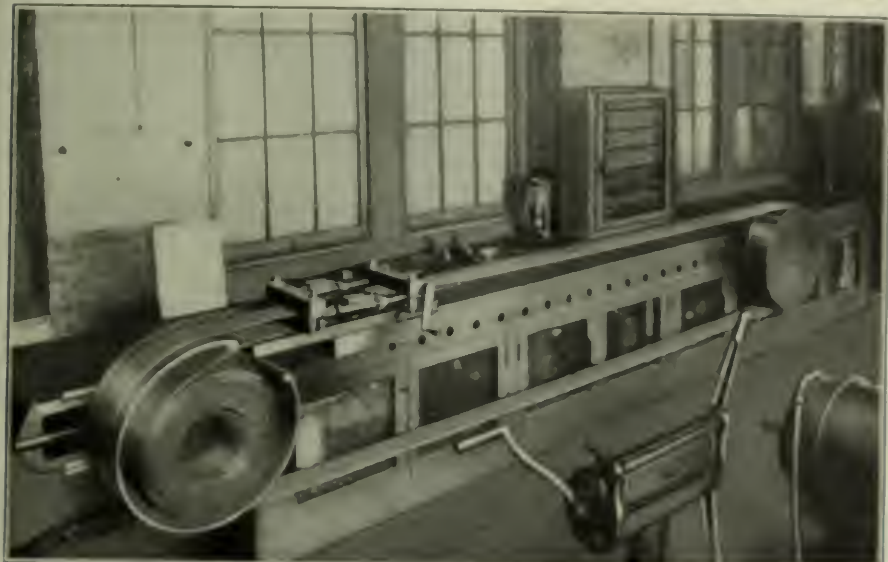


FIG. 1. BELT-BENCH IN THE SHOPS OF THE LINK BELT COMPANY, NICETOWN, PHILADELPHIA. THE USE OF THE BELT SCALES IS SHOWN IN DETERMINING THE LENGTH OF A NEW BELT

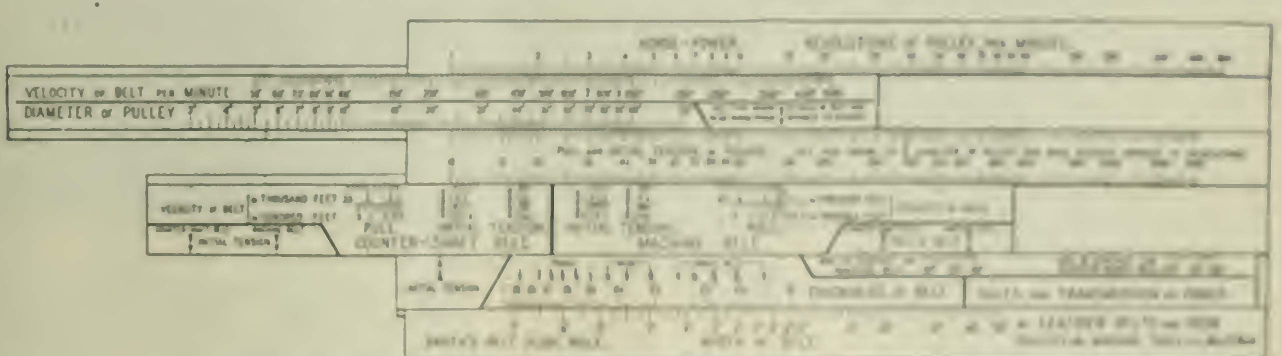


FIG. 2. [illegible] FOR THE MORE CONVENIENT SOLUTION OF BELT PROBLEMS GIVEN BY THE DIAGRAM

**Proc., A. S. M. E., Vol. VII, p. 549.

*Abstract of paper presented at the monthly meeting January 12, of the American Society of Mechanical Engineers.

vertical line marked 140 degrees and then the new diagonal until it intersects the vertical marked 170 degrees at the top of the diagram, in the field marked "Arc of Contact," and then continue horizontally until we intersect the interpolated vertical line for the belt speed 1700 feet already noted.

From the point of intersection we follow the diagonal upward and to the right until we meet the vertical scale of pounds, on which we now read the belt pull to be 140 pounds; and continuing horizontally until we meet the vertical line extending upward from the point corresponding to the belt speed originally found on the scale of belt speeds in this section of the diagram, and from this line diagonally to the vertical scale of horsepower, we read off the horsepower transmitted to be 7.2.

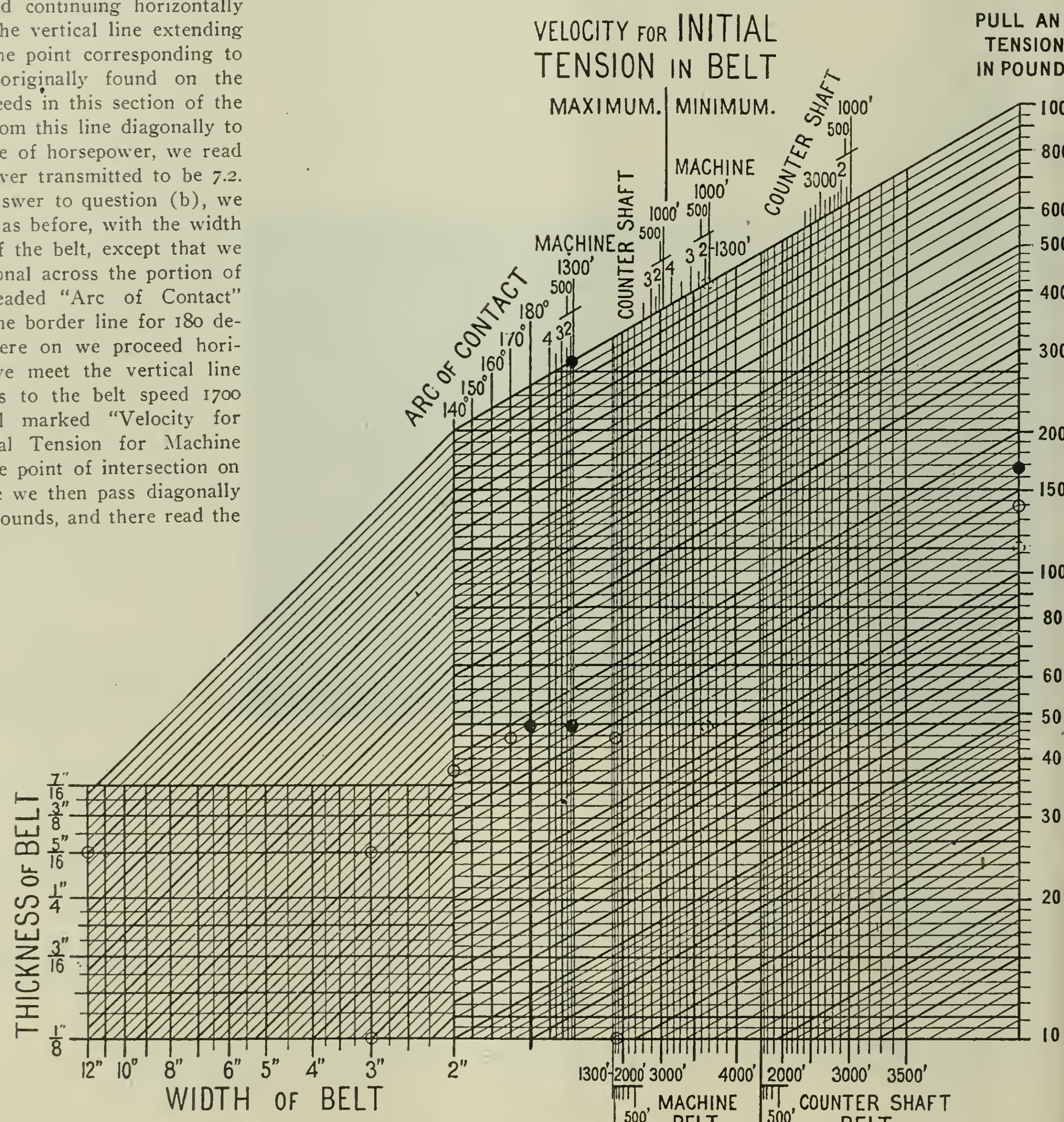
To get the answer to question (b), we proceed exactly as before, with the width and thickness of the belt, except that we follow the diagonal across the portion of the diagram headed "Arc of Contact" until we meet the border line for 180 degrees. From here on we proceed horizontally until we meet the vertical line that corresponds to the belt speed 1700 feet in the field marked "Velocity for Maximum Initial Tension for Machine Belt." From the point of intersection on this vertical line we then pass diagonally to the scale of pounds, and there read the maximum initial tension to be 168 pounds. Those movements for this solution on the diagram that differ from those for the answer to question (a) are indicated by little filled-in circles around the various points of intersection noted.

For the answer to question (c), we proceed in every respect as we did for question (b), except that we, of course, proceed from the point corresponding to the belt speed 1700 feet in that field of the scale on the top line of the diagram which is marked "Velocity for Minimum Initial Tension for Machine Belt." The answer read off on the vertical scale of pounds is 113 pounds. The movements for this solution on the diagram that differ from those for the answer to question (b) are indicated by little dotted circles around the points of intersection.

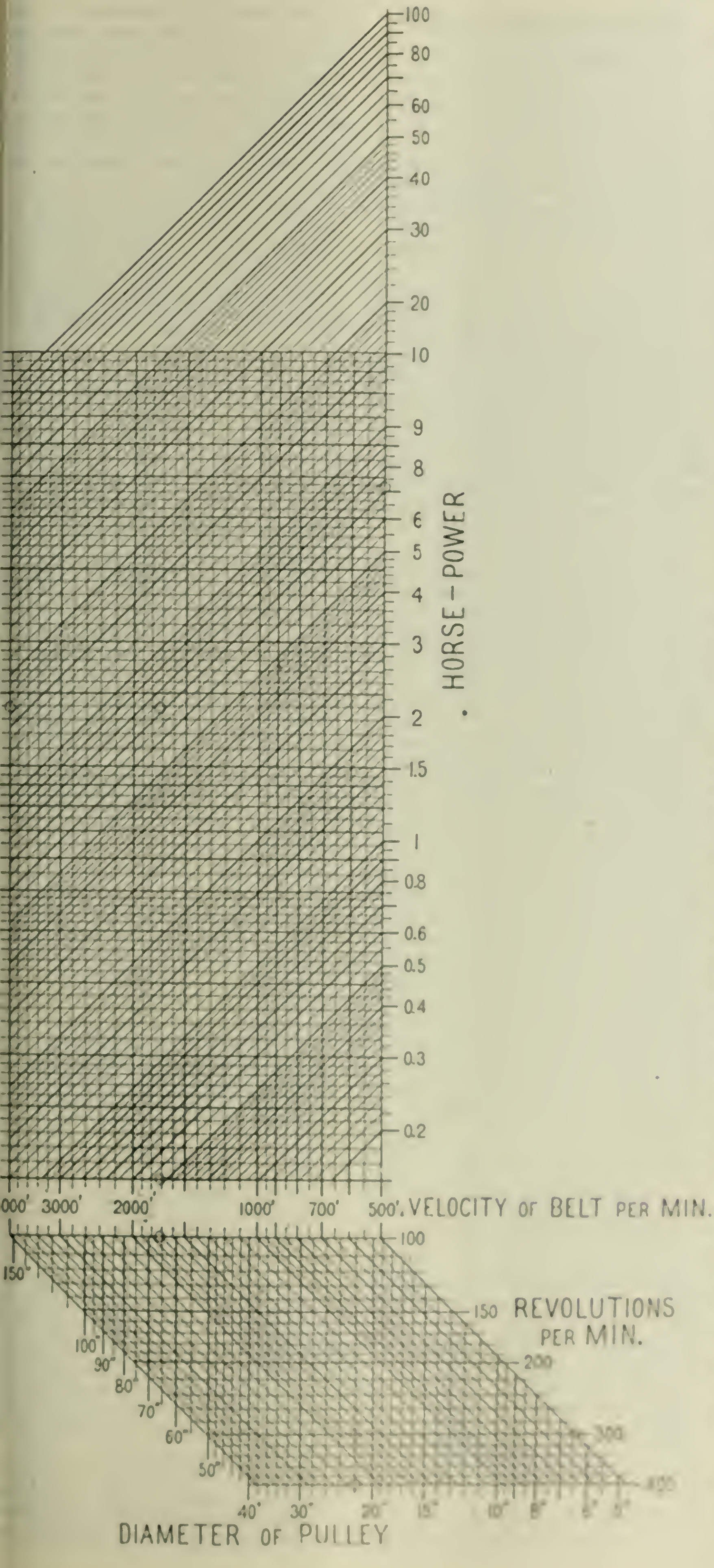
EXAMPLE 2: The countershaft in Example 1 is to be driven by a belt to run at a speed of 3000 feet per minute. (a) What diameter of pulley is required to give this belt speed? (b) What pull must the belt transmit? (c) What width of double belt must be used? (d) And what will be the initial tension under which the belt must be put up, and to which it must be again retightened after falling to the minimum? (e) What will be its minimum tension?

Solution: (a) As the countershaft is to make 300 revolutions and the belt is to run at 3000 feet per minute, we turn to the small diagram at the right-hand bottom corner of the main diagram, proceed horizontally to the left from the point marked 300 on the scale of revolutions on the right, until we meet the diagonal line from the point marked 3000 on the horizontal scale of velocities. From the point of intersection we then go vertically down to the scale of pulley diameters, and there read off 38 inches as the nearest even diameter.

(b) To get the pull of the belt we remember that the cone belt was found in Example 1 to transmit 7.2 horsepower. We therefore note that point on the vertical scale of horsepowers at the extreme right of the main diagram which corresponds to 7.2, and then follow the diagonal from this point toward the left, until we meet the vertical line extending up from the point marked 3000 on the scale of velocities on the bottom line of this portion of the diagram. From this point of intersection we continue horizontally to



VELOCITY FOR PULL OF BELT



the left to the vertical scale of pounds, on which we then read off the pull 80 pounds.

(c) From the point corresponding to these 80 pounds we now continue diagonally to the left until we meet the vertical line extending up from the point corresponding to the belt speed, 900, on the scale marked "Velocity for Pull of Countershaft Belt" at the bottom of this central portion of the main diagram. From this point we continue horizontally to the vertical line corresponding to the arc of contact, which, not being given, we will assume as 180 degrees, and then again diagonally to the extreme left-hand section of the diagram. Any combinations of width and thickness from points in the diagonal along which we are now moving, will then give a proper belt, and assuming as in Example 1 a thickness of 3/16 inch, we find the width to be 3½ inches.

(d) To find maximum initial tension for this belt, we proceed exactly as in Example 1, except that we use the scale marked "Velocity for Maximum Initial Tension for Countershaft Belt" at the top of the middle section of the diagram, and then read this off on the scale of pounds as 137 pounds.

(e) Similarly, we find the minimum initial tension to be 67.2 pounds.

In his paper "Notes on Belting,"* F. W. Taylor referred to belt clamps provided with spring balances for weighing the tension in a belt. In the case of endless belts these scales are put directly on a belt in its final position over its pulleys, while in the case of a belt with wire lacing, this is cut to length under the required tension on the specially designed belt bench illustrated in Fig. 1. As will be seen, this bench is provided with a pair of pulleys which can be so adjusted that a tape line will measure the same around these pulleys as over the pulleys on which the belt is to run. A belt cut and laced to give a certain tension when the bench pulleys have been properly adjusted, will then be of a length to assume the same tension over its own pulleys.

This indirect way of securing a desired tension in a belt was first suggested by our fellow member, Gideon [illegible], who also made the drawings from which the first bench and the first improved belt scale were made by the Bethlehem Steel Company in the year 1900.

To sum up, the writer's work on the subject has mainly consisted of the following:

(a) To establish a mathematical formula for the relation between the tension in a belt and the stretch due to that tension, based on experiments made at different times by Wilfred Lewis, Fred. W. Taylor and himself.

(b) By means of the knowledge of the elastic properties of leather belting, explained by this formula, to develop a formula

*Trans. A. S. M. E., Vol. XV, p. 204.

mula for the relations between the tensions in the two strands of a belt-transmitting power. which formula takes account of the influence of the sag in a horizontal belt, and agrees substantially with the results of the experiments made by Mr. Lewis, when plotted in the manner first done by Professor Aldrich.

(c) To establish a formula to express the relation between the coefficient of friction between a belt and a cast-iron pulley, and the velocity with which the belt slips or slides over the pulley, as revealed by plotting the results likewise obtained by Mr. Lewis.

(d) The construction of a diagram embodying the formula expressing the relation between the two tensions in a belt, the well-known formula for the loss in effective tension due to centrifugal force, and the likewise well-known formula for the ratio between the effective parts of the two tensions, as determined by the coefficient of friction and the arc of contact of the belt on its pulleys. These formulas are so correlated on the diagram that problems dealing with the contained variables may be solved graphically, while a direct algebraic solution is possible only for a vertical belt, or what is the same thing, by neglecting the effect of the sag of a horizontal belt. A plate containing this diagram accompanies Mr. Barth's paper.

(e) Also by means of the better knowledge gained of the elastic properties of leather belting, to develop a formula for the creep of a belt on its pulley due to the difference in the tensions in the two strands, along the lines outlined by Professor Bird in his paper on "Belt Creep," read at the Scranton meeting in 1905.

(f) The construction of diagrams showthe pulling power and other relations of the two tensions of a belt of 1 square inch cross section and 180 degrees arc of contact at different speeds, under certain conditions and assumptions recommended by the writer. Also a modification of these diagrams for extended practical use, on which may be read off: (1) The pulling power of a belt of any width and thickness and any arc of contact, between 140 and 180 degrees: (2) the initial tensions below which the belt must not be allowed to fall in order to confine the slip and the consequent loss of efficiency of transmission within certain limits; (3) the initial tension to which it is recommended that the belt be retightened after falling to this minimum limit. (Plate 2 of the paper, reproduced herewith.)

(g) Finally, the construction of a slide rule serving the same purpose as the diagram just mentioned, but which is much handier than the diagram. See Fig. 2.

An exchange states that sileo-vanadium steel is now used in making transformers, as on account of its improved magnetic quantity it decreases the core loss.

The Effect of Steam Jacketing

To the Editors:

I inclose a copy of a letter written to Bryan Donkin, of London, with whom I had numerous interviews when he was upon the Continent.

This letter is interesting from the theories which are there brought out and which have since been recognized as correct and largely applied.

H. Bollinckx.

Brussels.

M. Bollinckx' Letter to Mr. Donkin

I am in receipt of your kind letter of the second instant, and have just finished reading the pamphlets which you inclose.

I conclude, firstly, that the marine machines are not very economical, as I have always thought, and of which I have had proof in my own country in a compound vertical machine of 500 horsepower consuming nearly 10 kilograms (22 pounds) of steam per horsepower-hour.

All that you say in your paper is perfectly correct according to my idea, and it is by following these ideas that I have constructed my engines for a long time:

(1) The admission of the steam at the top of the jacket in order that the water shall be thrown to the bottom of the jacket and that the cylinder shall be freed from drops of water.

(2) Surfaces carefully polished in order to diminish initial condensation.

(3) The smallest amount of surface possible in the presence of the entering steam, and these surfaces well polished as above stated.

(4) To diminish, if possible, the clearance space; but I attach less importance to this last point.

As I have written you before, I try to make my cylinders as thin as possible, and it is for this reason that I use the heavy reinforcing rings in order to give them the necessary strength. I am going to use the same thing for the heads of my cylinders, and even for the pistons. I am going to heat the pistons, as M. Berger-André, of Thann, has done, as the reason that I have for heating the cylinder wall is the same as that for heating the piston, and it is only the difficulty of heating the latter which has delayed my doing it up to the present. But within the last six months I have been able to obtain tubes strong enough so that I could make a hollow piston rod by which I will introduce the steam, and into which will pass a second tube for taking out the water of condensation. M. Berger-André has obtained in this way an economy of 5 per cent., but the difficulties of construction and of maintenance led him to abandon the idea.

I have read with much interest the account of your tests on the Sulzer engine, in which you introduce the steam during the compression and before the admission. I am astonished that this filling up did not cause the pressure to mount higher in the clearance space, which goes to prove the enormous amount of condensation which is taking place in that space at the moment of the injection of the steam; and certainly if the surfaces are not of a certain temperature one will never obtain a certain pressure by compression in that space.

I come now to the tests in which the jacket was heated by steam having a higher pressure than that which was used in the cylinder. I have read a great many reports of tests made upon this subject, and yours interest me the more because you have approached the subject with so much care. The economy is low but I should certainly have said that it would have been more considerable. I do not know to what to attribute this effect. I have already investigated the subject of the tests on the compound engines constructed by my competitors and myself, but they have only resulted in confusing my ideas, for I have constructed compound machines (and they also) where the jacket of the larger cylinder and the receiver were heated with steam at six atmospheres and the efficiency remains the same as that of machines in which the receiver is not provided with a reheater and in which the jacket of the low-pressure cylinder is heated simply with the charge coming from the high-pressure; that is to say, with the same steam which operates in the low-pressure cylinder itself. It may be that when the jacket is heated by steam of a greater pressure than that which is used in the cylinder, there is practically no circulation and that the water deposited about the cylinder, the film of water, as you say, hinders the transmission of heat. I do not know anything about it, but the fact is there.

I know also of the tests with superheated steam, and Schaerer sent me an apparatus four months ago, but it is not yet in place so that I cannot make tests upon my engine. The superheated steam will, of course, give less advantage when one has a good boiler which furnishes dry steam and a good compound engine which does not consume more than 5.7 kilograms (12.5 pounds) of steam per indicated horsepower like ours.

One thing which astonishes me also is that engines where the steam coming from the boiler circulates in the jacket before entering the cylinder do not give a greater economy when the passages (the entrances for the steam to the valve) are so small as to produce a fall in pressure of one or two atmospheres. In effect, this constitutes a jacket operating at a pressure higher than that of the steam in the cylinder, and the steam itself is somewhat superheated, owing to its sudden loss of pressure.

Hirn and Hallouer pretend to have obtained good results in this way and concluded even that expansion is unnecessary to the economical use of steam and that throttle governing is quite sufficient. Is this your own opinion?

Jackets heated by means of oil must operate poorly, as the conducting power of the oil is not good. I believe that a very thin jacket could be made to give good results, and I believe that if the cylinder barrel is well provided with fins it will transmit heat still more quickly,

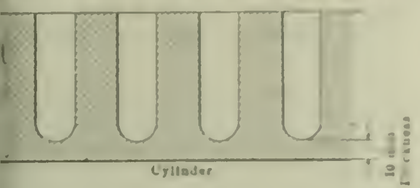


FIG. 1

and that the difference in temperature between the metal interior of the cylinder and the steam will be reduced. If you reduce this difference you reduce also the initial condensation. Is this your idea?

I have also experimented (but the engine, I believe, was not well run during the test) with an apparatus in the receiver for separating from the steam coming from the high-pressure cylinder on its way to work in the low pressure all the water which it contains.

I always use a separator upon the high-pressure cylinder, and I believe that if the water can be separated from the steam before it enters the low-pressure cylinder, it would do a great deal of good.

H. BOLLINCKX

[M. Bollinckx' letter is accompanied by blueprints reproduced herewith, showing

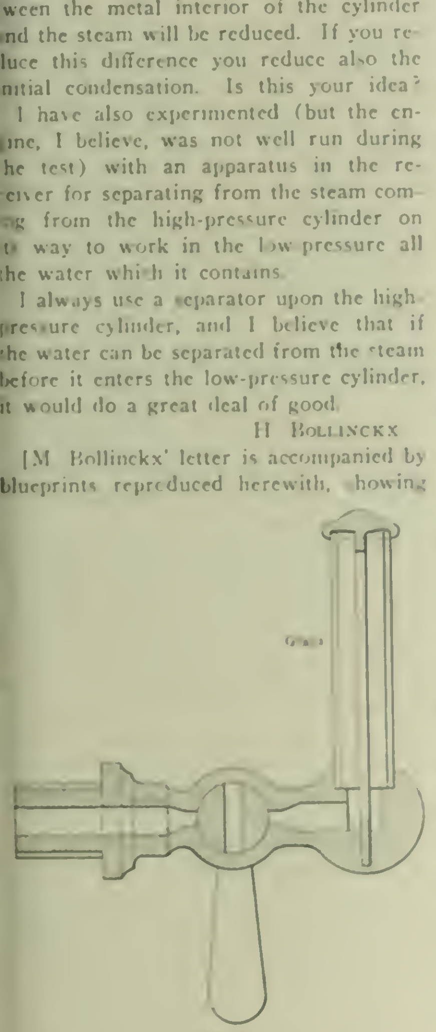


FIG. 2

in Fig. 1 the grooved exterior wall of the cylinder, and in Fig. 2 an indicator for showing the action of the steam. At the period of admission the steam in the glass is foggy. It clears up somewhat during expansion by reevaporation, and the instant the exhaust valve opens it becomes clear, showing the formation by reevaporation of steam which goes to the condenser. Donkin invented such an instrument, but that here shown is claimed by M. Bollinckx to have been invented independently by himself.—EDITOR.]

Alcohol versus Gasolene for Internal Combustion Engines

BY JAMES E. STOREY

There has been considerable comment on the possibilities of denatured alcohol as a substitute for gasolene in internal-combustion engines. A close analysis of the relative merits of the two fuels brings out some facts which are not generally known, and which are of interest to both the engine operator and the designer.

Gasolene consists principally of a mixture of pentane and hexane. The heat value of these compounds is about 21,000 B.t.u. per pound, while that of alcohol is but 13,700 B.t.u. per pound. However, there is a compensating factor which eliminates most of this difference. The reaction which expresses the explosion of gasolene vapor is as follows:

$$\begin{array}{l} \text{Gasolene vapor} \qquad \text{Air} \\ 2\,C_6H_{14} + 19\,O_2 + 76\,N_2 = \\ 12\,CO_2 + 14\,H_2O + 76\,N \\ 2\text{ vols.} + 19\text{ vols.} + 76\text{ vols.} = \\ 12\text{ vols.} + 14\text{ vols.} + 76\text{ vols.} \end{array}$$

Hence, 97 volumes of explosive mixture produce 102 volumes of "burned" gases, there being a certain increase of volume due to the increase in the number of gas molecules. Thus, if 1 cubic foot of the mixture were exploded, 1.0515 cubic feet of gaseous products would be formed even if no heat of combustion were given off. The specific heat of the resulting gases would be about 0.18387 at constant volume. Since 1 pound of pentane requires 15.9 pounds of air, there would result 16.9 pounds of spent gases; 3.11 B.t.u. would be required to raise the temperature of this weight of gas 1 degree Fahrenheit. Taking the heat value of gasolene as 21,000 B.t.u. per pound, the rise in the temperature of the exploded gases would be 6750 degrees, theoretically.

Following the same line of reasoning for alcohol under the same conditions will give results which show the relative values of the two fuels. The equation for the combustion of alcohol vapor is as follows:

$$\begin{array}{l} \text{Alcohol vapor} \qquad \text{Air} \\ C_2H_6O + 3\,O_2 + 12\,N_2 = \\ 2\,CO_2 + 3\,H_2O + 12\,N_2 \\ 1\text{ vol.} + 3\text{ vols.} + 12\text{ vols.} = \\ 2\text{ vols.} + 3\text{ vols.} + 12\text{ vols.} \end{array}$$

or 16 volumes of mixture produce 17 volumes of spent gases. There is, therefore, an increase in volume due to the increase of gaseous molecules, but this increase is not as great as with gasolene vapor. One cubic foot of the original alcohol mixture makes 1.0625 cubic feet of spent gases. The specific heat of the exhaust gases at constant volume is 0.17998. One pound of alcohol requires 10.72 pounds of air, making 11.72 pounds of gas, which requires 2.07 B.t.u. per pound to raise the temperature 1 degree Fahrenheit. The temperature would be raised theoretically 6618 degrees, which is more than 100 degrees less than that computed for the gasolene mixture.

OTHER INTERESTING FACTS

A close study of these reactions brings out some other interesting facts. For example, one volume of gasolene vapor requires about 50 per cent. more air than the same volume of alcohol vapor. On referring to the formula it will be evident that each alcohol molecule contains oxygen, and therefore does not require as much oxygen for combustion as a hydrocarbon molecule. However, that oxygen contained in the molecule greatly facilitates the combustion. Everyone knows that alcohol will burn without smoke, while gasolene always makes smoke unless it is first vaporized and then mixed with sufficient air. It is probable that there would be less trouble from cylinder deposits of soot with alcohol than with gasolene.

As to mixing of the charge, there is little advantage for either fuel. If anything, the alcohol vapor is slightly heavier than the gasolene vapor; therefore the latter will diffuse somewhat more rapidly.

The foregoing facts indicate that gasolene is superior to alcohol in nearly every way. The volumetric increase of the former is over 2 per cent. greater and the theoretical temperature of explosion is 130 degrees higher; consequently, the initial pressure of the exploded gasolene mixture will be greater than that of the alcohol mixture. Tests have probably been made and will be made which show that alcohol is as good as gasolene, or even better, but the blame should be put on the carbureter or the mixture rather than on the fuel. A few years ago when the industrial alcohol craze struck this country people expected too much from this fuel because of the ease with which it could be manufactured and the variety of products from which it could be made. In spite of the fact that the revenue has been removed from industrial alcohol for some two years, the price is still too high to consider it as a fuel on any practical scale. With alcohol at the same price as gasolene, there would still be a difference in favor of gasolene.

Another feature which should not be overlooked is the ease with which alcohol can be diluted with water. Unless the alcohol were bought from a reliable dealer, it would have to be tested before use or it might cause no end of those "mysterious" gas-engine troubles. Gasolene can be diluted only with a hydrocarbon, such as kerosene, and while it may not vaporize so readily, yet the kerosene will develop power when ignited in the cylinder.

With alcohol as high in price as it is and gasolene as low as it is, the proper direction for investigation is along the line of the better combustion of gasolene or other hydrocarbon mixtures.

POWER AND THE ENGINEER

DEVOTED TO THE GENERATION AND TRANSMISSION OF POWER

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January 5	46,000
January 12	38,000
January 19	38,000

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

Contents

The Line "Recognizes" the Staff

The engineer, realizing his absolute responsibility for the ability of the vessel to move, has been accustomed to shrug his shoulders in the inconspicuous background while press and public and officialdom lauded and feted the captain of a vessel which had made an exceptional run. "Fighting Bob" Evans modestly brushes this credit aside. "I am not the one man who took the fleet to San Francisco," says he. "The man who brought the fleet around the Horn is the man who boiled the water in the fireroom and the man who peeled the potatoes. They have done as much to take it, step by step, as the keen-eyed officer on the deck or the gray-haired captain on the bridge."

The pendulum may hit the engineer in swinging back.

Hackneyed Contributions

There are some engineering subjects which, like the poor, will always be with us; such as how to keep the ashpit clean, methods of firing practiced fifty years ago, necessity of keeping the water level at the second gage, objections for and against valves in the water-column connections, loss of boiler economy for each one-sixteenth inch of scale, whether the pressure should be on the stem or disk side of a globe valve, and whether a belt should be run hair or flesh side to the pulley.

Superheated steam has been a live topic for discussion, and many articles have been written by those who did and did not know what they were talking about; but with the passing of the years, many of the old notions regarding the use of superheated steam have been dispelled, especially regarding its effect upon packing, cylinder lubrication and the operation of valves other than those of the poppet type. Not many years ago, a member of a certain engineering society had under way the preparation of a paper, to be read at the next meeting of the society, regarding the difficulties encountered in using superheated steam, and especially dealing with its nonuse in the ordinary type of steam engine. Doubtless the paper would have been read before an intelligent body of men as planned had it not been pointed out that the difficulties which were singled out as restricting the use of superheated steam had been so overcome that they were not classed as difficulties, any more than any other feature in steam-plant operation.

In posing before the public as an authority the individual should know that his position is unassailable. If a writer makes an erroneous statement it will be strange if someone does not bring the matter to his attention. The one who is mistaken in his beliefs may have some excuse, and the one who does not know may learn through the school of criticism. Both of these kinds of writers are being constantly met with by the editorial force of this paper, and they are dealt with courteously and a helping hand is given when required.

The Future Large Gas Engine

Reciprocating steam engines for land service are built up to about twelve thousand brake horsepower and turbines up to fourteen thousand kilowatts, or about twenty thousand brake horsepower per unit. Twin-tandem gas engines have been built in this country up to five thousand four hundred brake horsepower, or one thousand three hundred and fifty horsepower per cylinder, using a rich gas; with less "snappy" gas the same engine could doubtless be worked up to fourteen or fifteen hundred horsepower per cylinder by building it with higher compression. These figures mean, obviously, that the gas engine of the future for large power-plant service must be built in much larger units than the present knowledge of design permits, if it is to compete with steam. Urban central stations cannot afford to provide one and a quarter square feet of generating room ground plan for each brake horsepower of output, which is about the size of the huge Gary plant. Nor is it usually profitable to divide the total output of even a big station into twenty or more units.

The greatest internal cylinder diameter thus far employed in this country is forty-four inches; somewhat larger cylinders are in successful service abroad, but the difference is not important from the viewpoint under discussion. To develop ten thousand brake horsepower at eighty-five per cent. mechanical efficiency a twin tandem four-stroke engine would need cylinders not less than eighty inches in diameter, which is far beyond any recorded size ever built.

The chief difficulty in the way of building large engines is the enormous quantities of heat to be got out of the cylinder per cycle, which difficulty is augmented by the well known decrease in the ratio of wall surface to volumetric capacity with increasing diameters. Consideration of this feature of the problem alone would lead straight away from the accepted "ideal" of a hemispherical combustion chamber and in the direction of a flattened extension of the cylinder proper, but only actual experiment can determine how far one could go in that direction without developing other difficulties of a more or less prohibitive nature.

Whatever may be the method of doing it, however, it is quite evident that the construction of much larger units than have yet been produced must be made practicable if the gas engine is to gain e standing in large power-plant work that its rapid improvement in operating characteristics bids fair to justify.

Boiler Plant Capacity

The average plant consisting of several boilers is laid out to operate on one stack, and this stack is generally proportioned properly to serve the boilers installed. It often happens that the original capacity is soon outgrown and the need of additional boilers is felt, and these are installed and connected to the stack without any thought being given to the question of whether the stack is of sufficient capacity properly to care for the added boilers.

It sometimes transpires, too, that, owing to several such additions of boilers, the overloading of the stack becomes so pronounced that further additions to the boiler equipment tend to reduce the capacity of the plant as a whole rather than to increase it.

It should be the duty of every progressive engineer to know at what points the capacity of his plant will be reached first, so that when the call for additional power comes he will be ready to suggest how his employer's money can be most advantageously spent to obtain the desired increase in capacity.

In a boiler plant there are three main features of general design that limit the capacity, and each of these is of practically equal importance, although this does not seem to be generally appreciated. The first, and the one which is often assumed to be the all determining factor, is the actual boiler capacity, or extent of heating surface. The second is the grate capacity or area; this is fairly well taken care of as a general thing, on account of additional grate surface being always installed with each addition to the boiler capacity. Thirdly, is the draft capacity, and this is liable to be anything in a plant that has been through several changes. It must be remembered that draft capacity does not mean simply a chimney capable of furnishing a given volume of air, but also that the gas passages from the grate to chimney are of ample proportions and proper shape; also, that the draft be of the correct intensity or sharpness to suit the quality of fuel used. Some of the lower grades of fuel are only burned successfully with artificial draft. The quality of the fuel also affects the grate area required.

If your boiler plant is showing signs of overload, determine individually if the heating surface, grate area and draft are properly related when the class of fuel used is considered, so that they may work in unison to produce the highest plant capacity. This correct proportioning of the several capacities will tend toward the economical generation of steam. Remember that all any boiler can do is to absorb a certain portion of the heat generated on the grate and to generate the full amount of heat that a given boiler is capable of absorbing efficiently, requires the correct grate and draft capacity for the particular kind of fuel used.

A Remarkable Statement

On January 4 the Supreme Court of the United States reversed the decision of the United States Circuit Court declaring the eighty-cent gas law confiscatory. In announcing the decision of the court, Judge Rufus W. Peckham made public an abstract of the opinion in which the following statement was made:

"The proof unquestionably shows great possible if not probable danger of explosion in the mains or other pipes if the pressure demanded were applied to them as they now are."

The State law in question required that gas of at least twenty-two candle power should be supplied at a pressure not exceeding two and one-half inches of water. It surely cannot be this pressure to which the court refers, as the stress set up in the walls of a twelve-inch cast-iron pipe three-fourths inch thick by this pressure would be too small to be measured. But what else can the decision refer to and why should that portion of the law be declared null and void? Illuminating gas does not explode on the application of pressure; in fact, we seem to have heard somewhere that air or rather oxygen in rather large quantities must necessarily be present along with illuminating gas in order that an explosive mixture be formed, and even then a spark or external heat is required to start the action.

It is not often that misinformation of this order appears in the decisions of our Supreme Court and it is highly probable that when the full text is made public the difficulty will have a rational explanation. However much the intricacies of the legal mind may be beyond the understanding of the average engineer, the basic principles of physics and chemistry are common property, and with the assistance of the public school system should be possessed by every citizen.

Steam Boilers and Dynamite

Boiler explosions have occurred from many causes other than that of low water, and as plenty of these causes are natural or legitimate enough of themselves, it is not necessary for the owner to celebrate the occasion by [illegible] or for the fireman to assert that some enemy had put dynamite into the boiler. The fact should not be overlooked, however, that careless superintendence begets careless workmen, and that when handling either a steam plant or high explosives certain rules and special precautions must be taken that would not be required of a man operating a wheelbarrow. That either dynamite or a steam boiler can be used for its respective work with perfect safety is known. That both have been used in ways resulting in great destruction of life and property is also known, but to intrust the use of either to incompetent persons is dangerous.

The incident related herein about the thawing of dynamite in a boiler room may seem to engineers as a case of "served them right for doing such a crazy thing" but maybe you are doing something just as careless in your own boiler room. To those not acquainted with the habits of dynamite, it may be explained here that at temperatures below 50 degrees Fahrenheit it is in a frozen condition, and that for effective use it must be thawed out. It is this thawing operation that has given so many opportunities for carelessness and ignorance to decrease the death-benefit funds of a certain class of fraternal organizations. The dynamite cartridges are thawed properly by placing them in a watertight vessel surrounded by water which is heated to a temperature not exceeding 130 degrees Fahrenheit.

In the power plant of a certain Western mine two 60-horsepower return-tubular boilers were installed and operated at about 80 pounds pressure. One of the miners soon discovered that it was an easy matter to thaw his giant sticks by placing them on a sawdust bed on top of one of the boiler drums. Now the miner did not know that the temperature of steam at 80 pounds pressure is about 324 degrees Fahrenheit. It was not long before the bed of sawdust was scattered and the remainder became soaked with the leakage from the dynamite sticks, thus bringing the nitroglycerine in contact with the heated boiler plate. The inevitable explosion happened on schedule time, but fortunately no employee was in range of the debris. Besides the effect of the shock on the boiler setting and the general wreck of the boiler-house covering, the only damage done was to "dish in" the top and sides of the drum until it looked like a derby hat that had been struck at an angle of 45 degrees by a foot-ball. That was on both of the boilers. All the [illegible] was fortunate.

[illegible] conducting electric current. If the distance between the terminal plates be halved, only half the number of ions will be formed and hence the current will be halved instead of doubled. Up to the point of saturation the current is directly proportional to the voltage, but above this point there is no further increase in current.

Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

Hopkinson Flashlight Indicator

It is generally admitted that for engines running at more than 200 or 300 revolutions a minute the ordinary indicator does not give satisfactory results.

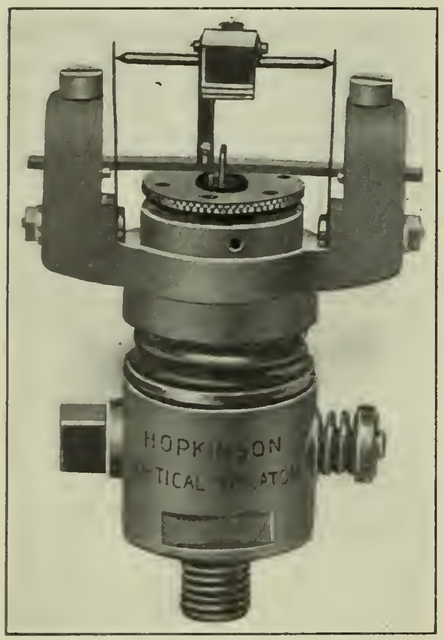


FIG. 1

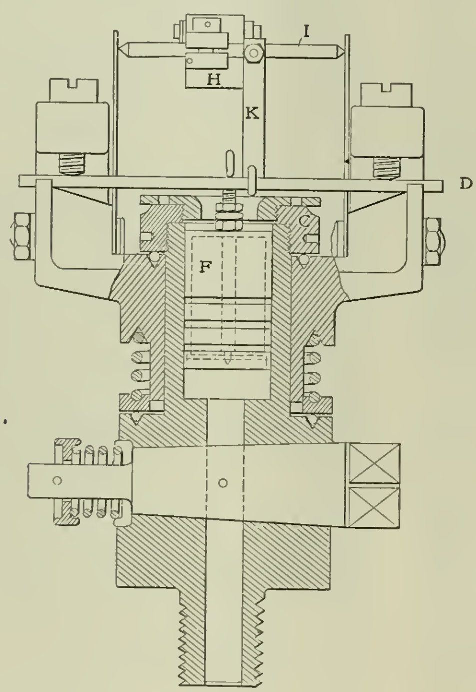


FIG. 2

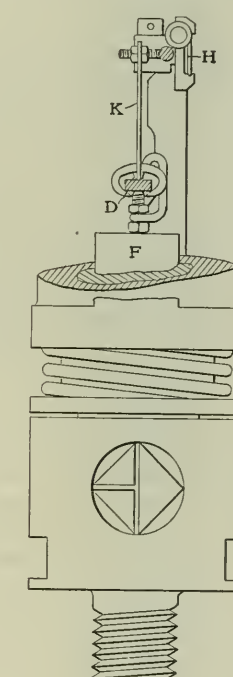


FIG. 3

FIG. 4

The inertia of its piston and parallel motion seriously distort the diagrams, while slackness of the motion joints and friction of the pencil on the paper introduce other errors which are by no means negligible. When we come to really high speeds, such as those of petrol and other engines, the only practicable form of indicator is the optical type, in which a minute motion of a diaphragm or piston, subject to the cylinder pressure, is magnified and made visible by means of a beam of reflected light. The optical principle at once does away with inertia troubles, and when embodied in a suitable type of apparatus is capable of giving valuable results at the highest speeds at which any engine can run. Very good work has been done with such indicators, which have now been in use for some years.

In the usual form of optical indicator the pressure of the steam or gas acts underneath a metallic diaphragm, which is attached to a mirror. The deflections of the diaphragm cause the mirror to rock, so that a spot of light reflected from it traces out a line on the card. The objections to this form are twofold: Firstly, that the deflections of the diaphragm are not exactly proportional to the pressure acting upon it; and, secondly, that the heat of the steam or gas is likely to affect the calibration of the instrument by altering the elasticity of the diaphragm. To avoid any possible source of error or trouble from these causes, Prof. Bertram Hopkinson, of Cambridge University, has devised the instrument shown in Figs. 1 to 3, which is manufactured by Dobbie-McInnes, Limited, of 57 Bothwell street, Glasgow, and sold under the name of the Hopkinson Flashlight Engine Indicator.

The distinctive features of the Hopkinson indicator are shown in Figs. 2 and 3. The body of the instrument is bored to receive a piston *F*, the top of which is fitted with a wire-hook arrangement which embraces at the center a flat steel spring *D* fixed transversely above the piston. The hook does not hold the spring tightly enough to prevent the piston taking its position freely in the bore. The spring is clamped at each end to the rotating head of the instrument in the manner hown. Before insertion it is slightly urved, but when in position it is held traight by a moderate pressure of the wo binding screws. Above the spring nd parallel to it, is a spindle I, to the cen- er of which a small mirror H is fixed

illustrated but in which an eccentric is fixed to the engine crank shaft, and a spring clip to the indicator head, although we understand that Dobbie-McInnes are prepared to supply better mechanical arrangements for most cases.

[illegible]

FIG. 5

FIG. 7

[illegible]

The spindle is carried on pointed centers, against which spring clips press. It, and therefore the mirror, are caused to rock by means of a thin steel strip K connecting the spring and spindle, the flexibility of the strip allowing it to accommodate itself to the circular motion of the spindle. The length of the diagram is obtained by rocking the head of the instrument around the body, the motion taking place on the ball bearings shown in Fig. 2. A motion of the head through an angle of about 3½ degrees gives a diagram 2 inches long. The motion of the mirror is only 1/40 inch, so that inertia effects are very small indeed. The indicator may be driven through a motion which is not

To render the diagram visible or to obtain a photographic record of it, a camera like that shown in Fig. 1 is attached to the indicator. A concave reflecting mirror is used, which throws a spot of light upon a ground-glass screen or photographic plate at the outward end of the camera. Should no permanent record be required, the object being simply to observe the pressure at one point of the stroke, or to note the general shape of the diagram, a telescopic arrangement as shown in Fig. 5 is used. The optical principle is illustrated in Fig. 6. [illegible]

FIG. 6

FIG. 8

[illegible]

Veeder Liquid Tachometer

The liquid tachometer described and illustrated herewith is manufactured by the Veeder Manufacturing Company, Hartford, Conn. This instrument makes use of a liquid in a device similar to a

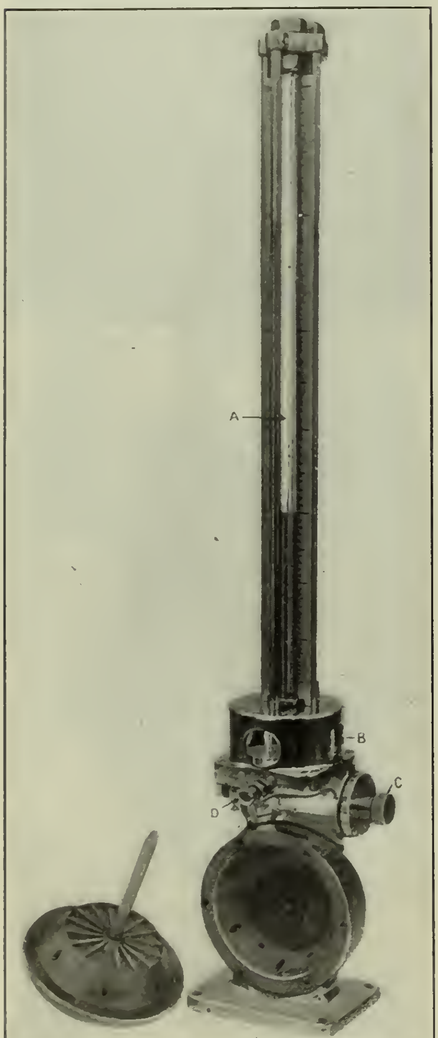


FIG. 1. VEEDER LIQUID TACHOMETER

centrifugal pump. Its principle in action is that the pressure developed by the centrifugal force of the liquid, when the instrument is running at a certain speed, is a definite quantity. This pressure forces liquid up the indicating tube *A*, Fig. 1, and is balanced by the pressure due to the hight of the column of liquid in the tube. Fig. 2 is a sectional view.

The instrument shown in Fig. 1 illustrates one of its present forms with the paddle removed. The only moving part is in the paddle, which imparts the necessary centrifugal force to the liquid contained in the body. A small reservoir *B* is located directly over the paddle case, in the center of which is a glass tube through which the liquid flows to the indicating tube *A*.

A suitable zero mark is provided around this small tube in the center of the reservoir. The liquid rises by capillary attraction in this small central tube somewhat above the level of the liquid in the reservoir. This enables the tachometer to be set at zero, a displacement clutch operated by small thumb nuts (shown at *C*) enabling the operator to raise or lower the hight of the liquid so that its surface shall be exactly at the zero mark.

A free passage is provided from the reservoir to the center of the paddle wheel, allowing the liquid to flow freely to the paddle wheel, from which it is thrown out through very small orifices in the periphery of the paddle case. A small handle *D* is placed at the front, with which to operate a valve to choke the passage from the pump to the indicating column. This is to prevent the dancing or vibration of the liquid column, due to

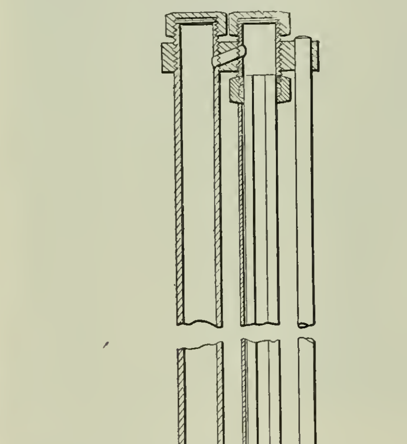


FIG. 2

any fluctuation in the speed of the revolving body whose revolutions are being indicated.

The blades of the paddle are radial so the device may be reversed. A ball thrust bearing is provided for the paddle shaft, thus eliminating any wear that would prove injurious. The outlets for the liquid consist of a number of small radial holes, equally spaced around the periphery of the paddle case.

The apparatus is so sensitive that at the maximum speed for which it has been constructed, namely, 2500 revolutions per minute, a difference of one or two revolutions is very noticeable. It is portable and there is no difficulty in holding the column practically vertical. It may be used either by holding it in the hand, the paddle-shaft wheel being driven by a short, flexible shaft thrust against the end of the revolving member whose revolutions are to be measured, or it may be fastened down and driven by gears.

Among the many applications to which the tachometer has been adapted is that of testing dynamos, engines and other machines having revolving members. It has also been adapted for switchboards, grouped with the other instruments, and gives a continuous indication of the revolutions per minute of either the engine or generator.

Obituary

Alfred R. Wolff, who died on January 7, at his home, 15 West Eighty-ninth street, New York, after an illness of several months, was born in Hoboken, N. J., March 15, 1859. His early life was marked by evidences of great ability and he graduated from Stevens Institute in the first half of his eighteenth year. He entered the United States revenue cutter service, where he remained for some years, leaving to become assistant to Charles E. Emery. Later he became a member of the firm of Whitman & Wolff, consulting engineers, and afterward opened an office and devoted his energies to heating and ventilation. He was an engineer of rare ability and wrote to some extent on engineering topics, such as "The Most Economical Point of Cutoff," "The Windmill as a Prime Mover," "Value of the Study of the Mechanical Theory of Heat," "Expansion of Steam and Water," "Friction of Noncondensing Engines," "The Influence of Steam Jackets on the Pawtucket Pumping Engines," "Recording Pressure Gages," "Steam Consumption of Engines and Water Meters." He served on several committees for the American Society of Mechanical Engineers, among the most important of which was the committee on standard pipe sizes.

The annual stag banquet of the Louisville Association No. 1, N. A. S. E., was held Thursday evening, January 7, at 8:30 o'clock, at the Galt house, Louisville, Ky.

Three 3500-kilowatt Curtis horizontal turbo-generators will be installed in the new power house of the California Electric Generating Company, Oakland, Cal.

Inquiries

Questions are not answered unless they are of general interest and are accompanied by the name and address of the inquirer.

Alternating and Direct Current

What is the difference between alternating and direct current, as regards direction of flow?

R. B.

Alternating current flows alternately in opposite directions; direct current flows always in one direction. Read the editorial on page 335 of the August 25 number of Power and The Engineer.

Absolute Terminal Pressure

Will you please explain what is meant by absolute terminal pressure?

A. W. P.

The term "absolute," as used in speaking of steam pressures, means pressure reckoned from a perfect vacuum of 14.7 pounds below atmospheric pressure. The absolute terminal pressure would be the terminal pressure reckoned from vacuum and expressed in pounds pressure absolute. If the terminal pressure were two pounds absolute, it would mean that the pressure was 12.7 pounds below the pressure of the atmosphere, or about 26 inches of vacuum.

Cylinder Ratio for Compound Engines.

What is the proper cylinder ratio for compound engines?

E. H. S.

This must be settled by the conditions under which the engine is to be operated. With a steam pressure of from 125 to 200 pounds, if the engine is to run noncondensing, the cylinder ratio that will probably be found to be the best will range from 2½ to 1 to 3 to 1. For condensing engines with a fairly steady load, and for steam pressures from 125 to 150 pounds, a cylinder ratio of from 4 to 1 to 5 or 6 to 1 will give economical results.

With noncondensing engines there is little to be gained by compounding for a steam pressure of less than 125 pounds.

Ratio of Expansion

Will you please explain what is meant by ratio of expansion and how to find it?

M. O. D.

Ratio of expansion is the proportion the total volume of the steam in the cylinder bears to the volume at cutoff. To find the ratio of expansion, divide the stroke in inches by the number of inches of the stroke completed when cutoff takes place. To be exact in calculating the ratio of expansion, the clearance must be known and taken into account. If, for instance, the effect of the clearance is such that it adds 1 inch of cylinder length to the volume of the cylinder at each end, this must be added to the stroke of the piston and to the piston travel before cutoff. Suppose the stroke of the engine to be 30 inches and the cutoff to take place after the piston has traveled 6 inches. Nominally the cutoff would be at one-fifth stroke and the ratio of expansion would be 5, but actually the cutoff would be 7/31 of the stroke and the ratio of expansion would be 4.428.

The Horsepower of Belting

I have a belt, 16 inches wide, passing over two pulleys, each of which is 5 feet in diameter and running at 200 revolutions per minute. What is the greatest limit of horsepower that it will transmit?

W. M. C.

There are a great many different rules for calculating the horsepower of belting, all based on the results of practice under different conditions. One rule very commonly used says that a belt 1 inch wide running 1000 feet per minute will transmit one horsepower. In your case you have a belt 16 inches wide running 3140 feet per minute and, according to the rule, it will transmit

$$\frac{16 \times 3140}{1000} = 50.24$$

horsepower. Another rule says that at 70 feet of belt surface per minute one horsepower will be transmitted. Applying this rule you will have

$$\frac{3140 \times 1.33}{70} = 59.65$$

horsepower. These rules are meant to be applied to single belts. Double belts will transmit from 70 to 100 per cent. more power than single ones. They may also be overloaded 200 or 300 per cent. for some time, but this practice destroys the elasticity of the belt and shortens its life.

Book Reviews

The Steam Turbine. By James Ambrose Moyer. John Wiley & Sons, New York. Cloth, 370 pages, 6x9 inches, illustrated. Price, $4.

The author has been instructor of experimental engineering at Harvard, has been an engineer on experimental work in the steam-turbine department of the General Electric Company, and is now engineer with Westinghouse, Church, Kerr & Co., so that he is well equipped to treat the subject, both by analysis and from observation. The book is intended as a manual for the practical engineer, who is designing, operating or manufacturing steam turbines, "rather than a compilation of manufacturers' catalogs combined with a digest of standard books on thermodynamics and mechanics." It was intended primarily for the use of the author's assistants in the experimental testing and engineering departments of the companies with which he is connected. An introduction of nine pages tells of the development of the turbine and includes the familiar pictures of the productions of Hero and Branca, without which no writer upon the subject seems able to get started. A chapter upon the Elementary Theory of Heat explains the entropy diagrams and the calculation of the available energy is shown in an easily understandable way. The real turbine work starts with a chapter on Nozzle Design, followed by one on Blade Design. Mechanical Losses in Turbines are then considered, and a chapter devoted to the Method for Correcting Steam Turbine Tests. Seventy-eight pages are then devoted to the description of commercial types. Succeeding chapters deal with Governing, Low-Pressure Turbines, Marine Turbines, Testing, Steam Turbine Economy, Stresses in Blades, Drums and Disks, Gas Turbines, and Electric Generators for Turbines. The book is written in such a way as to be understood by the practical engineer of moderate attainments and is an excellent presentation of the things which a turbine man ought to know by a man who has had exceptional opportunities for finding them out, and who knows how to tell them simply and well.

Cyclopedia of Civil Engineering. By Frederick E. Turneaure, [illegible] dean of the College of Engineering, University of Wisconsin, assisted by a corps of civil and consulting engineers and technical experts. Published by the American School of Correspondence, Chicago, Ill. Eight volumes, each containing about 400 pages, 7x10 inches, with more than 3000 illustrations. [illegible]

It would be next to impossible properly to review this encyclopedia in these columns; therefore, no attempt will be made to do so. It is a general reference work on Surveying, Railroad Engineering, Structural Engineering, Roofs and Bridges, Masonry and Reinforced Concrete, Highway Construction, Hydraulic Engineering, Irrigation, River and Harbor Improvement, Municipal Engineering, Cost Analysis, and kindred topics. The list of authors and collaborators includes the leaders in the fields designated. In addition, the standard technical authorities of America and Europe were freely consulted and the best that they have to offer has been incorporated in this work.

The aim has been throughout to prepare a work which, while adequate to meet all demands of the technically trained expert, will appeal equally to the self-taught practical man, and [illegible] has been attained. The work covers not only the fundamentals that underlie all civil engineering, but their application to engineering problems of every sort. In effect, it is a compilation of [illegible] instruction books of the American School of Correspondence, incorporating what is believed to be an ideal method for the education of the busy workingman. The [illegible] and illustrations are [illegible], and altogether it is a work which it will [illegible] to have on [illegible]

Business Items

W. H. Smead, formerly mechanical engineer for the General Fire Extinguisher Company, Atlanta, Ga., has opened an office for himself in the McAdoo building, Greensboro, N. C., where he will make a specialty of designing steam-power plants and heating systems. While with the fire-extinguisher company he designed the power piping for the New Orleans waterworks, White Oak Cotton Mills and other plants.

James H. Jarvis, chief engineer of the Charlotte General Electric Company, of Charlotte, Mich., has sent a letter to C. P. Bassett, of Charlotte, manufacturer of the McNaughton grate bar, in which he says: "We have had some of your McNaughton sectional grate bars in use for more than a year and we find them to be very economical of fuel. They do not overheat or clog and they are just as straight as the day they were put in, the construction of the bar being such that they will not warp, and they make a nice even surface to fire on."

The business heretofore carried on by the American Engineering Specialty Company, with headquarters at Chicago, and branches and agents in various cities through the middle West is now conducted in the name of Warren Webster & Co., with main office and works at Camden, N. J. This change will give to architects, engineers, contractors, users and intending purchasers of "Webster" apparatus the full advantages of the "Webster" organization, which now covers all parts of the country. It implies no change in the personnel. The same representatives with whom the trade is already acquainted will be glad at all times to give inquiries their best attention.

The Northern Electrical Manufacturing Company, Madison, Wis., announces the enlargement and removal of its St. Paul district office to 1046 Security building, Minneapolis, Minn. This betterment of their sales office facilitates closer relation with their customers in the twin cities and improves their office surroundings. T. E. Drohan, who has been representing them in the St. Paul office, will continue in charge of the Minneapolis office. His experience as superintendent of the Northern works makes it possible for him to serve customers in his territory to excellent advantage, as his sales interest is coupled with an intimate knowledge of manufacture and design.

Methods of cooling water for steam-condensing and other plants are fully described in Bulletin 104, "Water Cooling Towers," just issued by the Wheeler Condenser and Engineering Company, of Carteret, N. J. After explaining the physics of water cooling, the different types of cooling tower are discussed, more especially the Wheeler-Barnard tower, the essential feature of which is the use of galvanized, woven-wire mat as the "filling" medium over which the water trickles. This tower is built in the forced-draft, natural-draft and open styles, and the numerous full-page illustrations adequately show its construction and manner of installation. There are also various tables on humidity, air and vapor mixtures, etc., which should be of value to engineers.

The Westinghouse Machine Company reports good progress during recent months in the steam-turbine business, despite the general depression existing in the machinery market. While business has been considerably below normal, there have been many encouraging features in all directions of power application. Out of the most important business covering some twenty machines ranging in size up to 10,000 horsepower, they find the usual activity in electrical, power and traction work, and a fair demand from various industries, including phosphate, cement and rubber mills, steel car works and oil refineries. Inquiry for exhaust steam turbines is active, and several equipments have been contracted for. While there have been important power extensions in turbine equipment, the steam-engine business of the Westinghouse Machine Company has been fairly active, as is evidenced by the number of orders for engines recently received.

Cia Azucarera del Panuco, Tampico, Mex., has placed an order with the Westinghouse Machine Company for a complete producer gas-electric power plant. This initial installation will consist of a vertical, 3-cylinder, single-acting engine and a 150-horsepower suction producer, designed to operate on small anthracite. The use of the suction producer in such large sizes has proven thoroughly practicable, and considerable business is anticipated along this line. Even larger sizes of producers of the suction type are contemplated by the builders. The New York Standard Watch Company, of Jersey City, N. J., also operates a suction producer gas plant of considerable size, and recently added another unit to its plant. A number of contracts have been let for gas engines operating temporarily on natural, or illuminating gas, with the intention of later changing over to producer-gas operation. A 200-horsepower plant has been ordered by Seaver & Co., Chelsea, Mass., and by the Cambridge Gas Company, Cambridge, Md. The Shelbourne Falls (Mass.) Electric Light Company has adopted the power gas system and has ordered a 175-horsepower Westinghouse suction producer for anthracite.

C. S. Davis, president of the William B. Pierce Company, of Buffalo, N. Y., recently gave out the following interview: "Notwithstanding the business depression of the past year, we have more than held our own in business. The fact that we have increased both our factory and office forces during the past year would seem to bespeak a healthy state of affairs. The fact of the matter is, our proposition, the Dean boiler-tube cleaner, is a fuel saver of the first order. As a rule in busy times people are prone to overlook the loss of fuel due to scale. Then, too, lots of fellows are willing to let 'well enough' alone. 'Maybe we have scale, as you contend,' they tell us, 'but we really haven't the time to investigate.' So the waste goes on. Well, this past year our words fell on fertile soil. People wanted to cut down expenses. They had time to investigate. Were they wasting coal? Did they have scale without their knowing it? Here was an opportunity to find out. Lots of concerns, with only remote thought of purchase, ordered the Dean on trial just to ascertain its merits. When they saw what the Dean did, they were only too glad to send us their check. So, we reaped a good harvest."

New Equipment

The Orofino (Idaho) Electric Company is constructing a hydroelectric plant.

The Seattle (Wash.) Ice Company is erecting a new plant, which is to cost $300,000.

The Merchants Power Company, Memphis, Tenn., is erecting an addition to its plant.

The citizens of Tacoma, Wash., will vote on proposition to build a municipal power plant.

The citizens of Conroe, Texas, voted to issue $77,000 bonds for construction of water-works.

St. Joseph's Hospital, Baltimore, Md., has awarded contract for the erection of a power house.

The Findlay (Ohio) Table Manufacturing Company will install a new steam turbine in its power plant.

The Cincinnati (Ohio) Traction Company has filed plans for a new power house to cost about $32,000.

It is said the Paxton (Ill.) Electric Company is considering plans for the installation of a 20-ton ice plant.

The Humbird Lumber Company, Sandpoint, Idaho, is considering plans for a power plant in connection with mill.

W. T. Wingate has been granted franchise by the City Council to operate an electric light system in Maysville, Mo.

It is reported that the Merchants' Heat and Light Company, Indianapolis, Ind., will erect an additional power house.

The Fairfield (Iowa) Gas and Electric Company contemplates remodeling plant at an expenditure of about $40,000.

The Kentland (Ind.) Light and Ice Company is planning to build an electric light, water and ice plant. Hugh Hill, president.

The Independent Ice Company, Nashville, Tenn., has been granted permit to erect factory building, boiler and engine rooms.

It is reported that the Citizens Electric Company, Williamsport, Penn., will install additional boilers, engines and generators.

The Charleroi (Penn.) Water Company is considering the installation of a filtration plant and a new duplicate pumping station.

Bids will be received until 11 a.m., Feb. 5, by Capt. C. H. Lanza, Key West, Fla., for furnishing condenser, filter, feed-water heater, etc.

The Prospect Rock Heat, Light and Power Company, Georgetown, Penn., is being organized, and site has been secured for power house.

It is reported that the City Council, Kearney, Neb., has passed an ordinance providing for the issuance of $100,000 bonds for water-works system.

The Paulding County Electric Company is asking bids on dam and power house to be erected on Punking Vine creek, near Dallas, Ga. W. S. Lotus, of Dallas, is president.

The citizens of Blacksburg, S. C., voted to issue $15,000 bonds for the construction of an electric light plant, etc. P. H. Freeman is chairman of Public Works Commission.

Bids will be received until Feb. 2 by the board of Water Commissioners, Kenosha, Wis., for a horizontal cross-compound high duty pumping engine of 6,000,000 gallons capacity in 24 hours.

The Southern New Hampshire Street Railway Company is contemplating the erection of a new power station in Methuen, Mass. The present power plant is located at Portsmouth, N. H.

It is reported that the Rock Island Southern Railroad Company will shortly place contracts for the construction of power plant on Edwards river. W. W. McCullough, Monmouth, Ill., is general manager.

Setting the Valves of the Cummer Engine*

An Old Time Engine with Special Eccentric Shaft. A Study of Valve Movement and Explicit Directions for Overhauling and Valve Setting

BY H. E. COLLINS AND J. H. FRANCIS

The Cummer engine is probably not as well known as many of our American automatic cutoff engines, due largely to the fact that not many engines of this type have been built in the past 15 years. Previous to this time, say from 1884 to 1893, quite a large number were built ranging in sizes from 50 to 3000 horsepower. Nearly every State in the Union has one or more Cummer engines in use at the present time, and consequently there are many engineers more or less interested in a description of a simple method of setting the valves on this engine. A description of the valves, the valve mechanism and the governor might also be of interest to some not familiar with this type of engine.

The general design and arrangement of the engine is shown in Fig. 1. The cylinder is provided with two steam valves, two cutoff valves and two exhaust valves. These valves are of the flat gridiron type, and the seats for the steam valves are vertical, being on the side and at each end of the cylinder. Each seat has three steam ports. The exhaust-valve seats are horizontal, and located under the steam chest.

The exhaust-valve stem connects to the lower end of a rocker arm which is pivoted at its center and located about the center of the frame. To the upper end of the rocker is connected the steam-valve stem and also the eccentric rod, thus giving the steam valve a direct motion with the main eccentric, while the exhaust valves travel in the opposite direction. The valves all move toward the center of the cylinder in opening and toward the ends of the cylinder in closing.

The cutoff valve has two ports and its stem is connected to a slide to which also is attached the cutoff eccentric rod.

The eccentrics are mounted on a shaft running parallel with the crank shaft and driven by a train of three spur gears inclosed in an oil-tight case, which also serves as a bearing for one end of the eccentric shaft and the intermediate-gear spindle. This arrangement gives the same direction of rotation to the eccentrics as to the crank and the same speed, as the gears are all of the same size. The advantages claimed for this arrangement are a smaller shaft for the governor and consequently smaller eccentrics and, of course, less friction by reason of this. The arrangement allows also for the eccentrics being set in line with the valves, so that they can be driven directly without offset eccentric rods. As the eccentrics are smaller than would be required on the

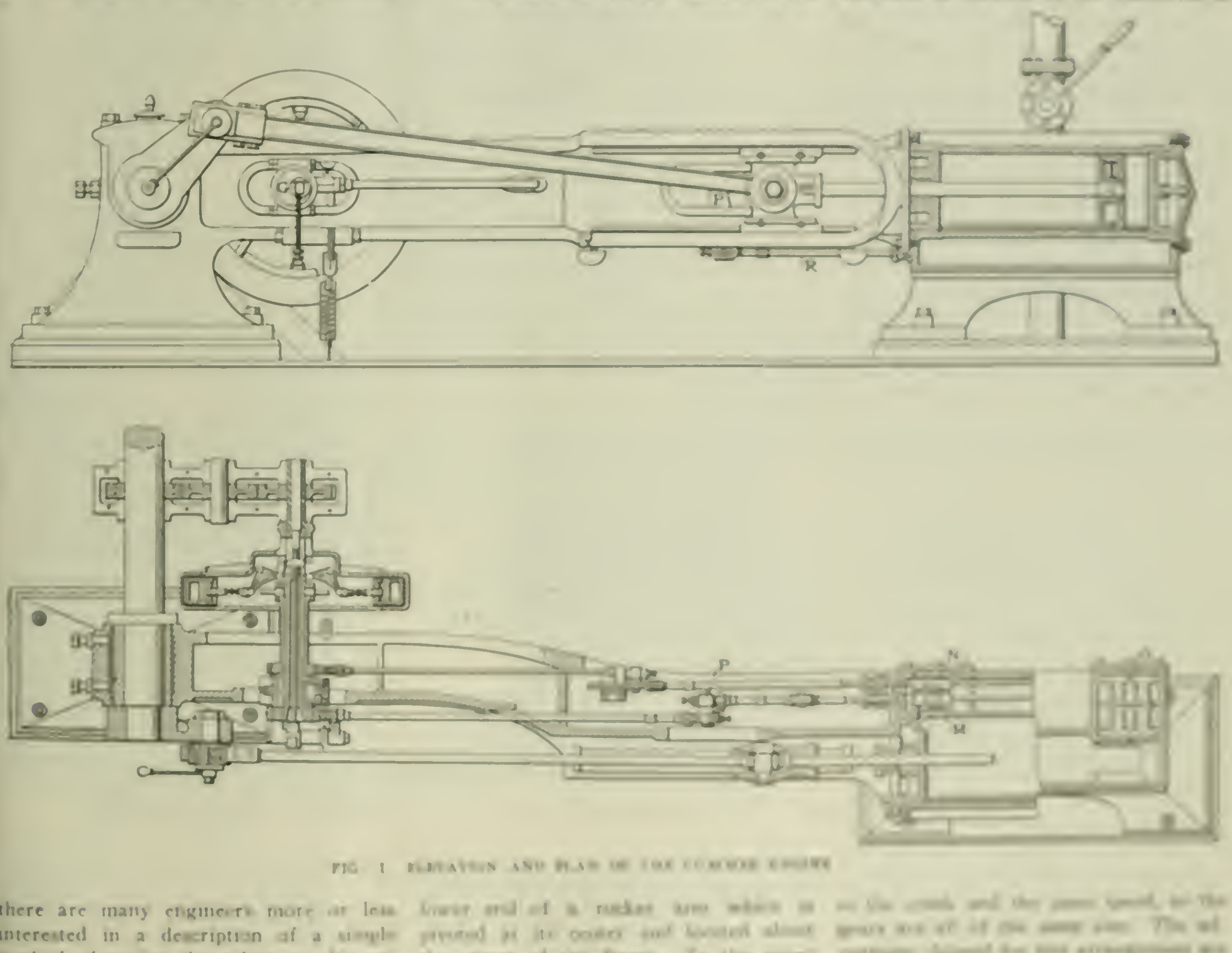


FIG. 1. ELEVATION AND PLAN OF THE CUMMER ENGINE

*Two articles were received simultaneously on this subject and have been combined in the presentation herewith.

main shaft, a shorter range of movement for the governor to operate the cutoff eccentric is obtained. With this particular design the working range of the governor is reduced to one-fourth that of many other designs. Another feature of this governor is the fact that speed changes can be made while the engine is running.

In Figs. 1 and 2 the main eccentric is at *G* and the cutoff eccentric at *H*. The main valve on the crank end is at *M*, the cutoff valve at *N*, and the exhaust valve seat on the head end at *O*. The main eccentric rod is connected to the top end of a reciprocating rocker *P*, from the lower end of which the exhaust valves are driven by the exhaust rod *R*.

By referring to Fig. 2 a clearer understanding of the governor and eccentric arrangement will be obtained. It will be noted that the eccentric shaft has one bearing in the engine frame at *S* and the other in the gear case at *T*. The governor case and cutoff eccentric ride on the main eccentric shaft, the cutoff eccentric and sleeve slipping on the shaft up to a shoulder, and extending back to the collar *U* which clamps to the cutoff-eccentric sleeve. The collar *U* has two pins to which are attached the links *V V*, shown in Fig. 3, so that when the weights *W W* fly out, they act on the cutoff eccentric, throwing it forward in its travel, or back when the weights come in again. The action of these weights is held in check by the weight and spring attached to the large bell crank *X*, shown in Fig. 2, which is under the engine frame and pivoted at *Y*. On the other end of this shaft is a rocker arm which acts on the thrust rod *A* in the hollow governor shaft. At the end of the rod is a crossbar *B* which extends through slots in the governor shaft. To each end of the crossbar *B* are attached the links *C C*, which in turn are attached to the small bell cranks *D D*, pivoted at *E E* and secured to the governor weights *W W* by the adjustable links *F F*.

With this arrangement the weight and spring on the large bell crank tend to hold the thrust rod in a direction toward the gear-case end of the shaft, and through the crossbar *B* and the bell cranks *D D* tend to hold the weights *W W* always toward the shaft center. Aside from friction the work that the centrifugal force of the governor weights has to do is to lift this dead weight and overcome the spring tension, and when it does that or is in turn overcome by these forces, the changing position of the governor weights operates the cutoff eccentric. By turning the screw *G'*, Fig. 2, the tension can be altered, and the purchase of the spring on the lever can be changed by putting the pin *H'* through any one of the holes provided for it. The dead weights can be lifted off or placed in position while the engine is in motion.

In Fig. 4 the main steam valve, the cutoff valve and the exhaust valve are shown in plan and section. The main valve admits steam through its three ports direct into the cylinder ports, and the cutoff valve uses one of its outside edges for a cutting edge and thus controls the three ports of the main valve with its two. In the same way the exhaust valve, with only three ports, controls the four exhaust ports under it. Figs. 5, 6 and 7 show more clearly the arrangement of the valves in the cylinder. The main valve *M*, cutoff *N* and exhaust *G'* can all be located.

VALVE ACTION DURING ONE REVOLUTION

Figs. 8 to 17 inclusive are used to illustrate the relative positions of all the valve edges for a given position of the crank and under varying conditions. In these illustrations the main steam and cutoff valves are shown in section over the steam ports for convenience in grouping and to avoid the use of dotted lines. As the true relative position of the valves in the cylinder are shown in the previous illustrations, this arrangement should cause no confusion.

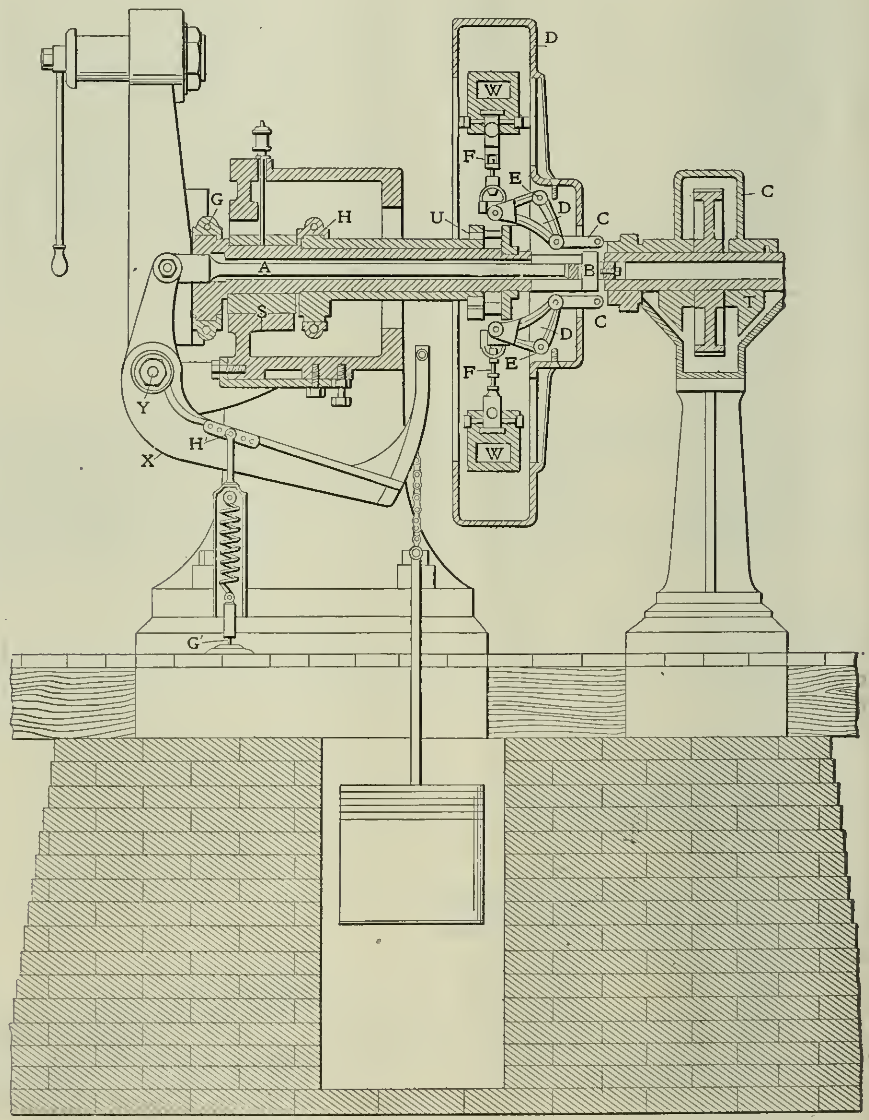


FIG. 2. VERTICAL SECTION ALONG THE CENTER LINE OF THE GOVERNOR SHAFT

Steam enters the steam chest *H'* at the top and passes the main and exhaust valves into the steam port *I'*, exhausting into port *J'* through exhaust valve *G'* into the exhaust passages *K'* and finally out at *L'*. The valve stems *K*, *L* and *R* in each case extend through the entire length of the steam and exhaust chests respectively.

The cylinder is equipped with six separate valves, two on each valve stem, or in other words three separate valves in six parts do the work of one ordinary slide valve.

In Fig. 8 the valves are all shown central on their travel over their respective ports. On the center line *A B* in each illustration are shown the valve circles or diagrams. The cutoff valve has greater travel than the main steam and exhaust valves, and the larger circle denotes the path of the cutoff eccentric, the inner circle denoting the path of the main eccentric. The position of the crank will be shown at *C*, the main eccentric at *M* and the position an exhaust eccentric would occupy at *E*, while the position of maximum cutoff is shown at $C\,O$. It will be noted in Fig. 8 and succeeding figures that the outside edges and inside edges of the cutoff-valve ports are the cutting edges, while the inside edges of the main steam-valve ports are the admission and cutoff edges for that valve. For the exhaust

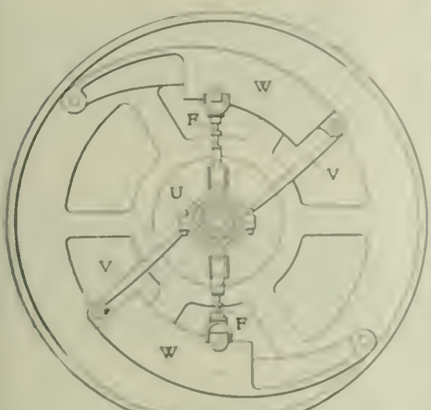


FIG. 3. GOVERNOR WHEEL

FIG. 4. VALVES OF THE FLAT GRIDIRON TYPE

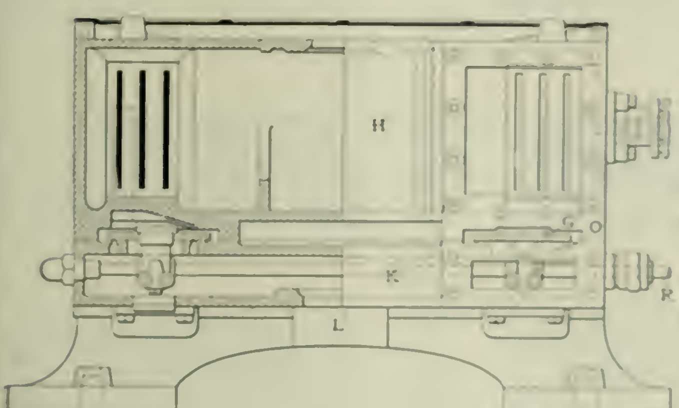


FIG. 5. ELEVATION AND PART SECTION THROUGH STEAM CHEST

FIG. 6. HORIZONTAL SECTION THROUGH THE CYLINDER

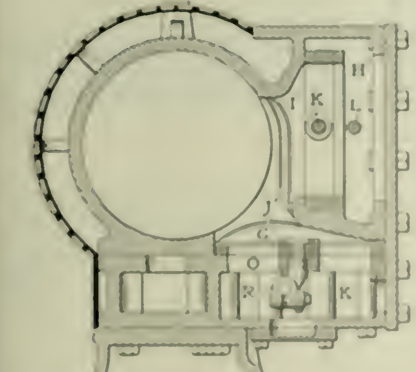


FIG. 7. TRANSVERSE SECTION THROUGH CYLINDER

FIG. 8

valve the outside edges of the valve and the inside edges of the ports are the working edges. To return to Fig. 8, the crank C is on the head-end center with the eccentrics and valves central. In Fig. 9 the eccentrics are advanced to the proper positions for operation with the crank C on the head-end center. The angle of advance for the main eccentric M is 30 + 90 degrees ahead of the crank C, and the cutoff $C\,O$ is advanced to 90 degrees beyond the main eccentric for the position of maximum cutoff. In this position of the eccentrics the main valve should have from 1/32 to 1/16 inch lead and cut off at about eight-tenths of the stroke, the cutoff valve performing its function at the same time. It will be further noted that the main valve on the head end is open for lead and is traveling fast to overtake the cutoff valve which is moving in the same direction. This insures a full steam-port opening through both valves. The exhaust valve is open on the crank end and closed on the head end.

Fig. 10 shows the main eccentric M advanced to its extreme travel to the left, which allows the main valve to open full to the head-end steam port and the cutoff valve to open full on the crank end, while the piston has advanced to about 20 per cent. of its stroke. It can be found here why the cutoff valve is given wider ports than the main valve. To insure quick action on the cutoff, greater travel is given, and for unrestricted port area, the cutoff ports must be wider. It will be noted that the cutoff valve does not restrict the main-valve ports when the latter are open full to the cylinder ports, although the cutoff valve is now traveling opposite to the main valve. From this point the main and cutoff valves travel together, but the cutoff valve travels fast enough to overtake the main valve and assist in the cutoff on the head end, when the piston has reached eight-tenths or more of its stroke, as in Fig. 11. In this figure the exhaust is [illegible] closed on the crank end and traveling toward release on the head end.

Fig. 12 shows the relative positions at the point of exhaust closure on the head end. The piston has traversed about 95 or 96 per cent. of its stroke, with the exhaust closing on the crank end. On the head end release will occur immediately at about 97 per cent. of the stroke. The cutoff valve still covers the main valve ports on the head end, but the eccentric *M* is now moving the fastest and will cause the main valve to overtake the cutoff by the time the piston has reached the end of its travel. This is shown in Fig. 13, where the crank *C* has reached the crank-end dead center. Here the main valve is shown open for lead on the crank end, and the head-end exhaust is open for release.

Fig. 14 shows the crank *C* advanced to the position opposite to that in Fig. 10, but the piston is not advanced as far on its return stroke as it was for the same angle of advance of the crank *C* on the other end. In other words when the crank-end steam ports are full open, the piston is at an earlier point of its stroke than on the head end. The head-end exhaust is also shown full open.

Fig. 15 shows the main steam and cutoff valves at the point of cutoff for the crank end, the exhaust traveling toward closure on the head end. In Fig. 16 the valves have advanced to the point of exhaust closure on the head end, from which point all parts will again reach the positions shown in Fig. 9. On account of the angularity of the connecting rod, all the functions of the valve are performed at an earlier point in the piston stroke on the crank end than on the head end.

The diagrams shown in Figs. 8 to 16 inclusive, represent valve action with the governor centrifugal weights at their inner position and the cutoff eccentric *C O* in the position shown. To give a minimum cutoff the *C O* eccentric must be advanced to the position of minimum cutoff, as shown by the full line in Fig. 17, the position for maximum cutoff being shown by the dotted line. The crank *C* has advanced far enough on its travel for the piston to have moved about one-thirtieth of its stroke. At that point the cutoff valve should cut off for minimum operation. The relative positions of the other valves at this point are indicated in the drawing.

Overhauling the Engine

In overhauling an engine it would be well for the engineer to examine the exhaust-valve clamp where it fits in the exhaust valve. As a rule, considerable lost motion develops at this point and some of the travel of the valve is lost. The ends of the slots in the valves should be dressed out, and a steel plate riveted to the side of the clamp. The clamp can then be fitted snugly into the valve. Care should be taken that the valve-stem hole is parallel with the face of the exhaust valve; also note that the travel of the thrust rod, which connects to the large

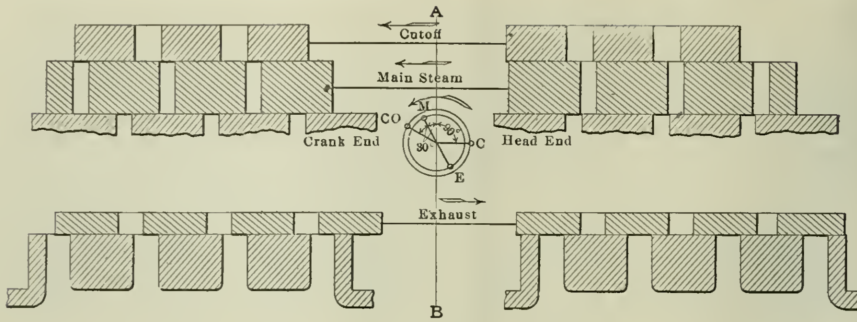


FIG. 9

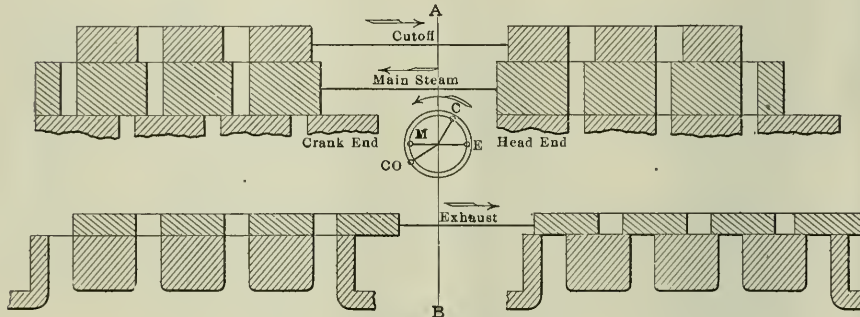


FIG. 10

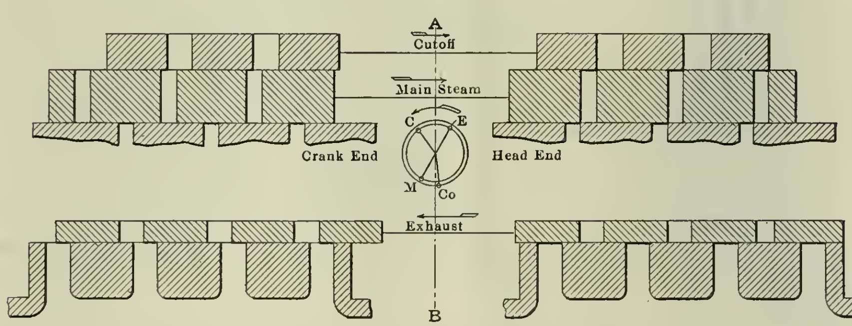


FIG. 11

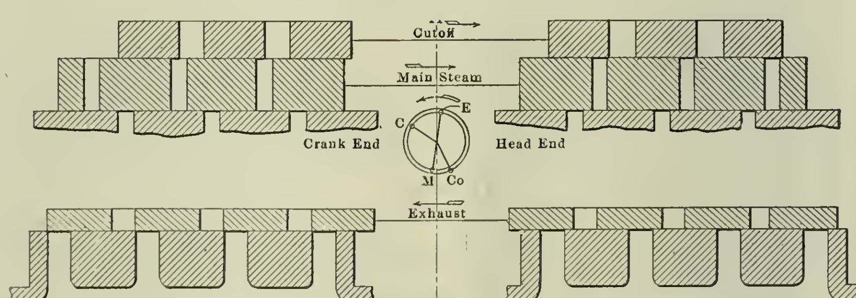


FIG. 12

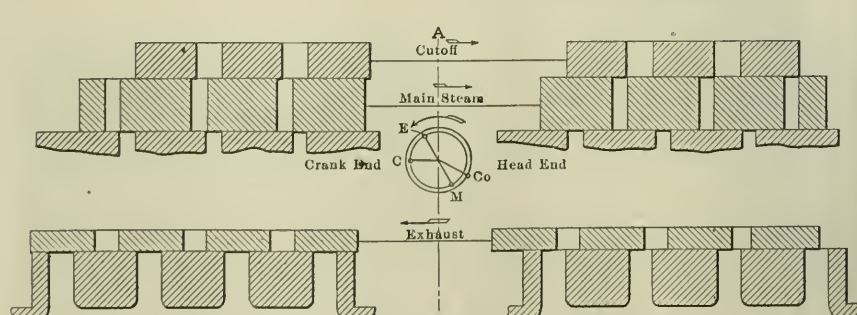


FIG. 13

bell crank, should be about 2½ inches for a 10x20-inch, up to 3½ inches for engines with 48-inch stroke. If for any cause this amount of travel is not obtained, the range of the cutoff is limited. It has been discovered on several engines where the governor had been dismantled for repairs, in the reassembling of the parts, the two knuckles that fit over the ends of the crossbar which passes through the governor shaft, had not been folded in between the two connecting links as shown at *A* in Fig. 18 or at *C* in Fig. 2. They had been connected as shown at *B*, Fig. 18, thus reducing the travel of the thrust rod about one-half, and instead of the engine being able to carry steam up to three-quarters of the stroke, the cutoff valve would close at less than one-half the stroke.

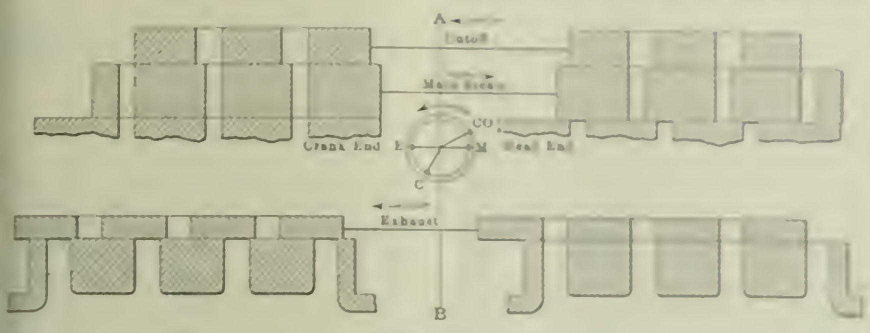


FIG. 14

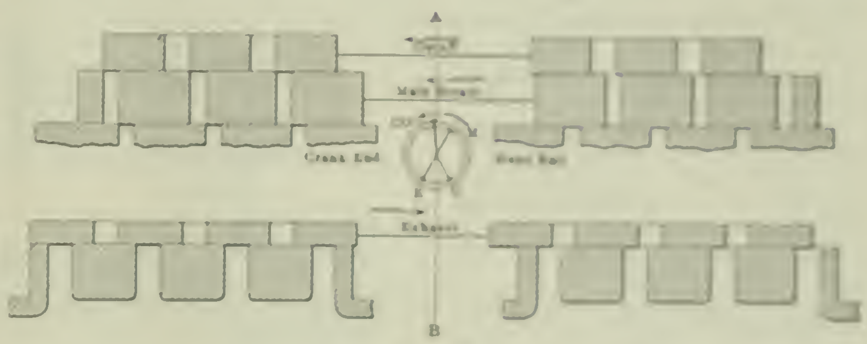


FIG. 15

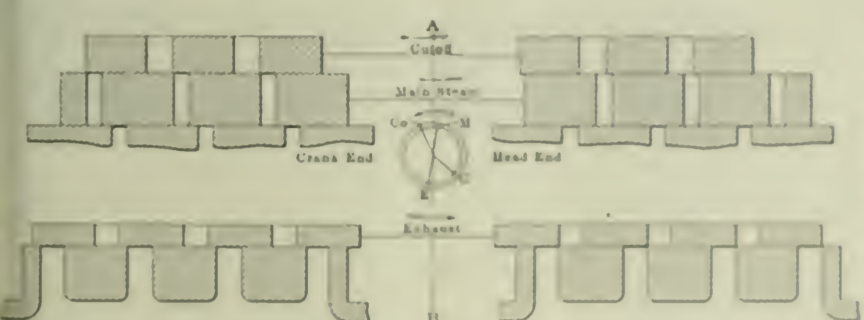


FIG. 16

FIG. 17

Setting the Valves

It will now be assumed that the engine is connected and the points mentioned taken care of. The upper half of the gear case and the intermediate gear should be removed. The weights also removed, and the spring disconnected on the bell under the engine frame. Adjust the main and cutoff eccentric so that when the eccentrics stand plumb up or down the rocker arm is in exactly a vertical position, and the cutoff slide is central in the bracket. These rods can then be secured permanently. The next step is to locate the steam valves in the relation to the ports in the cylinder and the main eccentric. Turn the eccentric shaft so that the throw of the main eccentric is on a horizontal line with the center of the shaft and toward the crank shaft. Locate and clamp the steam valve at the head end of the cylinder so that the ports show full open. Clamp the valve temporarily to the valve stem. Turn the eccentric shaft through 180 degrees, or so that the throw of the eccentric is toward the cylinder and locate the steam valve at the crank end of the cylinder in the same manner. Place the crank pin of the engine on one of its dead centers, say the one nearest the cylinder, and turn the eccentric shaft so that the steam valve at the head end of the cylinder shows about one-sixteenth lead. If the engine runs over, the relative positions of the crank pin and the eccentric will be as in Fig. 15. If the engine runs under, the pin and eccentric will be in the positions shown by the dotted lines.

The intermediate gear cover can now be placed in position, care being taken that the valve shows the proper lead when the gear is in place. Clamp the exhaust valve at the crank end of the cylinder so there will be 1/8 to 3/16 inch opening. Turn the engine in the direction it is to run. The steam valve should close at about three-fourths and the exhaust valve at about seven-eighths of the stroke. Turn the engine to the opposite dead center and adjust the steam valve on the crank end and the exhaust valve on the head end in the same manner. It may be necessary, if the exhaust valves do not open and close as desired, to advance or retard the eccentric one or more teeth of the driving gear. In case this is done the valves should be readjusted, giving them the proper lead as in the first trial. Up to this point the operation is similar to a slide-valve engine, with the exception that the steam and exhaust laps can be changed by either closing or extending the valves to their maximum extent. The setting of the cutoff valves is somewhat more puzzling, but if the following directions are carefully carried out no difficulty should be experienced.

The first step is locating the cutoff valve in relation to the steam valve and the cutoff eccentric. Turn the engine until the throw of the main eccentric is horizontal and toward the crank shaft. Now turn the cutoff eccentric, which as yet should not be connected to the governor weights, so that it stands in line with the main eccentric. Set the cutoff valve

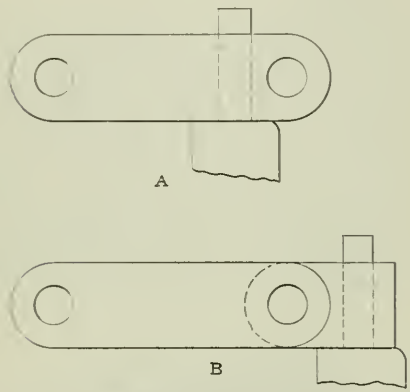


FIG. 18. A COMMON ERROR IN REASSEMBLING

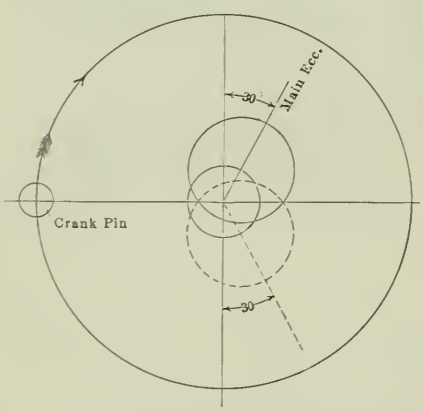


FIG. 19. RELATIVE POSITIONS OF CRANK AND MAIN ECCENTRIC AT DEAD CENTER

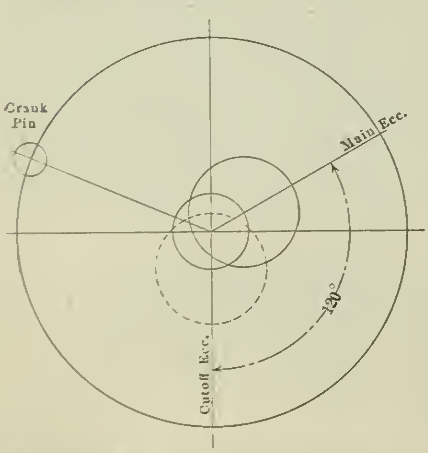


FIG. 20. RELATIVE POSITIONS OF CRANK, MAIN AND CUTOFF ECCENTRICS

at the head end of the cylinder so that its ports are lined up with the ports in the head-end steam valve as shown in Fig. 8. Rotate the engine until both eccentrics stand with the center of their throw toward the cylinder and locate the crank-end cutoff valve in a similar manner, bearing in mind that the outside ports of the steam valves are covered by the outside edges of the cutoff valves. The next step is to locate the cutoff eccentric in relation to the main eccentric.

Place the crank again on the dead center, say the one nearest to the cylinder. Now turn the engine in the direction it should run until the crosshead has traveled ¾ inch. Turn the cutoff eccentric over until the cutoff valve at the head end of the cylinder just closes the ports of the steam valve at that end. Move the governor weights out to their extreme outer position, care being taken not to disturb the position of the cutoff eccentric, and secure the weights to the cutoff sleeve by means of the clamp provided for that purpose. The relative positions of the crank, main eccentric and cutoff eccentric, if the engine runs over, will be as shown in Fig. 20. Turn the sleeve so that the weights are in their extreme inner position, and if the cutoff eccentric and valves have been properly located, the ports of the steam valve at that end will not be covered by the cutoff valves. Turn the engine again until the crosshead is in the same position at the other end of the stroke. Throw the weights out as before and if necessary adjust the cutoff at the crank end of the cylinder so that it just closes the ports of the steam valves. A slight readjustment of the valves may be necessary after an indicator card is taken.

A sufficient number of weights should be added to the bell crank to bring the engine to the required speed. The purpose of the spring on the bell crank is to give steadiness to the governor, and just sufficient tension should be given it to keep the governor from hunting.

To change the direction of rotation of the engine, the governor weights must be disconnected and reversed. The case is provided with two holes for the fulcrum pins at the ends of the weights for the new position of the weights. The valve setting will have to be entirely changed to suit the opposite direction of rotation.

Use and Abuse of Follower Bolts

By W. H. Wakeman

An engineer was sent to a distant city by a prominent engine-building firm to erect one of their large horizontal cross-compound engines. While he was assembling the parts he twisted off one of the follower bolts by bringing too much leverage to bear on it. Removing the broken stub he inserted another and broke that in the same way. Not daunted by this experience he put in another and caused it to share the same fate. The fourth victim was screwed in and practically twisted off like its predecessors, but it was down into position, and owing to the fact that the material was not completely severed, the head remained in place. The engineer sent to the shop for three more bolts, succeeded in getting them in, all other parts were assembled and the engine was started.

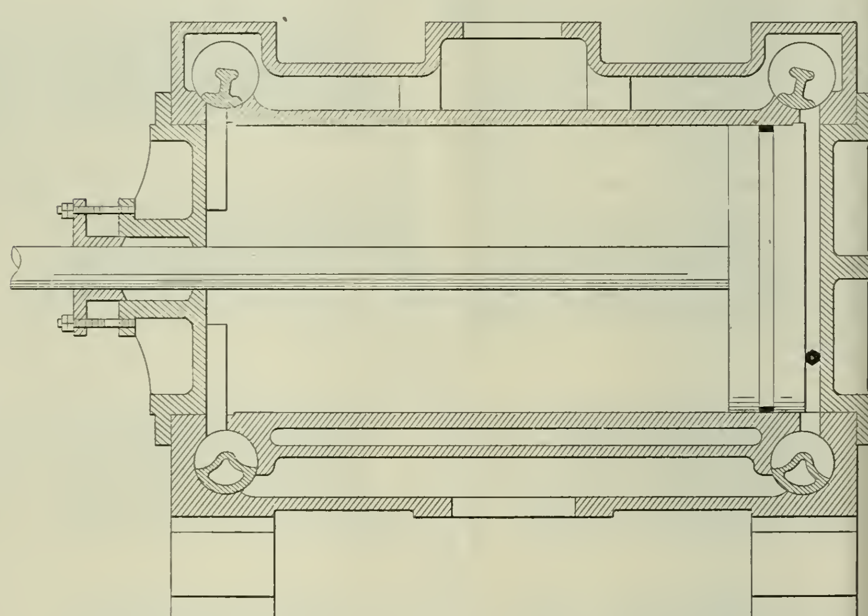


FIG. 1. SHOWING WHERE BOLT HEAD LODGED

After the engine had been in service a short time, the head of the bolt that really was broken when put in, but did not fall apart at that time, came off and, while falling toward the bottom of the cylinder, was caught between the head and the piston, as illustrated in Fig. 1. This shows that it stopped at a thin part of the head, and due consideration of the momentum of the heavy parts as shown, also of the very great leverage exerted by the crank due to its position near the inside center, makes it plain that something was broken before that piston began to move in the opposite direction. The cylinder head proved to be the weaker part; consequently, the bolt head was forced through between two webs as shown in Fig. 2, although the hole is made comparatively larger than it was originally.

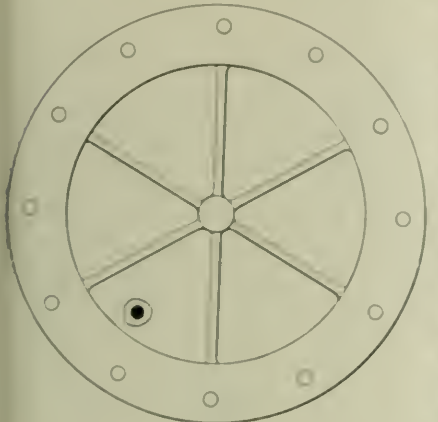


FIG. 2

The head was removed, taken to a machine shop and the ragged hole bored round. It was tapped with a 3-inch pipe tap, a plug screwed in and in $1\frac{1}{2}$ hours the engine was in service again.

There are several lessons to be learned from this incident. Of course, the follower bolts ought to have been a better fit in the threads made to receive them, but taking this condition as actually found the erecting engineer should have discovered the imperfection before he twisted off the first bolt, because they ought always to be loose enough to screw down into place without using a leverage of more than 12 inches, which is sufficient to force a bolt down properly, if it is a good fit, yet is not enough to spoil it if only a tight fit has been provided.

Having destroyed one bolt by applying too much force, there certainly was no excuse for repeating the operation once, while the repetition of it twice causing the failure of a third bolt under the same conditions shows that experience is not always a competent teacher, although failure of a scholar to comprehend the lesson presented is not always to be charged against the instructor. If we take into account the fracture of the fourth bolt, which was really accomplished the same day, the evidence of poor judgment is greater still, but this was not demonstrated until a later period.

A Defective Bolt Discovered in Time

The first engine that I had charge of was fitted with Dunbar packing rings and a follower plate held in place by four bolts. I took these out one day for cleaning and examination, and while replacing the bolts I twisted one of them until it was practically broken in two, but having a well developed sense of feeling, even while lifting on a wrench, I was aware of the fracture, or crack, before the parts became entirely separated; consequently, I not only instantly ceased turning the bolt head, but was able to turn the whole bolt backward, thus removing the lower part of it without further trouble. This was a defective bolt, as the leverage was not sufficient to ruin a sound one.

A socket wrench with a square, straight handle was made for these bolts, and I always used a monkey wrench of a certain size on this square handle, as shown in Fig. 3, which is a plan of the cylinder and piston. From this handle to the place where force was applied by hand was 10 inches. For about 30 years I have used a similar wrench on various engines, and have not increased the leverage mentioned. Having never fractured another follower bolt, nor had one work loose in practice during this time, it is good evidence that the rule adopted is practical and safe to follow.

Intelligent Application of the Wrench Requisite

A little practice in connection with intelligent application of the wrench used, and due observation of results secured will enable any engineer to avoid much of the trouble and worry that we frequently hear of along this line. For illustration, when screwing in a follower bolt, it is not difficult to decide whether it is binding in the threads, or if it is going in loosely until the head strikes the follower plate. In the former case it ought to be taken out and a suitable tap turned into the hole, or, if this is not practicable, a die may be used to cut the threads down until the bolt will fit tight but still will go in until the head holds the light of a tallow dip or a smoking petroleum oil lamp, in the very early morning, after some weary hours of labor on repair work; therefore, the tendency is to be less careful than under better conditions. If a follower bolt is too tight it may still have sufficient torsional strength to be forced into place without fracture, but remember that the action of steam tends to fasten it more securely in place, and the time will surely come when somebody will have to take it out. Due consideration of the "golden rule" and the possibility of having to remove it yourself should be sufficient to prevent leaving it in bad condition.

If the bolts are too small there is usually but one remedy, which is to put them in and get the engine started on time, but measurements ought to be taken and new bolts made without delay. Put them in place, not the first chance that is presented to find the engine dismantled for some other purpose, but make an opportunity in the very near future.

In any case where five or more follower bolts are used in a piston, it will do no harm to leave one out for a day to be used as a model by which to make new ones that are a snug fit in a hole in a piece of cast iron tapped out for the purpose, into which the old bolt is a loose fit. Of course, it is better to use micrometer calipers if they are available, but having completed many such jobs in a satisfactory manner with only common and inexpensive tools, it seems appropriate to make suggestions along this line for the benefit of others. Although expensive tools are now available for making repairs in one plant, there is pleasure sometimes in using less advanced methods where good results are secured, and I am free to admit that in some cases the work is done in less time than a more scientific but less practical machinist would require.

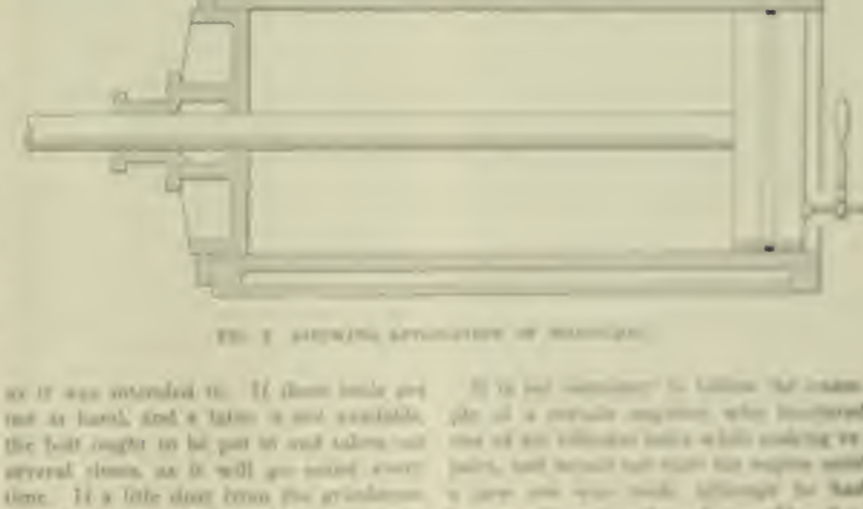


FIG. 3. SHOWING APPLICATION OF WRENCH

as it was intended to. If these tools are not at hand, and a lathe is not available, the bolt ought to be put in and taken out several times, as it will go easier every time. If a little dust from the grindstone trough is put on the threads it will assist in shortening the time required to make a good fit. Personal experience has taught me that such jobs are frequently done by

It is not necessary to follow the example of a certain engineer, who fractured one of his follower bolts while making repairs, and would not start the engine until a new one was made, although he had been given time to do so. The day was lost because he [illegible] his [illegible] in the engine room, [illegible] the loss of many dollars.

Blowing the Works Whistle Automatically

Interesting Description of an Arrangement for Doing This, without Depending upon the Human Element, Except to Wind the Clock

BY FRANK SAWFORD

There are probably very few works of any pretensions without a steam whistle for giving the signal to start or quit work, as the case may be; ranging from the small shrieker for the little shop, to the deep-toned chime whistle for the large works. In most cases the whistle is left to the care of the watchman or fireman, who pulls a string at the appointed time, and very often the only guide he has to rely on for indicating the appointed time is a pocket timepiece of greater or less reliability.

It is thought the following description of an arrangement for blowing the whistle automatically, and dispensing with the human element entirely, except so far as is necessary to wind and check the clock, will be found useful in many works. The arrangement consists of four principal parts: the whistle, the magnet for blowing it, the relay for closing the circuit and the clock.

The clock may be of any pattern desired, but should preferably be of the regulator type, with a pendulum beating seconds, and should be capable of keeping time to within five seconds per week. An additional wheel is required in the clock movement making one revolution in 24 hours, and also a circuit-closing arrangement to operate the relay. The relay in turn closes the power circuit and operates the whistle magnet. The clock should be placed in a suitable position, where it will be free from vibration and where it can be readily checked and corrected. The office is the best place.

The relay may be near the clock or the whistle magnet, as may be desired, the only connections required being a pair of wires from the clock and another pair to the magnet. The magnet should be placed as near to the whistle as possible, and connected to the whistle valve by a small flexible steel wire or chain.

The whistle will, of course, need to be above the roof of the boiler house, and steam should always be left on right up to the valve, the valve being attached to the whistle, and the bottom of the pipe should be drained to insure dry steam. The whistle will then respond promptly when operated. If there is much pipe exposed to the open air above the roof of the boiler house, it is preferable to have the pipe well lagged with nonconducting composition, for, if it is left bare, it is quite possible that considerably more steam will be condensed than will be used by the whistle.

The Clock

Referring to the sketches and taking in hand the clock first, Fig. 1 shows an outline of the circuit-closing device fitted to the movement, *A* being the minute hand, *B* the hour hand. On the minute-hand arbor is fixed the double cam *C* on which rest two ⅛-inch diameter steel rods *D*. These rods are fitted into little hard-rubber blocks *E* which insulate the rods from the clock frame, and from each other. The rods are held by small pinching screws in the rubber blocks. A piece of

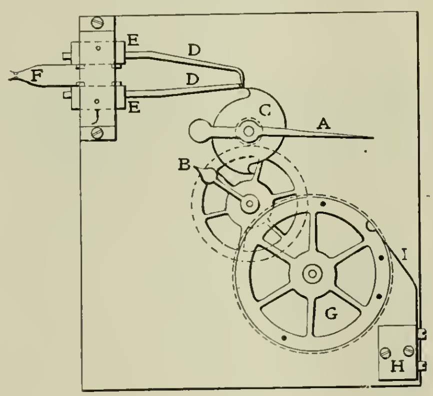


FIG. 1. CIRCUIT-CLOSING DEVICE FITTED TO CLOCK MOVEMENT

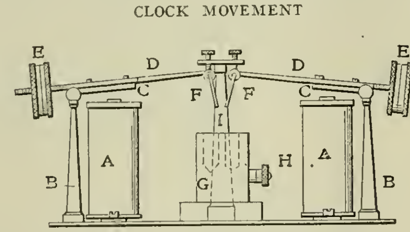


FIG. 2. THE RELAY

steel rod, shouldered at each end to form pivots, is fitted tightly into each rubber block at right angles to the steel rods *D*, and insulated from them. The complete rods are mounted in the brass frame *J*, which supports the pivots at the front end, the rear-end pivot being supported by the clock plate. At *F* are shown the contact springs, of phosphor bronze about 0.005 inch thick, with small platinum tips at the outer ends, the inner ends being secured to the hard-rubber blocks by two small screws. The action of this arrangement will be apparent. Upon the cam *C* advancing, the lower of the two rods *D* falls, bringing the bronze spring *F* into contact, and closing the circuit. The circuit is again broken when the upper rod falls.

The duration of contact may be made as long as desired by adjusting the distance between the ends of the rods *D*. The ends of the rods *D* which rest on the cam *C* should be bent at right angles, so as to lie across the cam, and both the tips of the cam and the ends of the rods should be filed square to knife edges to allow the rods to fall clear and also to permit a close adjustment. If nicely fitted, the duration of contact may be made as short as five seconds if desired. This make and break will take place every half hour.

Another contact-making device is necessary to complete the circuit at the times when it is desired to blow the whistle. On the arbor of the hour hand *B* is fitted a pinion meshing into a wheel *G*, which should have a ratio of 2 to 1, wheel *G* thus making one revolution in 24 hours. If wheel *G* has 48 teeth and the pinion on *B* 24 teeth, each tooth on *G* will correspond to half hours. This will be found very convenient for locating the contact pins, which are of brass about 1/16 inch in diameter by 3/16 inch long, riveted into the rim of the wheel *G*. The positions of the contact pins on the wheel rim may easily be found by dividing the rim into 24 parts corresponding to 24 hours and fitting the pins at the times it is desired to blow the whistle. At *H* a hard-rubber block is secured to the clock frame. This rubber block carries a phosphor-bronze spring *I*, which makes contact with the brass pins in wheel *G*. It is not necessary to have a platinum tip on this spring, as, owing to the revolution of wheel *G*, a rubbing contact is obtained and the pressure of the spring may be made comparatively heavy, the thickness being preferably about 0.025 inch.

The action of these two contacts is as follows: Contact is made by cam *C* every half hour, and the duration of this contact is made as long as it is desired to blow the whistle. This half-hour contact is connected in series with the contact on wheel *G* and spring *I*, and current cannot flow until both contacts are made, and it is interrupted when either contact is broken.

Thus the whistle blows at the times determined by the pins on *G*, and for a length of time as determined by *C*. If it is desired to blow a code call, this could easily be arranged fo by providing a suitable cam at C. The rest of the clock may be of ordinary first class construction and calls for no description beyond that previously given.

The Relay

The relay, Fig. 2, which is operated by the clock circuit-closing device, and which in turn operates the whistle magnet, should be capable of being operated by about six ordinary dry cells, and should have magnets and contacts in duplicate, to eliminate the chances of failure as much as possible. The type shown in Fig. 2 was adopted by the writer and proved very satisfactory. As may be seen it is extremely simple. The magnet spools *A* are 1 inch in diameter by 2 inches high, and wound with No. 28 Brown & Sharpe silk-covered copper wire, the cores being 3/8-inch diameter soft steel, with hard-rubber washers fitted tight at each end

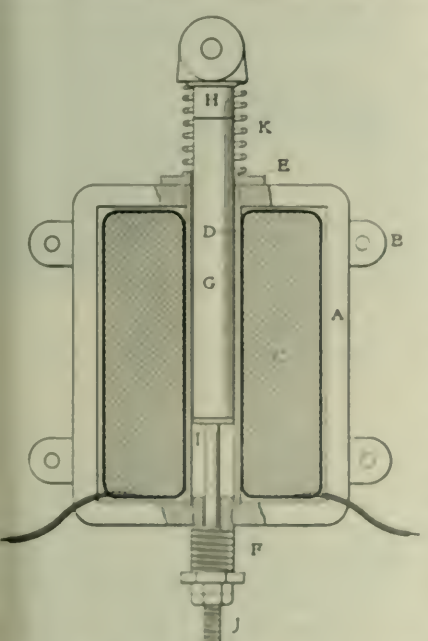


FIG. 3. SECTION THROUGH WHISTLE MAGNET

to form the spool. The soft-steel cores are riveted to a yoke of similar material 1 inch wide by 1/8 inch thick. The complete magnets are secured to a brass baseplate by screws through the yoke. The armatures *C* are of the same size and material as the yokes, and are mounted above the magnets *A* on brass edges which fit loosely into holes drilled in the top end of *B*. Across the armatures and at right angles to them are secured brass rods *D*, 1/4 inch square, the outer ends being turned and screwed to carry the adjustable counterweights *E*, and the inner ends carrying the forked pieces *F*. These forks are simply small pieces of No. 14 Brown & Sharpe gage copper wire fitted through hard-rubber bushings in the ends of the rods *D*, the ends of the forks pointing downward. At *G* are shown two mercury cups. These cups are brass blocks secured to a hard rubber base and have two 3/8-inch holes drilled in the upper end of each to contain the mercury, and a terminal *H* for connection to the circuit.

At *I* is a brass pillar carrying a cross piece on top with two small adjusting screws, as shown. Normally the ends of the rods carrying the forks *F* are held up against the adjusting screws by the counterweights *E*, the hight of these adjusting screws determining the distance between the forks and the mercury cups, and also the distance between the armatures and the poles of the magnets. The distance between the forks and the mercury cups should not be less than 1/8 inch, and not more than 1/4 inch between the armatures and the poles of the magnets. Any desired adjustment within these limits may be made by means of the counterweights *E* and the adjusting screws on *I*.

The two pairs of magnets *A* are connected in parallel to the wires from the clock, and the mercury cups *G* to the whistle circuit. When the clock circuit is closed, the magnets *A* pull the forks *F* into the mercury cups *G*, which closes the whistle-magnet circuit, and upon the clock circuit being again opened the counterweights *E* pull the forks out of the mercury cups up to the screws on *I*. The counterweights should be adjusted so as to pull the forks up smartly, but not heavy enough to prevent the magnets operating the forks. A drop of oil should be floated on top of the mercury in the cups *G* to prevent oxidation by the arc formed on breaking the whistle-magnet circuit. All of the various parts are mounted on a brass baseplate of suitable size, and should be fitted into a dust-proof box with glass top and sides.

Whistle Magnet

This is of the solenoid type and is shown in section in Fig. 3. At *A* is the magnet yoke which is a rectangular forging and has four lugs *B* attached for mounting. The coil *C* is fitted into the yoke *A* and is wound on a wooden former about 1 1/4 inches in diameter with No. 20 Brown & Sharpe silk-covered copper wire and the completed coil should measure about 4 inches in diameter by 6 inches long. The former is removed after winding, and the coil completely covered by linen tape wound lengthwise through the hole and round the outside, and then varnished. Short pieces of flexible lamp cord should be soldered to the ends of the winding to facilitate connection to the circuit. The coil is held in position within the yoke by a brass tube *D* which should be a moderately tight fit inside the coil.

The brass tube is secured by a brass plate *E* screwed to *A* by two small screws, the bottom end of the tube *D* being let into a recess 1/16 inch deep in the yoke *A*. At *F* is an adjustable plug with a check nut screwed into the yoke *A* and entering into the tube *D*. The soft-steel plunger *G* has a brass head *H* screwed and pinned into the top end, the bottom end having a brass washer *I* soldered thereto. A short piece of 1/4-inch brass rod *J* is also screwed tight into the bottom end of the plunger, this rod passing loosely through the plug *F* and having two nuts as shown. The brass spiral compression spring *K* holds the plunger up in its highest position, that is, with the nuts on *J* resting against *F*. Upon the coil *C* being energized, the plunger *G* is pulled downward against the tension of spring *K* until the washer *I* strikes *F*. The function of this washer is to prevent the plunger sticking to plug *F* by the residual magnetism retained in the magnetic circuit, thus insuring a prompt return of the plunger when the coil is deenergized.

The stroke of the plunger may be varied by adjusting the nuts on rod *J*, and the most effective pull of the plunger is found by adjusting plug *F*. A hole is drilled through the top end of *H* for

FIG. 4. DIAGRAM OF CONNECTIONS

attaching the cords or chain leading to the whistle valve. Care must be taken that the cord leads straight in line with the center line of the plunger to allow it to work freely, otherwise sufficient side strain might be put on the plunger to prevent its working. The plunger should be 15/16 inch in diameter, and the bore of the brass tube 1 inch.

The whistle calls for no special description beyond that already given, except that the valve should operate freely, and the cord should be led from the whistle lever at the most effective angle. The magnet is powerful enough to operate any size of whistle which can be operated by hand. The larger sizes of whistle usually have a small pilot valve to operate the main valve.

Electrical Connections

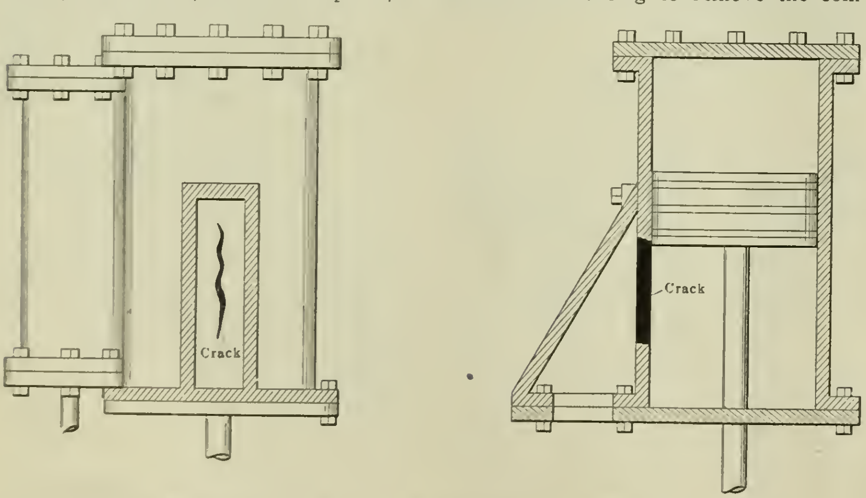
Fig. 4 shows a diagram of connections, *A* being the clock, *B* the relay and *C* a six-cell battery of ordinary dry cells; *D* is a single-pole switch for cutting out the relays when it is desired to stop the whistle; *E* is a pair of terminals which may be used to connect to a fire-alarm system, or to a push button; *F* is the whistle magnet, and *G* a double-pole switch for connection to the power circuit.

The magnet as described is suitable for connection to a direct-current circuit of 110 volts. For any other voltage the winding of the coil may be modified accordingly. This apparatus may appear somewhat elaborate from this description, but it may be said that a similar rig has been in use for many years, and has never been known to fail, and moreover has had practically no attention beyond winding and adjusting the clock.

A Split Cylinder on the Steamship "St. Paul"

The fact that the American line steamship "St. Paul" arrived at New York two days late upon a recent trip was attributed by the press to stress of weather, but was partly due to a cracked high-pressure cylinder.

Steam was reported coming in considerable quantities from the high-pressure gland of the port engine and a shutdown was ordered. An examination showed that the steam was not coming from the gland, but from an opening in the bottom of a bracket, as shown in the accompanying sketch. The bracket was hollow, and a crack, which was open 1/16



SHOWING THE CRACK IN A CYLINDER ON THE STEAMSHIP "ST. PAUL"

of an inch and 2½ feet long, connected its interior with that of the cylinder.

The high-pressure cylinder was cut out by blocking the piston valve in the mid-position and admitting the steam directly to the first intermediate receiver. The revolutions were cut down on this engine to 66 per minute, but the full speed of 86 revolutions was kept up upon the starboard engine. Some six hours was occupied in making the repairs. The piston rings in the high-pressure piston were found broken, and one of them jammed over another in the same slot.

Catechism of Electricity

923. *If the commutator is eccentric or too rough to be smoothed evenly by means of a file, what should be done with it?*

It should be turned down in a lathe. If the armature is large and difficult to remove from the machine, a portable lathe or truing device can be attached directly to the shaft of the armature as shown in Fig. 282, and the commutator turned down without removing the armature from the motor. The armature should be held stationary and the device revolved around the commutator by hand, using the shaft as a bearing. The tool is moved across the commutator by a screw feed actuated by a detent clamped to the shaft.

If the armature is small and easy to remove from the machine, it should be placed in an ordinary stationary lathe and the commutator turned down in the usual manner.

924. *In case it becomes necessary to remove the commutator from the armature, how should this be done?*

The simple device shown in Fig. 283 is convenient for this purpose. It consists of two pieces of iron *c* and *c*, shaped to fit back of the collar *b* on the commutator spider. Through holes in the ends of *c* and *c* are passed bolts *e* and *e*, and over the outer ends of the bolts is slipped the bar *f* which bears against the shaft *d*. Before commencing to remove the commutator it is necessary to have all the wires disconnected from it. By screwing up the nuts *g* and *g*, the spider and commutator will be drawn off. After producing the first strain on the bolts, however, it may be necessary to give the commutator a light rap to start it.

925. *What characteristic features are present when the sparking is caused by weak field magnets?*

The speed of the motor will be unusually high with weak field magnets unless the magnetism is very low or lacking altogether, in which case the motor will run very slow, stop or perhaps run backward. If the pole pieces are tested by holding a piece of soft iron near them there will be little if any attraction.

926. *How may the trouble be definitely located?*

Place wooden chips under the brushes so they do not come in contact with the

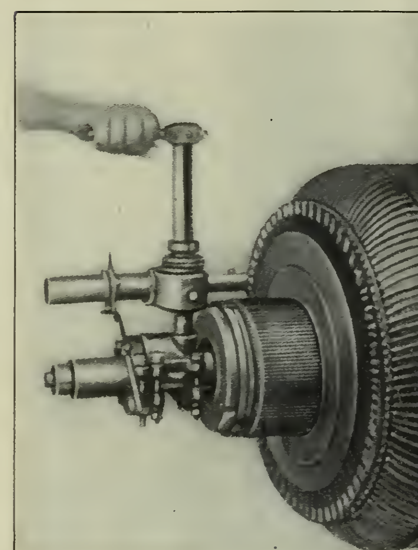


FIG. 282. COMMUTATOR-TRUING DEVICE MOUNTED ON THE ARMATURE SHAFT AND OPERATED BY HAND

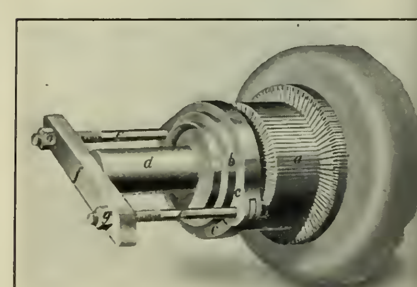


FIG. 283. SIMPLE DEVICE FOR REMOVING THE COMMUTATOR FROM THE ARMATURE

commutator, and with the field rheostat short-circuited, close the field coils upon the supply circuit. If upon opening this circuit there is no spark there is a broken wire or connection somewhere in the circuit. If there is a spark the circuit is not broken, but one of the magnet coils may be short-circuited. This may be determined by testing with a piece of soft iron which when held between the pole piece of the short-circuited coil and the adjacent pole piece will be attracted to the latter, but not to the former. Another method of testing for a short-circuited field coil consists in passing a current through the field circuit and measuring the drops of potential across the different coils. A short-circuited coil will show little or no drop in comparison with he others. A short-circuited coil may be caused by its wire being grounded at two points on the frame.

One of the field coils may be reversed, producing a weak field. This can be determined by passing a current through the field circuit and moving a compass needle from one pole piece to the other in succession. The needle will reverse its direction at each succeeding pole if none of the coils is reversed.

Condenser and Back Pressures in Refrigerating Plants

By F. E. Matthews

How does a refrigerating engineer know when the condenser pressure and back pressure of his plant are right for most economical operation? What are the proper pressures?

In general, with an engineer who is familiar with the underlying principles on which the efficiency of refrigerating systems depends, it is largely a matter of judgment. Such judgment must be based on knowledge of the temperature of the condenser water, whether there is sufficient condenser surface for the compressor and whether or not the condenser pipes are free from uncondensable foreign gases. With these things known to be right, condenser pressure for different temperatures of cooling water should be approximately as follows:

1 gallon per minute per ton per 24 hours—							
Temperature of cooling water, degrees F	60	65	70	75	80	85	90
Condenser pressure, gage, lb	153	200	220	[illegible]	[illegible]	[illegible]	[illegible]
Temperature of condensed liquid ammonia, degrees F	95	100	10[illegible]	110	11[illegible]	[illegible]	[illegible]
2 gallons per minute per ton per 24 hours—							
Condenser pressure, gage, lb	130	1[illegible]	168	18[illegible]	200	[illegible]	[illegible]
Temperature of condensed liquid ammonia, degrees F	77	85	90	[illegible]	[illegible]	[illegible]	118
3 gallons per minute per ton per 24 hours—							
Condenser pressure, gage, lb	125	140	1[illegible]	170	18[illegible]	[illegible]	215
Temperature of condensed liquid ammonia, degrees F	75	85	90	95	[illegible]	[illegible]	[illegible]

Similarly, the evaporating or back pressure within the expansion coils of a refrigerating system depend upon the temperatures on the outside of such coils, i. e., the air or brine to be cooled. For average practice back pressures for the production of required temperatures should be approximately as follows:

Temperature of room, degrees F		10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Back pressure, gage, lb	[illegible]	10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Temperature of ammonia, degrees F	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

In every event the condenser pressure should be kept as low as possible and the back pressure as high as possible, narrow limits between such pressures being as important to the efficiency of a refrigerating system as wide ones are to that of a steam engine in which the economy increases with the range between boiler pressure and condenser pressure.

The full importance of this truth is seldom recognized by either the operating or the supervising engineer, and neither strives for the last pound of increased back pressure half so diligently as for the last inch of vacuum in the steam condensers, although the pressure is of relatively far more importance than the latter in its effect on the general efficiency and economy of the plant.

As regards both condenser and back pressure, the limit that should be striven toward, but which, of course, can never be reached, and produce work, is when the pressures in the condenser and expansion coils, respectively, are such that the corresponding liquid temperatures are the same as that of the condenser cooling water and the cold-storage brine temperature, respectively, to be produced.

Atmospheric ammonia condensers employed in temperate climates where cooling water of from 55 to 70 degrees Fahrenheit is available usually contain about the square feet of heat radiating surface per ton, and as indicated in the first table, are cooled by from one to three gallons of water per minute per ton per twenty-four hours.

Not only does the amount of cooling water required per ton vary with its temperature, but also with the cooler temperatures required and the condensing pressure encountered.

If, for example, a cooler is to be maintained at 20 degrees Fahrenheit, a back pressure of 15 pounds is to be carried resulting in 0 degree ammonia within the expansion coils, and the head pressure be 145 pounds, only 0.75 gallon of cooling water will be required, provided it be sufficiently cool to rise 20 degrees in temperature and still be 10 degrees cooler than the temperature of the condensed ammonia corresponding to the pressure.

Now, the temperature corresponding to 145 pounds head pressure is 82 degrees Fahrenheit, so that 82 − 30 = 52 degrees, the required temperature of the cooling water.

Where there is only one temperature to be produced in the cold-storage compartments a back pressure is usually carried, such that the temperature corresponding to that pressure will be about [illegible] degrees Fahrenheit below that of the cooler temperature. Under average operating conditions the cost of the amount of expansion pipe required to allow of this range in temperatures balances up fairly well with the loss in efficiency that would be encountered if less expansion piping were installed and a lower back pressure carried.

Where several different temperatures are to be maintained with one back pressure no fixed rule can be followed, and each individual case must be figured out separately. If only a small per cent. of the total cooling work be low temperature, it is usually advisable to reduce the temperature range between the liquid ammonia and the surrounding air making up for the reduced range by the installation of inversely proportionately more pipe. In this case the expenditure of an abnormal amount of pipe in a small per cent. of the entire duty allows of an increase in efficiency of the entire plant.

While the necessity of producing a low temperature in a single box reduces the efficiency of the entire plant—or that part of it which is required to carry the low back pressure because of that low temperature—there is a slight compensation for the decreased efficiency in the way of decreased first cost of expansion piping for the higher temperature boxes. The ammonia pressure and temperature being reduced in order to cool the low temperature box may be sufficiently colder than the high-temperature boxes as to allow the pipe surface in the high-temperature boxes to be reduced often as much as [illegible] per cent. This condition would obtain when the difference between the ammonia and the high-temperature boxes becomes 41 degrees Fahrenheit.

In general, the engineer should endeavor so to manipulate his expansion valves as to carry the highest back pressure possible and still produce sufficient refrigeration in his coldest coolers. The limit to possibilities in this direction is when no more ammonia feed can be put on the expansion coils without causing liquid ammonia to return to the compressor, causing it to pound and the ammonia rod stuffing boxes to leak.

The back pressure can be carried materially higher and the efficiency of the plant can be materially increased by keeping the expansion coils free from the insulating effect of ice on the outside and oil on the inside. Opportunity should be taken to remove the oil from the expansion coils every two or three months at most, and oftener if a considerable oil is thought to have worked into the system.

If the engineer is always on the alert he can [illegible] opportunity to shut his machine down for a few hours sufficiently often to allow the ice to melt off the expansion coils, not only allowing the system to operate more economically when it is running but also to save a considerable number of hours operation without [illegible] temperatures and consequently materially reducing the operating expenses of the plant.

[illegible] the refrigerating effect of [illegible] by [illegible] down expansion [illegible], reducing the back pressure, and [illegible] away [illegible] the refrigeration is not needed, [illegible] the doors of the various boxes will [illegible] than they are a little colder than required, [illegible] down the machine. [illegible] will be surprised at the saving that can be effected.

Inaccuracies Due to Drum Motion Distortion

A Practical Analysis of This Cause of Errors in Indicator Diagrams, with Results of Tests to Determine Their Magnitude in Various Cases

BY JULIAN C. SMALLWOOD*

Everyone who has considered the subject is aware that that exceedingly useful device, the indicator diagram, is full of errors. The straight-line motion of the indicator and the apparatus for reducing the motion of the engine crosshead may be faulty in principle or workmanship, or both. The indicator spring rarely records steam pressures truly and the drum motion does not, by any means, accurately correspond with that of the crosshead. Of these four sources of error, however, the first three are under control and, if they exist, constant. Thus, a high degree of excellence in workmanship may render negligible any errors in the duplicating and straight-line motions when their design is correct. Indicator springs may be accurately calibrated and compensation made for their error. But inaccuracies due to drum-motion distortion are neither constant for different conditions of speed nor easily determined for particular ones. Therefore these inaccuracies are worthy of special attention. It is the purpose of this article to make an analysis of them and to present the results of tests made to determine their magnitude under different conditions.

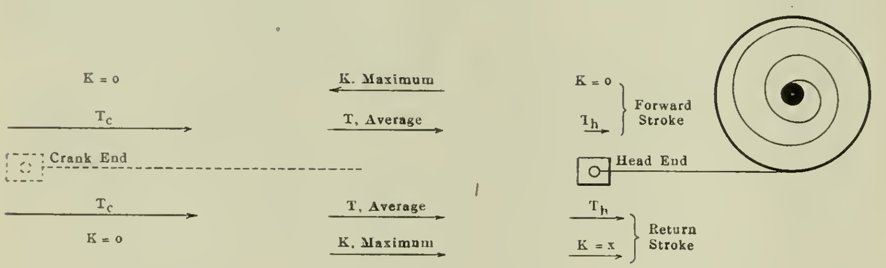


FIG. I

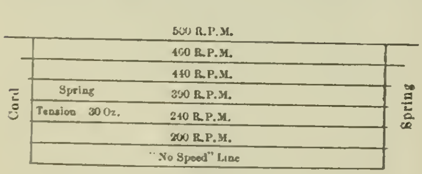


FIG. 2

It is well first to consider the cycle of events in the nature of an indicator and the forces controlling it. Fig. I represents a plan section of a drum, the string of which is attached to the pin of a device to reduce the movement of the crosshead of an engine to the length of the indicator diagram to be taken. The pin is shown at the head-end dead center in full and the dotted figure represents the other end of its stroke. The spring is shown by the spiral, one end of which is fastened to the drum, the other to the axis upon which the drum oscillates. Beginning at the head-end dead center there is a certain pull in the cord which is resisted by the spring tension T_h at this point. As the crosshead moves to the left, this tension will increase in a rate proportional to the extension of the spring, becoming maximum, T_c, when the drum has revolved as far as it will go in a clockwise direction. Thus the average value of the spring tension is $(T_h - T_c) \div 2$. The work done by this force is expended in overcoming the kinetic energy of the drum. This latter varies as the square of the drum's speed. Now, the motion of the crosshead is approximately harmonic and therefore the velocity of the drum is zero at the extreme positions of its travel and maximum in its mid-position. These forces are represented in Fig. I by the arrows. It is obvious that the least distortion will ensue when the maximum value of K (or the force of acceleration at mid-stroke) is just balanced by an average drum-spring tension.

Considering, now, the reverse motion, it is seen that the spring tension is the only force acting and that it is maximum at the crank-end dead center and diminishes in the same way as it has increased. This force imparts kinetic energy to the drum which stores part of it until the end of the cycle, when it is delivered in an effort to stretch the cord. The tension T_h also operates to do the same.

In the foregoing discussion no attempt has been made to point out the inaccuracies of the drum motion between its limits, the object being to determine the deformation only at the ends of the stroke. It will be seen that this is dependent upon five quantities, namely, the spring tension, the revolutions per minute, the elasticity of the cord, the mass of the drum and the length of the diagram, the first and last of which may be conveniently varied to suit any particular conditions. Further, the deformation at the crank end will be produced by an abnormal stretch of the spring, while that at the head end will be permitted by the elasticity of the cord. The former may be expected approximately to vary directly as the mass of the drum, length of diagram and square of the revolutions per minute, and inversely as the spring tension. Similarly the latter will vary directly as the spring tension and the elasticity of the cord.

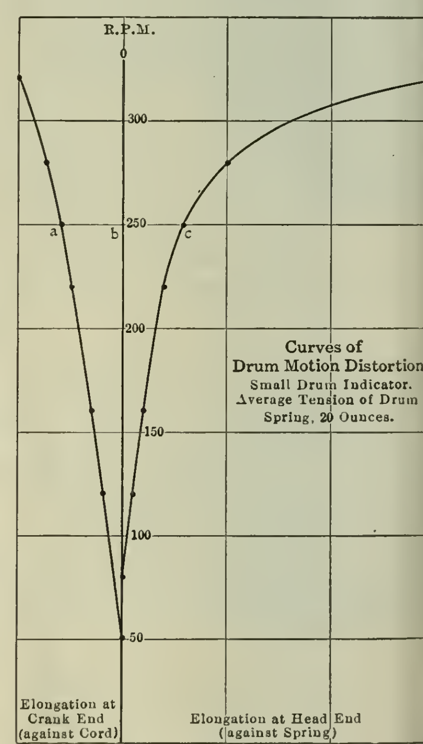


FIG. 3

To Minimize Drum-motion Distortion

It follows from the above considerations that to reduce drum-motion distortion to its minimum it is necessary to have the mass of the drum as small as possible, the

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cord as nearly nonelastic and as short as may be and the reducing motion such as to give the smallest diagram that will be convenient to use. Further, and more important, the spring tension should be adapted to the speed of the engine to be indicated, so that its average value just balances the force of acceleration of the drum in its mid-stroke and is no greater, for, if it is greater, the effect will be to increase the deformation due to the stretch of the cord.

With these considerations in mind an attempt was made to measure by tests the magnitude of the deformations produced by drum-motion distortion. The results of these tests are presented by the curves accompanying this article. Two indicators, whose drums were of different weights, were used. They were connected to a crosshead of 4 inches stroke which derived its motion from a small motor supplied with a heavy flywheel to obtain uniformity of rotation. Speeds were varied through fine gradations by changing the motor resistances and braking the crank shaft. Determinations at various spring tensions were made, each set being begun by making two vertical lines with the indicator pencil at the ends of the "no-speed line." In this way overtravel at each end could be determined, care being taken to keep the diagram in one position on the drum for each run. Fig. 2 shows one of the diagrams taken. The results were plotted as shown in Fig. 3, where horizontal distances represent percentages of elongation laid off to either side of the vertical zero line, and vertical distances represent revolutions per minute. Thus the groups representing the action of the

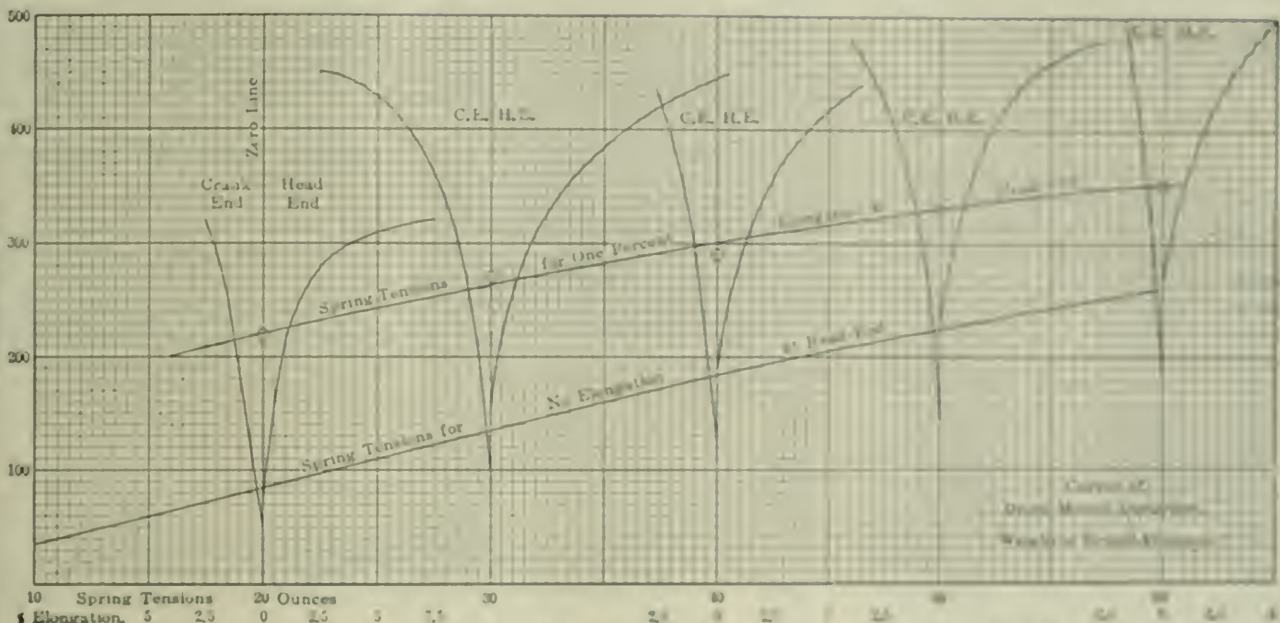


FIG. 3

lighter of the two drums tested with an average spring tension of 20 ounces, shows that up to 50 revolutions per minute the drum follows the reduced motion of the crosshead very closely, but that above this speed the distortion at the crank end, against the stretch of the cord becomes measurable and increases rapidly with increasing speed. The elongation on the head end against the tension of the spring does not begin until a speed of 80 revolutions is reached. At 250 revolutions the elongation at the head end is equal to *a b*, and on the crank end to *b c*, each equal to about 1½ per cent. At a little above 300 revolutions the fling is sufficient to throw the drum against the stops on the head end and no increase of speed would be practicable at this drum tension.

Diagrams Made with Different Spring Tensions

In Fig. 4 a number of such diagrams made with different average spring tensions are grouped upon the same chart for each of the two drums. The points at which distortion begins upon the head end are formed by the curve *A B*, which represents, therefore, the number of revolutions per minute at which overtravel at the head end commences for any particular spring tension. Another curve is drawn through the points at which head-end elongation is 1 per cent. Overtravel at the crank end is ignored, since it is permitted by the stretch of the indicator cord which is in turn dependent upon its length and texture. It would therefore be impracticable to apply a general rule for setting the drum spring for this end.

The weight of the moving parts of the heavier indicator drum was found to be about 37 per cent. greater than that of the lighter.

The indicator cord used in the tests was 2 feet long. Although of very good quality, it showed in a preliminary test a stretch of 0.05 of an inch per foot per pound dead weight, and this after it had been previously stressed.

Inspection of the curves may astonish some engineers who are accustomed to place unquestioned reliance upon the truth of indicator diagrams. The inaccuracies shown, however, may easily be verified by a simple trial. It appears that deformation begins with comparatively low speeds and that the speed corresponding to the beginning of deformation increases with the increase of spring tension. With low spring tensions the deformations become enormous at high speeds. It will be noticed, too (considering the curves for the lighter indicator), that though the deformations at the two ends of a diagram are nearly equal immediately after the critical speed has been reached, beyond this the elongation due to overtravel against spring tension becomes greater in a progressive ratio. This is as would be expected since the cord is limited in its elasticity, while the spring is not. The difference is not so marked in the curves for the heavier indicator, but this is probably due to the fact that higher spring tensions here are needed to overcome the inertia of a greater mass. Thus, upon the return stroke both T_h and K have a greater value than would obtain in the small drum, and the cord stretches accordingly. And, finally, it may be observed that the head-end elongation varies approximately as the square of the speed, that the crank end varies at a somewhat lower rate and that the head-end elongation at constant speed varies nearly inversely as the spring tension.

Consider, now, the error introduced into an indicator diagram by the inaccuracy of the drum motion. Fig. 5 represents a diagram which has 3 per cent. elongation at one end and 1 per cent. at the other. An inspection of the curves will show that this amount of distortion may ordinarily be met with. The mean ordinates obtained from the distorted and correct diagrams are 1.06 and 1.03 inches, respectively; that is, an error of about 3 per cent. In measuring the cutoff from such a diagram it will readily be seen that the error may be still greater. In some cases, however, the error due to increased area of the indicator diagram may be offset by the increased base length, so as to make the error in the mean hight negligible.

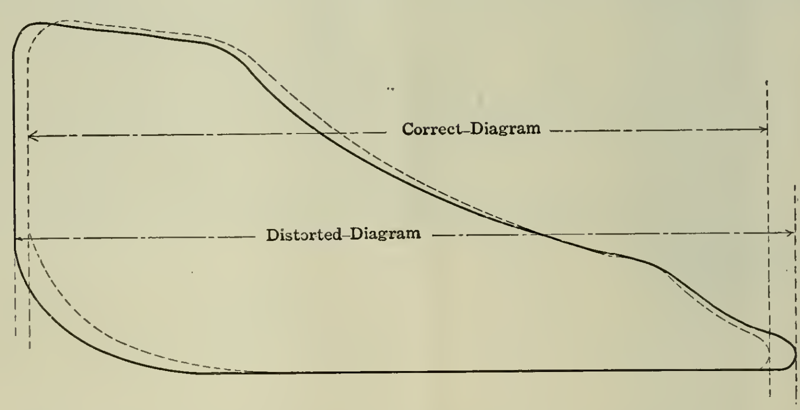


FIG. 5

Deformation at Mid-stroke

Hitherto nothing has been said concerning the amount of deformation in mid-stroke. This is difficult to determine and requires special apparatus, but it is hoped that a presentment of the subject may be made at some later time. For the present purpose, however, it will be sufficient to make the following observations:

Starting from the head-end dead center the tension of the spring is small, while the opposing force due to the velocity of the drum is zero. Hence no appreciable distortion can result since the stretch of the cord is small. If this initial stress could be maintained in the cord the drum's motion would be an exact duplicate of that of the crosshead. According to the best setting of the drum spring as previously determined there will be, however, no stress in the cord at mid-stroke. Beyond this the work done by the spring increasingly exceeds the kinetic energy of the drum and therefore the pull in the cord will increase and deformation due to its stretch will increase up to the end of the stroke. Upon the return stroke the tension in the string is diminishing up to the end of the crosshead's travel. It is thus seen that under the best conditions there is a varying stress in the cord throughout a complete motion of the drum and we may therefore expect distortion of the diagram in all its parts, and the farther the stress in the cord departs from a uniform one the greater will be the inaccuracy. Obviously if the spring tension at mid-stroke is greater or less than is necessary to overcome the effect of inertia at this point this departure will be more marked.

The results and considerations presented lead to the conclusion that a perfect indicator diagram correctly representing the relation of pressure to piston position cannot be made with a spring-actuated drum, because of the inaccuracies introduced by drum-motion distortion. These inaccuracies may be reduced to the minimum by using piano wire instead of cord, as short as possible in length, and by properly adapting the spring tension to the speed of the engine to be indicated.

Allowing for Errors

The following simple procedure is suggested to allow for errors when accurate determinations are desired: Before putting in the indicator spring when indicating an engine two vertical lines may be drawn to correspond to the ends of its stroke. These are perpendiculars at the extremities of a "no-speed line;" that is, a line drawn by turning the flywheel at such slow speed that no effect of inertia is produced. Leaving this card on the drum, if the engine is now run at the various speeds at which it is to be indicated and horizontals drawn at these speeds, the elongation will be shown by the distances of the ends of such lines from the neighboring verticals. The corrections may then be made after the engine has been indicated. These corrections, of course, involve only the elongation of the diagram and do not consider deformations at mid-stroke, but the former is very likely the more considerable.

It is suggested that the device for tightening the spring of an indicator be marked in such a way that the tension of the spring may be adjusted for any desired amount without actual measurement. This may be simply accomplished by first measuring with a spring scale the tension at the limits of the drum travel for each adjustment and marking with a series of lines the locking device to correspond. From the curves presented in this article the indicator may then be conveniently adjusted for any particular test so that the least error results.

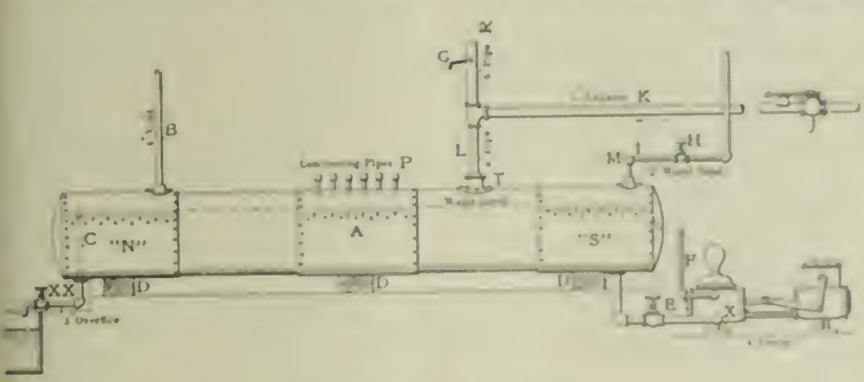
Reservoir Moved by Internal Forces

By J. O. Frazier

A few years ago the writer had an exciting experience with an old boiler which was used for the collection of water from the heating coils in a sugar house. The boiler was 36 inches in diameter and 60 feet long, and when nearly full of water was moved endwise about 1 foot from an internal conflict of exhaust steam and water. An unusual combination of circumstances was necessary to produce the results brought about, whose remote probability of simultaneous occurrence, as well as the necessities of rush work in connection with other machinery, had perhaps been the reason why the matter had not received more serious consideration and some means provided for their accommodation. The action of the contributing elements will best be understood by reference to the sketch.

In this illustration, *A* represents the reservoir, which many years before had served as a plantation boiler, when plain cylinder boilers without any flues were the prevailing type on the plantations. This reservoir received all the condensed steam from the evaporating apparatus of the house, which entered through the pipes *P*. There was a 5 inch exhaust steam connection *L*, which served to admit a small portion of such surplus exhaust steam as might exist at any time into the reservoir, from which all the boiler pumps received their supply. Another outlet, which then existed on the other side of the house, gave relief to the greater portion of the exhaust.

In putting up a double-effect evaporating apparatus the preceding year, the system had been piped to the new apparatus. Considering it was to run nearly all the time (and when it didn't run there were presumably few of the pumps or engines running) and to prevent the expense and time of changing the pipes *K* and *R*, which were only 6 inches in diameter, they were left as the sole outlet for such surplus of exhaust as might exist at any time. There were about 300 engine horsepower in the house and about 50 steam pumps, with steam cylinders ranging from 16 down to 5 inches in diameter, so it will be seen that the size of the pipe depended upon to carry off the surplus was out of all proportion to the sizes of the engines and pumps. It is a usual condition in such houses that when the double-effect evaporator, which generally



RESERVOIR AND CONNECTIONS

consumes all the exhaust steam, is not running but few of the machines are in operation, and thus the strong probability that the pipe would never be called upon to relieve more than a small portion of the total supply. So the larger pipe system which served the evaporator, some of it of 8-inch and 10-inch pipe, was just piped through the relief valve *I*, which was loaded to carry a pressure of 7 pounds in the exhaust system for supplying live exhaust steam evaporating apparatus, and that gave final relief to a presumable could discharge, the other outlet having been plugged.

The homemade butterfly valve, shown in pipe *K* at *G* had been put in years before to deflect exhaust, which then could never be considerable in amount, into the reservoir, for its value in mingling with the boiler-feed water. There were a vent pipe *B*, 4 inches in diameter, to prevent there ever being any pressure in the heater, as they called the reservoir, a 2-inch overflow pipe *C* and a 2-inch water inlet *T* to supply such additional cold water as might be necessary to make up the boiler supply. There were four boiler pumps feeding from the reservoir, all coupled about as the one shown at *X*. The reservoir was resting on wide wooden blocking *D* only a few inches from the ground.

While making the rounds one day and while in front of the boilers, behind which the reservoir was located, the writer heard and felt a commotion of unfamiliar sounds and it took several seconds before these sounds could be located behind the boilers in the neighborhood of the reservoir. Rushing around to this point a sight met the gaze which will not grow dim for a long time to come. There was that heavy reservoir of water, which could not weigh much less than 15 tons, actually bouncing, first in the direction of *N*, then in a few seconds, with a greater movement toward *S*. There was surely too much steam from somewhere, and the only possible source was the evaporator. Upon investigation it was found that the evaporator had been shut off, and the steam of the whole house, which was in full blast, had been turned toward the heater. The first move was to raise the weight on the relief valve *I* and turn the steam back into the evaporator.

Back in the boiler room the commotion had subsided; the heater was there, or nearly there, but what havoc among the piping. Suction pipes of all four pumps, as at *E*, were broken and all the hot water was running out of the reservoir over the floor. All boiler-feeding apparatus was disabled, and there were 15 boilers with a working head of steam. Well, the fires were all covered with dirt, ashes, water and anything else that would smother a fire; then began a rush for chain tongs, pipe fittings and all the paraphernalia of a hurry-up job, and by pressing everybody and everything into service, and with considerable good luck, which came in a while coming the engineer's way, the plant was running again in about three hours, with many makeshifts in the way of pipe fittings. It is well to explain that in those houses very hot feed water is so universally used that the possibilities of independent feeds with an injector is scarcely thought of and is practically unknown in the sugar house.

Even with the disaster which was wrought to the piping, there was on the whole less damage done than would be expected from such a commotion. The pipes *B* and *K* extended up through an old iron roof and did not suffer; overflow *C* was broken near *XX* and also the elbow *M* on the cold-water inlet. All the smaller pipes connected with the reservoir had enough spring in them to allow it to escape.

As to the combination which brought about the trouble and the action of the conflicting forces, the man who operated the evaporator was new at the business and had not learned how to keep the apparatus working by feeding water when the supply ran short. He threw the relief valve J open and the steam, endeavoring to get out through an opening far too small at best, found the butterfly valve, which had not been shut for a long time, closed and consequently deflected all the steam down into the reservoir on top of the water. When the commotion began the water tender put more water on at the supply pipe I, which would quite naturally make matters worse. First, the volume of steam coming in through L would force the water to the end N and plug up the vent B, which under the circumstances would be of little service. Then the flood of cold water coming in at I would so condense the steam as to create a lower pressure at the end S, which would cause the water to surge back toward that end, to be followed by an accumulated pressure sending it back toward N.

It would be hard to form an accurate idea of how long this action continued, but judging from circumstances perhaps from five to eight minutes. During this period it was evident that the reservoir was acted upon in alternating directions, with a period of about ten seconds each way, that it launched toward N about 1½ inches, then about twice that amount toward S, making a total gain toward S of 14 inches before the commotion was over. Among the provisions made for the prevention of a possible repetition of the trouble, at least in such violent form, was a sheet-iron flange, with only a 1-inch hole for drainage between the flange T and the reservoir. The butterfly valve G was taken out altogether.

Experiments on Gas Producers

By W. H. Booth

In a recent paper read before the British Iron and Steel Institute by W. A. Boru, some interesting facts relating to producer gas were made known. These had to do very largely with gas as produced for furnace work to which the regenerative principle is applied, and the experiments bear upon the use of water vapor in the air fed to the producer. The argument put forward by the authors, for R. V. Wheeler collaborated in the work, was that it was not advisable to put more steam into the air blast than corresponded with a saturation temperature of 60 degrees Centigrade; that is to say, assuming air at 60 degrees Centigrade to be saturated with water vapor that amount of water vapor would be the ratio of steam to be supplied. With any higher ratio of steam the thermal efficiency falls and the gas becomes less suited for furnace work. Experiments showed that with even less ratios of steam better results were obtained in rapidity of gasification and high efficiency.

With a 60-degree Centigrade saturation temperature a producer rated to consume 16 hundredweight per hour (1792 pounds) was successfully worked at 24 hundredweight (2688 pounds) with a fuel depth of 42 inches.

The saturation temperature was successively lowered to 55, 50 and 45 degrees Centigrade, with the result as between 60 and 45 degrees that the average coal consumption (night and day) rose from 17.5 to 18.4 hundredweight per hour; the CO_2 produced fell from 5.10 to 2.35 per cent., the carbon monoxide rose from 27.3 to 31.6 per cent.; and the hydrogen fell from 15.5 to 11.60 per cent., methane remaining the same at 3.05 per cent. and nitrogen rising from 49.05 to 51.40 per cent.

The total combustible gas increased from 45.85 to 46.20 per cent., and its calorific value from 178.7 units per cubic foot to 180 gross, and from 166.9 net units to 170.5, the yield of gas per ton falling from 135,000 to 133,700 cubic feet. The steam consumption per pound of fuel was diminished from 0.454 to 0.2 pound, and while in the first case only 76 per cent. of the steam was decomposed, all was decomposed at the 45-degree Centigrade test. The ratios of the oxygen from the steam and from the air were 0.44 and 0.33, respectively, and the efficiency ratios 0.725 and 0.73. Thus the efficiency was practically the same.

As to the use of gas in furnace work, the authors state that their previous convictions as to the greater suitability of carbon monoxide have been confirmed and they emphasize the importance of carbon monoxide for steel melting or reheating furnaces.

Needless to say, where hot gas is being supplied direct from a producer to a furnace it is important that as high a percentage as possible of the steam should be decomposed, or otherwise there must be loss of excessive cooling without additional calorific capacity of the gas produced. The reactions in a producer are probably very complex. The general reactions expressed by $C + 2\,OH_2 = CO_2 + 2\,H_2$ comes more and more into play as compared with the reaction $C + OH_2 = CO + H_2$, when more and more steam is added; so that the equilibrium point of the reversible reaction $CO + OH_2 = CO_2 + H_2$ becomes shifted more and more to the right, as does also the reversible reaction $2\,CO = C + CO_2$. In one test the raising of the steam saturation temperature from 45 to 80 degrees Centigrade increased the carbon dioxide sixfold; doubled the hydrogen and halved the carbon monoxide. This question of equilibrium is one of the phenomena of mass action which deserves greater study than perhaps practical men have yet accorded it. This is especially so with regenerative working, for action and reaction occur in the gas during its passage through the regenerator. Equilibrium of any gaseous mixture, such as one of hydrogen, steam, carbon monoxide and carbon dioxide, is dependent upon the relative proportions of the gases and upon their temperature. At any given temperature the state of equilibrium is defined by the expression

$$\frac{CO \times H_2O}{CO_2 \times H_2} = K,$$

the product of the concentrations of the monoxide and the steam being a definite ratio to the product of the concentrations of carbon dioxide and hydrogen.

Hahn showed by experiment that for temperatures of 1086 to 1205 degrees Centigrade, which fairly correspond with the temperatures in the hottest parts of a regenerator, K varies between 1.95 and 2.10, so that practically we may assume K equals 2.0. Any mixed gas of the above order passing through a regenerator which has a higher limit of temperature of about the above figure will tend to arrange or rearrange its dynamic equilibrium until the above equation is fulfilled with the value of 2 for K; and the tendency will be the greater when the initial ratio is most removed from $K = 2.0$, for the stress tending to rearrangement will be greater. It is therefore useless to start with a gas too rich in CO_2 and H, for equilibrium will tend to produce $CO + H_2O$. A producer gas heated to 1100 degrees Centigrade will attain equilibrium with $CO_2 = 10.2$, $CO = 20.6$ and $H_2 = 18.0$, and was found to do so when it contained initially the above three gases in the ratios 17.8, 10.5 and 24.8.

The authors do not express any dogmatic opinions, but base their arguments on the assumption of the correctness of Hahn's formula for K and consider that this should be further investigated in order to prove or disprove its correctness. Incidentally the thought arises that the reactions within the cylinder of a gas engine are probably extremely complex, consisting of an innumerable rapid series of changes of equilibrium in the mass of the burning gas. But such violent reactions only make their joint effect felt as an integrated result in the shape of fairly even pressure, for the waves which appear on an indicator diagram and often form the subject of much speculative writing do not seem to live when the indicator spring is changed for a stiffer one of less movement.

The presentation of further experimental data in regard to superheated steam will be looked forward to with great interest, but what we now need is a thorough review of the properties of saturated steam. At present our knowledge of the heat required above saturation is probably more accurate than what we know about saturated steam.—Prof. R. C. H. Heck.

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Governor Link Arm Caused Trouble

Our company bought a 16 and 25 by 4-inch cross-compound engine. The governor was of the type shown in Fig. 1. This engine was belted to a 175-kilowatt generator and was operated at a speed of 250 revolutions per minute. It was concluded to make a direct-connected outfit of it, so a new subbase and field frame and an outboard bearing for the armature shaft were made. The flywheel was removed and a flanged coupling used to couple the crank and armature shafts together. In testing, the load was obtained through a water rheostat. When everything was ready, the engine was started, and when the speed got up to about 200 revolutions per minute the governor began to hunt, the speed running from 200 to 300 revolutions per minute, and then down again and so on. The engine was shut down and after several trials and many examinations the trouble was located. What made it more difficult was the fact that with a load the engine ran all right. I finally removed the cover plate E, Figs. 1 and 2, and found the eccentric strap F pulled back at the top, causing the cover plate to bind against the eccentric at A, and the strap against the eccentric at B, Fig. 2. I slacked off the springs and pulled the strap square on the eccentric, after placing three paper liners, each 0.01 inch thick, between E and F, Fig. 2.

I next removed all tension from the springs S, put more tension on springs S' and started up the engine; although it governed well the speed was only 180 revolutions per minute. I shut down the engine, took off the springs, disconnected the link L and placed the eccentric strap square on the eccentric. When I tried to put the link L back into the slot of the weight W I found the link was 3/16 inch out of line with the weight arm, so it had to be sprung into place (see the dotted lines in Fig. 2). When the tension was removed from the springs S there was so much play in the pins that the link would not bind, but when both springs were tightened they pulled the weight arm to its true center and held it there, and the link L had to be sprung into the slot in the weight, pulling the eccentric strap with it.

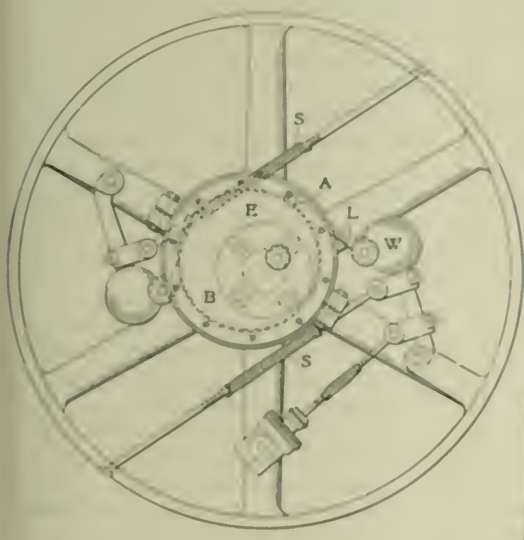


FIG. 1

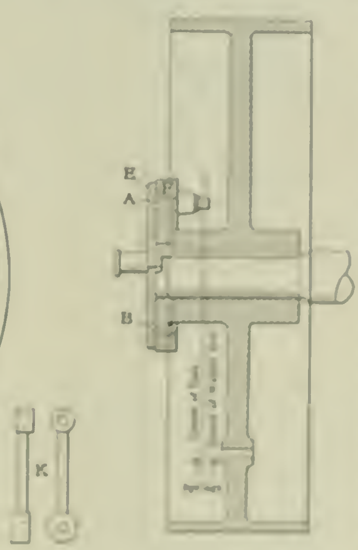


FIG. 2

I had a new link made with a 3/16-inch offset, as shown at K. The engine is governed very nicely by that means.

The superintendent could not see how it was that the engine had not given any trouble before. The reason is that it was belted to a large generator and had enough load to keep it steady, and there never was any time when the load was all off at once.

A. [illegible]

Chicago, Ill.

Induction Motor Operates as a Generator

Recently the local electric-light and power company installed a [illegible]-horsepower induction motor to run in multiple with a water wheel. The mill where this was done is situated on a small stream furnishing about [illegible] horsepower at full head, but is at the present time giving about [illegible] horsepower, which is not enough to run the mill.

The power company offered to put the motor in for a two months' trial, charging only for the current used during that time, but if the installation proved successful, the owner was to pay for the motor and installation, and a minimum bill of $2 per horsepower per month, the usual charge being $1. A smaller motor would have taken care of the installation, but would not have run the plant at times of low water.

The motor acts as a governor to the water wheel, which is without such a device, the speed running up and down, depending upon the rate of feed of stock to the machines. The motor is left on continuously and with the garnet machine running alone acts as a generator, supplying power to the feed line and running the meter backward. If the picker is thrown on, the meter immediately starts forward and the speed drops about 2 per cent., the motor running slightly above synchronous speed as a generator and below as a motor. But as this made a variation of speed of nearly [illegible] per cent. without the motor, it is considered more than satisfactory. With the garnet machine running alone the meter runs sometimes backward, sometimes forward, depending upon the flow of water to the wheel. The wheel gate is set to take the full flow of the stream, thus getting the entire benefit of the head.

This arrangement has been running one month, continuously, day and night except Sundays. It has turned out about [illegible] pounds of shoddy a day, which before it turned out only [illegible] per day of [illegible] hours.

It has used [illegible] kilowatt-hours, which sells at six cents, making $[illegible] for the month, or less than the minimum charge.

The owner is satisfied and will accept the motor, as he could not get this service with a steam engine, and he is already planning to run his garnet machines at a higher speed in order to get full benefit of the minimum bill.

The electric company is satisfied, as the customer runs his picker at non-peak hours and is helping them out at peak-load hours to a small extent.

JOSEPH B. CRANE.

Broadalbin, N. Y.

Hygrometry

Referring to W. Vincent Treeby's comments on Mr. Hart's contribution on hygrometry which appeared in the issue of January 5, Mr. Treeby says that when we state that steam is saturated we intend to convey the idea that it is saturated with heat units. The word "saturation" applied to any physical material is usually taken to mean that it is saturated or contains all of a given substance that it is possible to hold without losing any. For instance, in the case of a salt solution, brine is saturated when it contains or dissolves all of the salt possible without precipitation.

I believe that the word "saturation" when used in connection with steam is more or less a misnomer and does not convey a true meaning in this sense. By "saturated steam" I understand that the steam is generated and is held in contact with water. It certainly is not saturated with heat because heat can be added indefinitely, thereby producing superheated steam, except that it is in another sense saturated with heat units, or it contains as many heat units as it will contain while in contact with the water.

Technically, to my mind, it is saturated with water; that is, dry steam contains all the water it will hold without precipitation if it remains in a quiescent state.

C. W. C. CLARKE.

New York City.

Sea Water Caused Foaming

At one plant where I was employed we dug a well near a river in which salt water flowed. The soil was loose-sand gravel and the well was dug 12 feet below the river level at low water. We used 8x8-inch timber cut so as to form a hexagon curb 14 feet across, each tier of curb being 1 inch smaller on each side than the one below, thus forming a bell-shaped curbing. The ends were cut to fit, and were spiked at the corners and toe-nailed at the sides. The weight of earth on the outside assisted in pushing the curb down.

We dug out about a foot below the curb all around and six men standing on the curb, each with a piece of timber, gave a few blows all together on top of the curb to drive it down.

The well worked all right until a dry spell came and our supply of fresh water for the well, which came from the hills, failed, and we were soon pumping brackish water into our boilers.

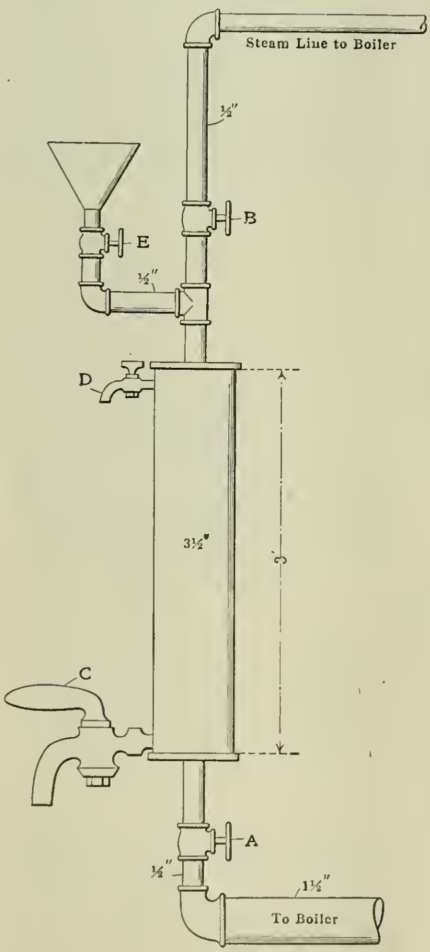
Dutch ovens were used, and when one was fired a little harder than the other that boiler would get busy passing water into the engine, and in five minutes there would be no water in the water glass. The engine, a 24x30-inch, was usually flooded to a standstill, or nearly so. When this happened we deadened the fire as quickly as possible, and after again getting the boiler filled to its proper level, it was put to work. This kind of trouble continued until the end of the summer.

D. F. BEDFORD.

Brantford, Can.

Compound Feeder

Referring to the illustration, it will be seen that this feeder operates with con-



BOILER-COMPOUND FEEDER

densed steam. It is made from a piece of 3½-inch pipe, 3 feet long, with the ends capped, the caps being tapped for a ½-inch pipe. It can be placed in any convenient part of the boiler room, preferably near the feed pipe and always below the water line in the boiler, the lower end being connected to the feed pipe between the check valve and the boiler with a ½-inch pipe.

The condenser pipe leading from the upper end to the dome or steam space should be about 6 feet high above the water level in the boiler. To fill, close the valves *A* and *B*, open the drain and air cocks *C* and *D*, and, after draining, close the drain cock *C* and fill by means of the funnel through the valve *E*.

By making the solution extra strong it is not necessary entirely to fill the body of the feeder, as it will finish filling with clear water from the feed pipe by slightly opening the valve *A*. When full, close the air cock *D*, open the valve *B*, and the feeder will operate, its rate of feed being regulated by the valve *A*.

GEORGE RUSSELL.

Spring City, Tenn.

High Water Level

This question of the proper hight of water in boilers is too often left to the fireman, who cannot, in many instances, tell how far below the gage the tubes are located.

A maker of boiler-feed regulators experimented as to the proper hight of water for economical steaming and found that the result of lowering the water line from three gages down to one gage was not very marked, but when lowered to 2 inches above the tubes a great difference in economy was made. In many localities the law requires the bottom of the gage glass to be placed 2½ inches above the flues, and the fusible plug about the same. So we have in practice at least 5 inches of water over the tubes, with the probability that the water will show at least 6 inches in the glass and more than 8 inches above the tubes.

If the tubes are carried high in the boiler the water line is so high that it is well up to where the cross section is narrow, and provides a small disengaging surface for the steam, causing extra friction and resistance for the steam to rise and separate, which is reflected back and means extra coal consumption. Having the largest space for the easy disengaging of the steam from the water means carrying the water line as low as possible.

It is true that piping will sometimes shake a boiler, but the water line should be carefully looked after in such cases.

In one steam plant feed-water regulators were put in. The old gage columns were left in place and the regulators placed on the side of the boilers. In these regulators the feed valve was held in position by the float, so that the valve was always open, a constant stream entering the boiler. The pressure in the feed pipe operated a pressure regulator on the pump, which was of such design that the only pressure on the metal diaphragm was the difference between boiler pressure and that in the feed pipe. With no more than 5 pounds extra pressure in the feed pipe the pump would supply the boilers with perfect regulation, with the feed valve well open.

The bottoms of the old gages were 4

inches above the flues and the engineer wanted the regulator set to carry 2½ inches of water in the old glass, making 6½ inches of water above the tubes. Carrying the gage half full would bring the water level nearly 10 inches above the tubes.

After awhile the water could not be kept up except by carrying about 30 pounds excess pressure in the feed pipe. As the water came in under the valve the excess pressure tended to raise it and depress the float which had to be more immersed so as to shut off the valve, and this tended to carry the water line higher.

The trouble was that the firemen were afraid to see the water so low in the glass and took measures to fill the boiler up so that it showed a half glass and the engineer partly agreed with them.

The result was that the water was carried 10 or 12 inches above the tubes, with increased cost for coal and increased moisture in the steam.

W. E. CRANE.

Broadalbin, N. Y.

Air Compression Under Difficulties

As an example of what may be expected in air compression when running the compressor with restricted inlet passages or valve opening, the accompanying indicator diagrams, Figs. 1, 2 and 3, should prove of interest to engineers who have compressors in their plants.

In Figs. 1 and 2 are shown normal conditions in the air end of a two-stage, 28 and 17 by 26-inch tandem compressor, connected to a 16 and 30 by 36-inch cross-compound Corliss engine. The first stage compresses to 25 or 26 pounds, and in the high pressure cylinder the compression is completed to 100 pounds. Recently an accident to the low-pressure side of the engine put that side out of business for twenty-four hours. As it was impossible to get along without air for any length of time, and still keep all parts of the plant in operation, the master mechanic de-

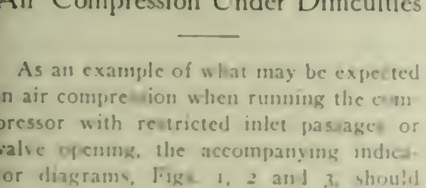


FIG. 1

cided to run the compressor on the high-pressure side alone. This was done in the following manner:

The low-pressure connecting rod was taken off, both steam and exhaust valves taken out and the bonnets replaced; also the positive-motion air-inlet valves and several of the poppet type of discharge valves on the first stage were taken out. This change allowed free exhaust of steam through the low-pressure steam cylinder, an air inlet, unrestricted as possible, through the low-pressure air cylinder, and an intercooler into the high-pressure cylinder.

When the compressor was started again it took over an hour's running at full speed to get the line pressure up to 80 pounds, whereas, with both sides "hooked up" we could always get the required 100 pounds in 10 minutes. It soon became evident that unless the demand for air was lessened, the pressure could not be raised above 80 pounds, which was about 25 pounds too low to operate some of the pumps and hoists.

After speculating on the interesting question of how much air the compressor was turning out in its one-sided condition, we decided that the trouble lay in the intake resistance to the air, due to taking it at atmospheric pressure (only about 12.5 pounds here) through passages and inlet poppet valves designed for air at 25 pounds.

The master mechanic then decided to get the required line pressure by running a 1-inch bleeder to the third stage of the four-stage high-pressure compressor alongside. The pressures of the different stages

FIG. 2

were 25, 115, 380 and 1000 pounds, and although the second stage would have suited the purpose better, the bleeder was connected to the third stage for reasons of despatch and convenience. A valve was placed in the bleeder to throttle the pressure and, the other end being connected to the discharge line of the crippled compressor, we soon had air enough for the demand. A couple of hours later when the quantity required was greatly reduced the compressor was able to hold 100 pounds with the bleeder valve closed, and then, wishing to see exactly what was doing in that hard working air cylinder, I put on the indicator and got the diagram shown in Fig. 3.

As expected, the admission line proved to be almost 7 pounds below atmospheric pressure, as compared with 1.5 pounds on the diagrams shown in Fig. 1. The diagrams also show that the piston actually traveled about one-fourth of the entire stroke before getting the pressure back to the intake pressure, as shown at A, Fig. 3, and about two-thirds of the stroke before reaching 25 pounds, as shown at B, which would be the regular intake pressure under ordinary conditions. By comparing the volumes V discharged per stroke, Figs. 2 and 3, it can be readily seen how the capacity was reduced.

Another interesting point is in comparing the compression curves under the different conditions. By plotting out the isothermal curve on Fig. 3, it will be seen that the actual curve gets much nearer to an adiabatic-compression curve than on Fig. 2, thus raising the mean effective

FIG. 3

pressure and hence the power required per unit of free air.

While Fig. 3 represents an extreme case, it goes to show that too much attention cannot be given to air intakes and inlet valves. For example, in making new valve springs to replace broken ones it is quite possible to make them much stronger than the old ones, or, in the case of positive-motion inlet valves, the point of admission might easily be too late, due to a slipped eccentric, lost motion in rod ends, etc., all of which would necessitate a greater degree of vacuum at the time of admission, and thus throw unnecessary work upon the compressor.

A case in point is that of an engineer who extended his intake from a few hundred feet out into a field, to get the intake away from the coal dust; and the first fall afterward the intake became clogged with leaves to such an extent that it took a 17-inch vacuum to get anywhere near enough air for the demand.

I have noticed that there seems to be very little practical information on air compression in the bulk of engineering journals, and if more attention were given to this important branch of our work, I am sure it would prove most acceptable to a large number of us who have compressors included in their plant. More light could easily be shed upon some phases of the work. For instance, I read not long ago the statement of an engineer to the effect that the only function of a receiver on an air line was the same as that of an air chamber on the discharge of a pump. I have always thought one of the most important reasons for a receiver being installed was to provide a place in which to cool the air, thus separating most of the contained moisture and allowing it to be blown off; also to provide a storage place, thus tending to prevent sudden reductions in pressure. When is the opinion of other readers on this subject?

J. A. Carruthers.

Bankhead, Can.

Criticism of Turbine Installations

I wish to make some comments upon the criticisms by E. H. Lane in the issue of January 5.

Mr. Lane comments upon the small size of the condenser, and also upon what he calls a deficiency in circulating water capacity in the condensing equipment. He states that the American practice is to allow not less than 60 pounds of condensing water per pound of steam; and, further, that the temperature of the water the year round must be considered. His figure of 60 pounds might be all right for New York City and vicinity, but it certainly would be insufficient in Florida and excessive in Labrador.

I will not attempt to answer Mr. Lane's question as to what temperature of circulating water is necessary to maintain the condensed steam at 28½ inches vacuum, as this would depend somewhat upon the design of the condenser.

As regards the size of the condenser, that is, the square feet of cooling surface, Mr. Lane states that the latest American practice is to allow 4 square feet of cooling surface per kilowatt for turbine installations. This was latest American practice in 1904. About 1906 the engineers of the country, and I suppose the manufacturers afterward, awoke to the fact that this rate of surface was excessive, especially in the larger units, and today the standard American practice for large units in temperate latitudes is about 2 square feet per kilowatt maximum rating, or practically half that quoted by Mr. Lane.

Another factor enters into this particular machine which, as I understand it, has a normal rating of only about 7000 kilowatts, the 10,600-kilowatt rating being a periodic maximum.

From the foregoing it will be seen that the ratio of the cooling surface to kilowatts at the normal load is 2.3 to 1, and at the maximum capacity is 1.3 square feet per kilowatt. The condenser provided is very close to the American practice today for large steam turbines. There are a number of 14,000-kilowatt turbines operating today in this country, having a maximum rating of 14,000 kilowatts for 24 hours, which are equipped with condensers containing 25,000 square feet of cooling surface, which maintains a vacuum of 28½ inches under all conditions and which gives a ratio of 1.8 square feet per kilowatt.

There are other machines which have a rating of 9000 kilowatts normal, which are provided with the same condensers. The steam consumption of these big turbines is practically the same as quoted for the Buenos Aires machine.

The reason for the small surface in this condenser not taking into consideration the temperature of water may be due to efficient design. The ordinary condenser as manufactured is far from efficient inasmuch as the steam does not get the best kind of action on the tubes.

I have a case in mind where the condenser surface was reduced about 15 per cent., which resulted in increase in vacuum of over ½ inch. This condenser had a ratio based on normal rating of turbine before changes were made of 3.4 square feet per kilowatt. After the changes were made the ratio was 2.9 square feet per kilowatt on the normal rating basis.

Where salt circulating water is used it is desirable from a maintenance standpoint to have as few tubes in a condenser as possible.

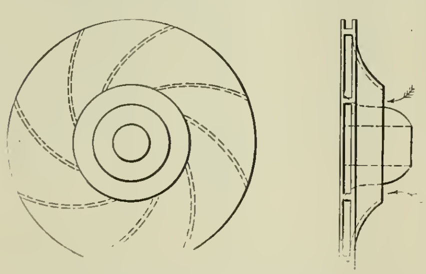
In reference to the installation of electric auxiliaries I can but agree with Mr. Lane that this is apparently a step backward rather than forward.

C. W. C. Clarke.

New York City.

Centrifugal Pumps

The recent discussion regarding the action of centrifugal pumps has brought



ONE TYPE OF IMPELLER

out some very interesting points. That it takes less power to run one of these pumps with the discharge valve partially or wholly closed is logical, and any operator of this type can easily demonstrate the fact to his own satisfaction, although the exact amount may vary greatly, depending on different details of construction, etc.

In regard to George P. Pearce's criticism of Mr. Kellogg's article, I beg to differ with him, especially where he compares a centrifugal pump to the water brake used by the Westinghouse Machine Company, as described on page 1025 of the June 30, 1908, issue. While the centrifugal pump is built on easy curves, to reduce friction loss to a minimum, the water brake is constructed to give the greatest possible resistance, resulting in the power being quickly transformed into heat. The appearance of the steel impeller and casing, after a few hundred hours' use, gives an idea of the violent impact between the moving parts, while the cast-iron impeller in a centrifugal pump will run month after month at 1000 revolutions or more per minute and not show any particular wear or sign of excessive friction.

The construction of impellers differs with different manufacturers, but in considering the type shown in the accompanying illustration the water, as it enters the center of the impeller, flows through easy bends to the periphery and here, where the velocity and friction are greatest, a smooth, narrow disk is found, which offers a minimum of resistance to the surrounding water. With the discharge closed there is no water flowing from the suction to the impeller and consequently no discharge at the periphery, and the body of water inside the impeller is motionless relative to the impeller, due to the pressure in the casing. The only power required would be that necessary to overcome the friction of this smooth water-filled impeller rubbing against the surrounding water, plus the friction in the bearings, etc. Altogether this friction cannot amount to a great deal and the fact that a turbine pump of this type will run in this condition for several minutes before there is any appreciable increase in the temperature of the water in the casing would tend to prove that such is the case.

R. Cederblom.

Gary, Ind.

Dashpot Does Not Seat

Why will not the head-end dashpot seat when the load is below 300 amperes and the hooks push it down?

The engine is a 30x48-inch Corliss, with seven-eighths cutoff and double eccentrics. The valves open away from the center of the cylinder and have equal travel; the same is true of the wristplates.

By using the starting bar and working the wristplate, the hook engages the catch block with a little clearance and the dashpot seats nicely. Why should it act so?

Elsworth Davis.

Zanesville, O.

Pumping Hot Water

In regard to C. R. McGahey's article under the above title, in the December 15 issue, I cannot see why it should be any more difficult to pump hot water than cold, if machinery designed for the work is supplied.

I have worked in three different plants, all over 2000 horsepower capacity, each equipped with open-type heaters, and this part of the plant was one of the least of our troubles.

If a plant is equipped with an outside-packed plunger pump, with either brass or good hard-rubber valves, large enough to handle the necessary volume of water, no trouble will be experienced beyond the ordinary amount of repair work. In two of the plants the pressure on the feed line was maintained by a pump governor, and the water level in the boilers was controlled by automatic feed-water regulators.

A pump should be provided with pet cocks on top of each water cylinder, in order to release air in case of failure of the water supply to the pump.

I have pumped water at 210 degrees and, in case of losing the water in the heater, have used a cold-water line to supply the pump until normal conditions were regained. The only perceptible change shown by the pump was the leakage at the glands, which gradually ceased as soon as the pump began to warm up with the return of hot water.

Occasionally in changing from cold to hot water it became necessary to open the pet cocks to relieve the water cylinder of steam or air, but we were not compelled to stop the pump, as this was only momentary, usually lasting over three or four strokes. In such a system the extra air chamber would be superfluous, and I disagree with Mr. McGahey about using a valve to choke the pump discharge, as this would compel the check valve at the boiler continually to open and close, due to insufficient pressure to hold it open, thus causing undue wear and a certain amount of hammering at this point. It would be better to throttle the pump discharge at the valve between the check and the boiler. I cannot understand why this could not be done with one boiler, the same as with two boilers connected to the feed line.

CHARLES A. CRYTZER.

Windber, Penn.

Cause of Trouble with Oil in Bearings

In the December 8 issue was published a sketch of bearings and shaft supporting a pulley, in which the writer describes a method employed in overcoming an oil trouble, but there was no explanation offered as to the reason why the oil in both outside chambers, in which oil rings were hung, were drained of their contents in the manner described.

Perhaps it is not generally known that in turning journals it is not so much the actual cutting of the metal as getting a clean chip, and an experienced lathe hand knows how to trim his tools in order to obtain a proper finish, thus destroying what would be observed under microscopical examination a complete series of spirals running the entire length of the shaft or journal. I believe that on the journals in question there was a series of spirals, and they naturally influenced the oil as soon as the shaft had bedded itself in the bearings.

It would be interesting to me, and no doubt to other readers, if the correspondent would fill both journals up to the centers, not from one end to the other, plug the holes up that communicate to each of the chambers, and let us know the result of the experiment.

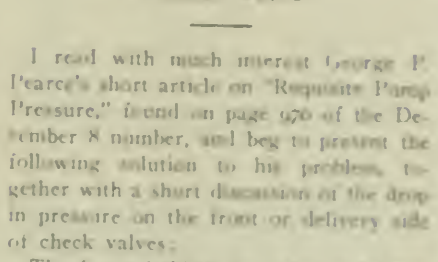
HORATIO W. HUTTON.

Glasgow, Scotland.

Pressure Required to Lift a Check Valve

I read with much interest George P. Pearce's short article on "Requisite Pump Pressure," found on page 970 of the December 8 number, and beg to present the following solution to his problem, together with a short discussion of the drop in pressure on the front or delivery side of check valves.

The forces holding the valve to its seat are the pressure per square inch into the



CONICAL OR PUPPET DOUBLE-SEATED BALANCING VALVE

area of the valve plus the weight of the valve, or in this case:

$$100 \times 19.63 + 5 = 1968$$

pounds. The force lifting the valve is the pressure per square inch beneath it into the area upon which that pressure acts. The area of seven 1-inch holes is 5.5 square inches; thus

$$1968 = 5.5 \times pressure$$

and

$$pressure = \frac{1968}{5.5} = 358$$

pounds.

This, of course, assumes that the valve cover makes perfect contact with its seat and prevents the fluid from the delivery side getting between the valve and its seat, which requires a perfectly tight-ground joint.

It is very evident in this case that if there were a gage placed on both the receiving and delivery sides of the check valve, there would be a drop in pressure after the valve opened from 358 pounds on the delivery side to 100 pounds on that of the receiving side. This would be true only provided that the pressure on the receiving side was due to a volume of fluid free to flow out and thus make room for the incoming fluid.

If the pipe conveying the fluid away from the receiving side were small compared with the size of the pipe and size of cylinder, I say the pump cylinder, on the delivery side of the valve, then the pressure on the receiving side would rise due to fluid friction in the discharge pipe, while the admission pressure would fall until the two were equalized, and then they would both continue to fall until the pressure at the valve was that due to the static head of fluid on the valve, when the valve would close due to the tendency of the fluid to flow back into the pump cylinders.

The trouble here is that the ratio of the area of the admission or delivery side of the valve to the area of the discharge or receiver side is too small.

George H. Anderson is correct in the statement that the total pressure P on the discharge or receiver side (back side) of a check valve is equal to the area of the passage plus the area of the seat multiplied by the pressure per unit area, while the total pressure P_1 on the admission or receiver side (front side) is equal to the area of the passage multiplied by the pressure per unit area. This, of course, assumes a balanced valve; the weight of the valve would increase the pressure on whichever side had to lift it.

The expression "area of the seat" should be modified to read the projected area of the seat on a plane parallel to the plane on which the area of the passage is measured.

Referring to the accompanying drawing, the area of the passage is the area of the circle, whose diameter is d_1, while the area of the seat is equal the area of the annular ring, whose outside diameter is d and whose inside diameter is d_1.

With correctly designed valves and ports having proper ratios of seat area to passage area, there ought not to be variations in pressures which would be perceptible on the ordinary gage.

In this connection it would be interesting to hear from someone who has spent considerable time in the design and operation of valves used for such a class of service.

The drawing shows a diagrammatic sketch of a conical or puppet double-seat valve which may be so proportioned that the pressure on the front side may be equal to that on the back at the moment of opening.

This is accomplished by bringing the fluid in contact with a recess in the valve as shown at aa. The fluid is led into this recess through the ports bb.

It is evident that if the area of this annular space, represented by $0.7854 (d_1^2 - d_3^2)$, be equal to the area of the annular $(d^2 - d_2^2)$, the valve will open when the pressure per unit area on the front is equal to the pressure per unit area on the back, since the areas exposed to the action of the fluid pressure are equal on both sides.

For valves having a circular cross section, the pressures will be equal on both sides at the moment of opening (neglecting the weight of the valve), when the valve is proportioned as expressed by the following equation:

$$d_2 = d_1^2 + d_3^2 - d_2^2$$

F. C. Helms.

Schenectady, N. Y.

Practical Hygrometers

The practical hygrometer described by J. J. O'Brien in the issue of December 29, will, as he says, "be accurate enough for all practical purposes;" but it will tell very little to the observer except that the air is more or less moist at one time than another. To obtain the percentage of humidity in the air by means of the instrument described, a set of tables is needed.

Such tables may be obtained by writing to the United States Department of Agriculture, Weather Bureau, Washington, D. C., inclosing ten cents (the cost of the tables) and asking for "Psychrometric Tables W. B. 235." These tables give considerable very useful information, including the methods of obtaining the formulas, and the use of various kinds of hygrometer. The hygrometer should be hung in a moving current of air.

As an illustration of the need of tables when using the apparatus in question, showing that the difference in temperature between the thermometers is not the only factor to be taken into consideration, if the barometer stands at 30 inches, the temperature of the air is 32 degrees Fahrenheit, and the difference between the wet and dry thermometers is 10 degrees Fahrenheit, then the relative humidity of the air is 2 per cent.

With the air temperature at 80 degrees Fahrenheit and a difference of 10 degrees Fahrenheit between the thermometers, the relative humidity is 61 per cent., a very different figure. The tables also give vapor pressure, and temperature of the dewpoint.

J. G. Ould.

Brooklyn, N. Y.

Indicating Engines

Having two weeks off recently, I decided to try engine indicating. I first called at a lumber mill where there was a Corliss engine rated at 100 horsepower. The superintendent did not think it worth while to bother, but when I told him that I would charge him nothing if the valves were found to be properly set, he agreed. Fig. 1 shows the manner in which the valves were operating.

I next called at a factory where a high-speed automatic engine was in use. The engine seemed to be running nicely, with the exception of a knock in the steam chest whenever the load changed very much. Both the superintendent and engineer were anxious to have the engine indicated; Fig. 2 shows the steam distribution. As will be seen, one end of the cylinder is developing all the power, and the other end is doing negative work. At *CA* is the expansion line and *CBA* are exhaust and compression lines.

The valve did not open to admit steam to this end of the cylinder. The exhaust valve opened at *A*, however, and exhaust steam entered. When the exhaust valve closed at *B* the steam was compressed.

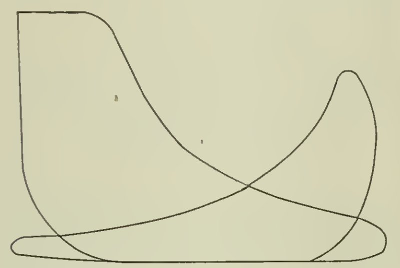


FIG. 1

The expansion line *CA* would lie directly on the exhaust and compression line were it not for the cylinder condensation but, owing to the little steam that does get in being condensed, a partial vacuum is formed in this end of the cylinder, so that the expansion line falls below the atmospheric line.

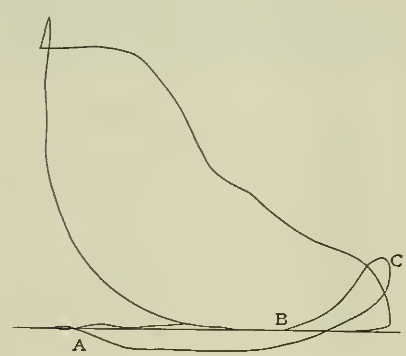


FIG. 2

This engine had been running so long this way that a shoulder was worn on the valve seat, and the valve could not be properly set until the seat was planed off. This explained the knock in the steam chest when the load changed.

I called on another engineer and was treated to a discourse on the slide-valve

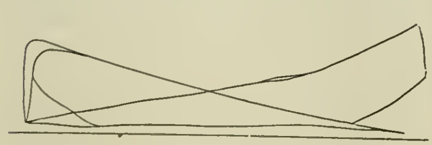


FIG. 3

engine and power-plant operation in general. He wound up by saying that he had been "running engines for 40 years" and had had charge of that particular engine for 12 years.

The president of the company employed me to indicate the engine. Fig. 3 shows what I found. The pencil was held on the drum for three revolutions when the diagram at the left was taken. There was about ¼ inch lost motion in the valve gear; thus, the points of steam distribution were not constant but varied for different strokes. The point of cutoff was varied so that one end of the cylinder would be carrying most of the load during one revolution; then, again, the other would carry the most. This card also shows how the compression and admission varied.

Out of twelve engines I found only one running with proper steam distribution.

Ray L. Rayburn.

Decatur, Ill.

Central Valve Engines

In a recent issue, J. J. Stafford contributes a description of "central-valve engines," which title, by the way, is a misnomer, as far as the term is understood in England, as the engine fitted with the valve gear which he describes is one of numerous types of high-speed, inclosed, double-acting engine. The term "central-valve engine" applies to a special and altogether different class of single-acting engine, in which type the piston rods are hollow and fitted with steam ports, the valves sliding up and down inside the piston rods, actuated by an eccentric in the center of the crank pin; there being two connecting rods, one on each end of the crank pin, which are worked from a long crosshead; or, in some sizes, from two short gudgeon pins, the whole arrangement forming a very interesting and economical combination.

It is not, however, my main object to point out the misleading definition, but to show that, even if Mr. Stafford is running several sets of high-speed engines, he is evidently not conversant with the most elementary principles of valve setting, as covering the simplest slide-valve engines.

His sketch shows that the two pistons are at the ends of their respective strokes, though how they have got there is a more difficult matter to arrive at, seeing that the lower high-pressure and the upper low-pressure ports are wide open for the admission of steam. He says: "In the position shown the high-pressure piston is at the bottom of the stroke, and the valve has just opened to admit steam to that end of the cylinder." I agree that "the valve has just opened to admit steam," with a vengeance. It cannot open any farther, because the piston valve is almost in its lowest position, and any farther movement of the eccentric will be toward cutting off the steam, before the piston gets far on its way, and the steam in the lower end of the high-pressure cylinder will be on its way to the exhaust, or receiver, before the up-stroke is anywhere near completion.

It is quite sufficient to deal with the high-pressure side alone, in considering the relative positions of the high-pressure crank and the eccentric (the position of the latter being assumed from the position of the valve as shown). The crank is on the bottom center, and the valve is at the bottom of its travel; therefore, if we imagine a line drawn through the center of the connecting rod and crank pin, that line would be coincident with the center line of the eccentric in its lower position, a peculiar combination, to say the least, and a scarcely workable one.

In the ordinary slide-valve engine, admitting steam to the cylinder from the "outer" edges of the valve, the eccentric is set at 90 degrees, plus the angle of advance, in advance of the crank, but in the class of valve under discussion, which admits high-pressure steam on the *inner* edges of the valve faces, the position of the eccentric is behind that of the high-pressure crank, or, say, 180 degrees from the position required in an ordinary slide-valve engine to run in the same direction. From this it will be seen, on examining Mr. Stafford's sketch, that the top edge of the ring *D*, shown in his Fig. 2, should be just below the top edge of the bottom high-pressure port, thus giving an amount of opening equal *only* to the desired lead for that particular size of engine, instead of giving full port opening in such a position of the piston as shown in the sketch referred to.

In conclusion, I would point out that the relative positions of the low-pressure crank and the eccentric (common to both cranks) are the same as in the ordinary slide-valve engine, and as Mr. Stafford rightly explains, the steam passes through the inside of the valve and over the outer edges of the valve faces, or rings, *A* and *B*, in his sketch.

J. BARNETT.

Manchester, England.

Introducing Steam into Heating Coils

I have charge of a heating and ventilating plant. In the fan discharge there was originally 6400 feet of 1-inch pipe, through which the exhaust steam of a 9x16-inch engine exhausted, the exhaust inlets being along one end of the coils. While handling the maximum quantity of air the end of the coils farthest from the inlet remained quite cool, while the end next to the inlet had a temperature of 130 degrees Fahrenheit.

It happened that on the side of the plenum chamber where the cold air entered, there was one room in particular where the cold air came in underneath and, the building being constructed of concrete, the floor of that room was always cold. There were also in the room a glass skylight, four large windows and four partially glass doors, while about one-third of the partition wall was glass. The occupants of this room complained at various times about it being cooler than the other rooms, which were all heated from the same plenum chamber.

The coils were put together with right-and-left couplings, 9 feet high, and inclosed in a casing of No. 20 sheet steel, with folded seams, riveted together. To take the two coils out, turn them around and introduce exhaust steam from the other side would cost about $75.

The following method was used. The casing was cut about 1 foot high and the

HOW THE JOINT WAS MADE

[illegible]

removed, so that steam at any pressure desired could be admitted and an equal temperature in both ends of the plenum chamber obtained.

[illegible]

Seattle, Wash.

Commutator Troubles

Referring to the inquiry of [illegible], concerning a commutator trouble, I would state that there are numerous causes for sparking brushes and commutators. It is sometimes due to poor machine design, and in such cases cannot be remedied by the operator.

[illegible]

Quincy, Mass.

[illegible]

and give the commutator a good sandpapering in order to remove any roughness, and fit the brushes to the commutator by drawing a piece of sandpaper back and forward under the face of each brush. Start up the machine and wipe a little dynamo oil on the commutator; if possible, run the machine without load for a few hours, wiping a little oil on the commutator occasionally in order to get a gloss.

H. Jahnke.

Milwaukee, Wis.

I believe the trouble is due either to overload, which causes the machine to heat up, or to a dirty commutator and brushes. Carbon brushes produce a coating on the commutator which insulates and blackens it in spots. This film is liable to mix with the carbon dust, coating the brushes with a nonconducting, sticky substance.

Vibration is another cause of sparking, and a poor foundation will cause the vibration. Belt slipping will also cause sparking, as will weak fields or a ground, and high or low bars will also cause this trouble.

Francis J. Doyle.

Benson, Minn.

The trouble with Mr. Baker's commutator is that it is not even. I advise him to turn it off and then sandpaper it. The brushes should be adjusted to the load, which will often stop the sparking. A little sandpapering of the commutator while running will, as a rule, keep it in good condition. I also find that a little vaseline used on a commutator keeps it in a smooth, glassy condition.

Why not try a set of graphite brushes in place of the carbon brushes? I find they give good results.

Maurice W. Campbell.

Brooklyn, N. Y.

I believe Mr. Baker's trouble is due to various causes, such as improper setting of brushes, uneven tension, poor connection between the brush holder and leads, but probably the real trouble is in the commutator.

I have found most of such trouble to be caused by high or flat bars. If the commutator is badly burned on one bar, it indicates an open coil.

H. E. Haslem.

Paterson, N. J.

A Chronograph

All specifications for steam engines which are to be used as prime movers for electric generators contain a paragraph stating the allowable variation in angular velocity of the revolving parts. This may or may not be lived up to by the builder, and can only be determined by actual test. The following is the description of a chronograph which has been used for this purpose with excellent results.

This instrument consists of a hollow drum made of an alloy of 75 per cent. aluminum and 25 per cent. zinc fastened to a spider and suitably mounted on a bedplate of the same material. The drum is connected to a clock and governor by gears, as is also the feed screw, on which is mounted a tuning fork vibrating 100 times per second. The ratio of the gears and the feed screw is such that the carriage moves about half an inch for each revolution of the drum. Near the end of the tuning fork is mounted a small magnet which keeps the fork in vibration. A general idea of the arrangement of the chronograph may be obtained from Figs. 1 and 2.

When any engine is to be tested six or eight small holes are drilled and tapped at equal distances on the edge of the rim of the flywheel, into which are screwed steel pins about 3 inches long. The chronograph is connected as shown in Fig. 3. A piece of blueprint paper is placed on the drum and the pointer at the end of the fork draws a continuous record, as shown in Fig. 4. A brass nozzle is so placed that a jet of salt water issuing from it will strike each pin in turn, closing the condenser circuit, as shown in Fig. 3, and in discharging through the drum make a spot on the record. After the record has been taken it is a very easy matter to determine the variation in the velocity of the flywheel by comparing the space in time between the spots on the record.

W. L. Durand.

Brooklyn, N. Y.

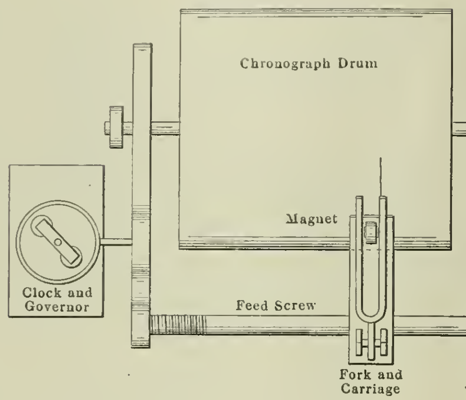


FIG. 1

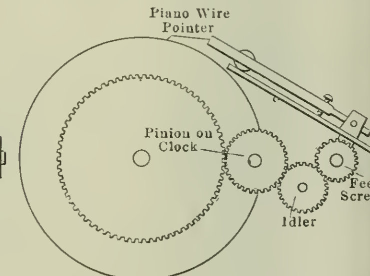


FIG. 2

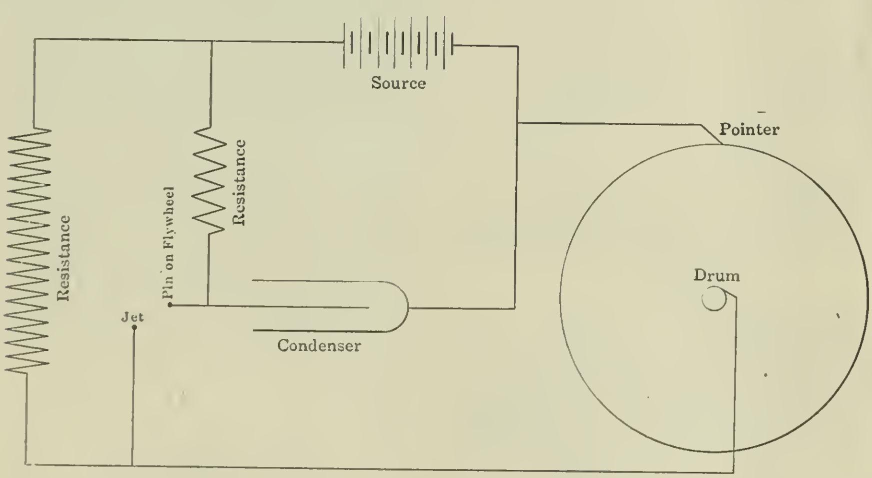


FIG. 3. DETAIL OF CONNECTIONS

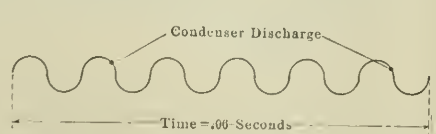


FIG. 4

Rope Drive for Governors

In an article in the December 8 issue, by Cornelius T. Myers, is shown a rope drive for governors. It seems to me that its only advantage is the reduced liability of the drive breaking. If the belt shown in Fig. 1 slips, it must be due to looseness of the belt or to "freezing" of the governor.

If the safety stop is adjusted so as to operate before the idler reaches the lower part of the belt, provided the upper part is the slack side, there can be no danger of slipping. If the governor "freezes," then the rope will either slip or break something.

It looks to me as if ball or roller bearings would serve a useful purpose in governor design to eliminate friction.

R. McLaren

Berlin, Can.

Mr. Sheehan's Motor Trouble

I have read with a great deal of interest the description by Thomas Sheehan, on page 1011 of the December 15 issue, of a peculiar case of trouble which happened with two compound-wound 250-kilowatt General Electric dynamos, one of which was driven as a generator by a water wheel, while the other was operating as a motor in a mill about half a mile away. The statement that the meters were reversed gives a clue to work from right away. This shows that the polarity of the generator had been reversed by the accident, which could have been accomplished in any one of three ways: By reversing the direction of rotation and the connections of the shunt- and series-field windings, by shifting the brushes back the distance of the pole pitch and keeping the direction of rotation the same, or by reversing the polarity of the field magnet without changing the direction of rotation or the connections of shunt- and series-field windings.

The first two methods resemble each other in that the magnetic flux traverses the magnetic circuit in the same direction in both cases, that is the polarity of the field remains unchanged. It is evident that the polarity of the machine in the present case was not reversed by either of the first two methods, which leaves only the hypothesis that it was reversed by reversing the polarity of the field magnet, which was doubtless accomplished in the following manner:

The connections of the machines are shown diagrammatically in Fig. 1, both the generator and motor-field windings being connected differentially, that is, so that the series-field winding opposed the magnetizing effect of the shunt winding, which has the effect of weakening the field strength as the load current increases.

When the beater was thrown on and pulled the speed of the motor down to a low value this caused a heavy current to flow through both machines, and this current flowing through the series-field windings and aided by the armature reaction due to the large current in the armatures, reduced the field strength of both machines to a very low value. The line current rose to such a value that the series-field winding of the generator completely neutralized the shunt-field winding and reduced the generator voltage almost to nothing, the voltage being merely that due to residual magnetism in the iron.

The rheostats in the shunt-field circuits of the machines were evidently adjusted so that the shunt-field excitation of the generator was considerably stronger than that of the motor, and assuming that the series-field excitation of the two machines was equal for any given current, the ratio of the strength of the shunt winding to that of the series winding was greater in the generator than in the motor. This being true, when the line current had increased sufficiently to neutralize the shunt winding of the generator, the shunt winding of the motor was more than neutralized and the polarity of its field magnet was reversed and built up in the opposite direction by the series winding.

The motor armature was still revolving with considerable inertia and built up a generator electromotive force with the

Fig. 1

polarity at its terminals reversed, but with the current flowing through the circuit in the same direction as before. This is all that was needed to overcome the residual magnetism of the generator and reverse the polarity of its field magnet and, consequently, that of the machine terminals.

As soon as the motor began to act as a generator it slowed down and soon stopped, while the generator, being driven by the water wheel, built up to normal voltage of reversed polarity, which left the motor armature short-circuited across the generator terminals as indicated in Fig. 2.

It is evident that the current in the line and series-field winding of the motor rose to a large value instantaneously, while the current in the shunt field came up very slowly, due to inductance (or not at all if the field rheostat was equipped with a no-voltage release), hence it is evident that the field of the motor was reversed by the current in the series winding and was also weak, while the

Fig. 2

polarity at the terminals was reversed, which would cause the motor to start backward at a high rate of speed with very poor commutation due to the large armature current and the weak field. Opening the line switch caused the motor to come to a standstill, and if the shunt field was excited, as it should have been, before the armature circuit was closed, the machine would start up in the right direction, but the meters would be reversed, due to the reversed polarity of the generator.

From the foregoing analysis it is evident that the field windings should be changed to a straight compound connection instead of the differential connection, or the same trouble will occur again.

E. C. Hales.

Schenectady, N. Y.

In regard to Mr. Sheehan's motor trouble, I would say that according to the arrangement of starting, there is no governor on the water wheels and the gates are throttled for a given load.

When the large beater was thrown on the probabilities are that the gates were not open far enough for the generator to supply the required amount of current to the motor to carry the load, and the motor was brought to a standstill. This practically caused a short-circuit on the generator, still further reducing its speed and voltage. This low voltage at the generator reduced the shunt-field current and left the fields in an unstable condition. Then, the large armature reaction, caused by the short-circuit current flowing in the armature, reversed the field magnetism of the generator, causing the reversal of polarity which is noted by the action of the meters.

The reason the motor started off in the opposite direction when the beater was thrown off is probably because the motor was differentially wound, and when the motor was almost stopped, and still connected to the line, the current circulating through the series field and armature was greatly in excess of normal, and the magnetic field set up by the series field overcame the weak shunt fields. They were weak on account of the low voltage at the motor, and the required field current was not sent through, thus causing the direction of rotation to be reversed. The excessive speed is due to the weak field.

It is natural that the motor should start up in the right direction after the shutdown, because on starting everything was in normal condition and the shunt field fully excited before the current was applied to the armature. If the line current is reversed, as shown by the meters, it will not change the direction of rotation of any direct-current motor. It would be advisable to have the fields of the motor connected up cumulatively and also recharge the shunt fields of the generator back to their proper polarity.

[illegible]

[illegible]

With reference to the experience of Thomas Sheehan, described on page 1011 of the December 15 number, I should like to offer the following explanation:

If the field windings were connected up when the machines were shipped by the manufacturers, they were probably arranged for cumulative compounding, that is, the shunt and series fields assisting each other. When such a machine is run as a motor without changing the field connections it will operate as a differential compound motor, the shunt and series fields opposing each other, because the relative direction of current in the series field has been reversed.

When the motor was stalled by the overload, there was, momentarily, an excessive current through the armature and the series field. This produced an excessive magnetomotive force opposing the shunt-field magnetomotive, and must have overpowered it, thereby reversing the residual. The reversed field would cause the motor to reverse its direction of rotation, which condition would endure until the shunt field again established the correct polarity. The weakening of the field on account of the differential action would account for the high speed.

SELBY HAAR.

Schenectady, N. Y.

It is my impression from reading Mr. Sheehan's letter that when used as a motor the machine's series fields were connected as they were originally, when the machine was to be used as a generator, with the result that when the machine was stalled the very heavy rush of current through the series fields was sufficient to overpower the shunt.

The voltage had probably dropped considerably at the same time, so that when the clutch was thrown off, the series field predominated, and the motor then acted as a series motor, reversed and tended to run away. Opening the circuit under heavy load and low voltage reversed the generator so that on starting again the motor operated correctly, the instruments, however, being reversed. It would be interesting to know what did happen at the generator end.

HENRY D. JACKSON.

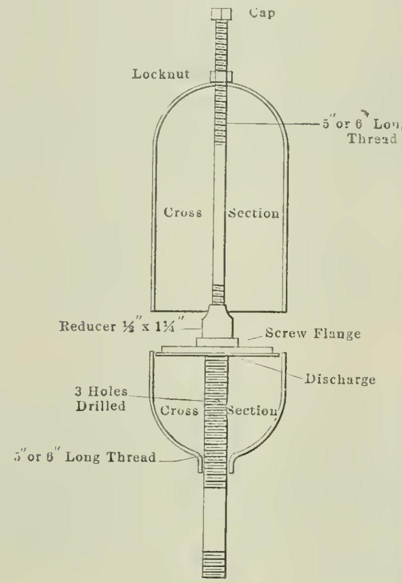
Boston, Mass.

Whistle Made from a Mercury Flask

The accompanying illustration shows a whistle made from a mercury flask. The flask was cut in half, about 3 inches from the filling plug, and tapped at the filling plug for a 1¼-inch pipe. A piece of 1¼-inch pipe, about 10 inches long, was cut with an ordinary thread on one end and on the other end a long thread about 5 inches long, and screwed in the smaller half of the mercury flask.

A disk was cut from a sheet of ⅛-inch copper plate, $\frac{1}{32}$ inch less than the inside diameter of the flask, and a hole cut in the center so as easily to slip over the 1¼-inch pipe. A 1¼-inch screw flange was riveted to the copper disk and screwed on the end of the pipe flush with the small half of the mercury flask. A ½x¼-inch reducer was made a locknut to keep the disk from working loose. The protruding thread was cut off flush with the reducer.

A piece of ½-inch pipe, 13 inches long, was cut with an ordinary thread on one end, and a thread 6 inches long on the other end, and screwed in the reducer. The larger half of the flask was tapped for a ½-inch hole and a ½-inch iron pipe screwed into it. This was screwed onto the 6-inch thread the required distance to



SECTION THROUGH THE WHISTLE

obtain the tone of the whistle and locked with a ½-inch locknut. The other end of the ½-inch pipe was capped.

A. C. HARRISON.

Jersey City, N. J.

An Error in Figures

In reply to the letter written by W. E. Sargent, and published on page 963 of the December 8 issue, I would say in defense of the N. A. S. E. that since Mr. Sargent got his information from the *Boston Globe,* I would much rather believe that the reporter for the *Globe* erred in his report, than to believe that Mr. Sargent was right, as per his formula for a 150-horsepower engine, using 30 pounds of water per horsepower-hour, running 10 hours per day, steam costing $15 per 1000 pounds, or a total of $675,000 per day.

I would suggest the following formula for Mr. Sargent:

$$\frac{150 \times 30}{1000} \times 10 \times 15 = \$675,$$

which would be an unreasonably high cost for power.

I would further add that in a locality where fairly good steam coal sells for $4.50 per ton, figuring about 7 pounds of water per pound of coal, this problem would figure out as follows:

$$\frac{150 \times 30}{1000} \times 10 \times 0.32 = \$14.40$$

per day.

From this result I would rather believe that the Boston association that gave the reporter the estimate on power cost, gave it as from 0.15 to 0.30 per 1000 pounds of steam, rather than from $1.50 to $3, which mistake could easily be made by misplacing the decimal.

C. G. SIGWALD.

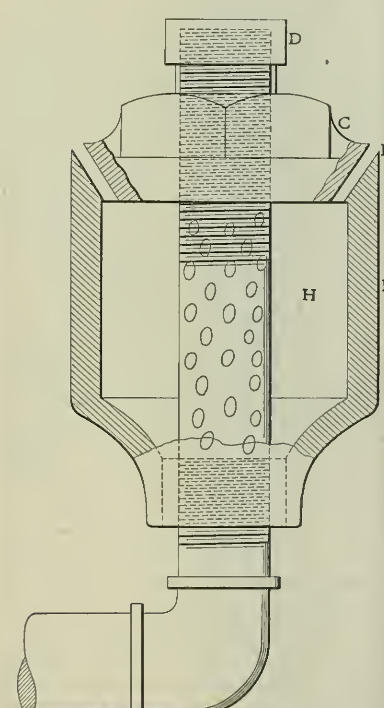
Minneapolis, Minn.

Homemade Blower Head

Herewith is a description of a blower head which I used in the stack of a 60-horsepower return-tubular boiler.

To make it I used a 2x¾-inch reducing coupling, turned out as shown at *B*. A short piece of ¾-inch steam pipe *A*, so threaded as to reach entirely through the coupling 1½ inches at the top, was obtained; also a reducing bushing turned down to cone shape as at *C*, and a ¾-inch pipe cap *D*.

The ¾-inch pipe was drilled with twenty ¼-inch holes, as at *H*, for the steam to pass to the body part of the coupling. The reducing bushing was screwed on, as shown, until the space *E* was $\frac{1}{32}$-inch wide.



HOMEMADE BLOWER HEAD

The idea is that the steam coming out in funnel shape will catch the entire column of air inside the stack and force it out, where a simple piece of pipe would only set a core of air in motion in the center of the stack.

HERMAN E. KING.

Columbia, S. C.

A Concrete Feed-Water Storage Tank

Why Such a Tank Is the Most Serviceable; Plain Directions for Building One; Used for Water Softening, Also, with the Lime Process

BY WARREN H. MILLER

Whenever a power plant uses city water, or, in fact, any source of feed water other than the direct suction of its own feed pumps from some natural supply on the ground, this feed-water supply at once becomes the most vulnerable point in the power system. Stoppage of this supply ties up everything. It is always sudden; it seldom lasts long; but in the short hour or so that it does last, there is nothing for it but to bank fires and shut off the steam all over the plant. Those who have managed large steam distribution systems do not need to be reminded of what a dangerous, uncertain business starting all this up again is.

If it is the city water you are dependent upon, your first notice is usually of the man with the monkey wrench, who announces that your main is going to be shut off in half an hour to make some change five blocks up the street. Or else it is a telephone call, to the effect that a main has burst and your main will be out of business until the street is dug up and the thing repaired.

If you pump your own feed water from a well your shrift is likely to be still shorter. The well-pump steam valve sticks, and you have precisely the capacity of the small storage tank to run your boilers on. In fact, it is absolutely essential to provide three or four hours' storage capacity for boiler-feed water. You must do this cheaply, and not use up any valuable building space, nor get too far from the power plant.

A cylindrical iron tank possesses a number of disadvantages. It holds little water for the land it occupies; it is expensive to buy and have delivered on the ground, besides requiring to be assembled on the foundation; it carries a depreciation of about 10 per cent. per annum and you can count on cutting it up for junk in fifteen years; it requires massive underpinning, unless the corner of some brick firewall is handy to the power plant, and heavy foundations if set on the ground. The cypress-stave tank is better, but has the same objections as to depreciation of iron work, area of floor space, etc.

Rectangular Concrete Tanks Best

On the whole, the rectangular reinforced-concrete tank offers the best proposition. It is easy to find ground space for it, in some angle around the power-house chimney, for example. It has no depreciation and requires no repairs. It costs hardly more than the foundations for an iron or wood tank. And at about the time you are thinking of replacing the latter because of old age, the concrete tank will still be gradually approaching its maximum strength—which is after the fashion of an asymptotic curve, as the mathematicians would put it.

The most economical way to get the thing up is to put most of the tank underground and leave not more than 6 or 8 feet above ground to resist water stresses. These mount up surprisingly with the height. At 6 feet the point of maximum pressure will be 432 pounds per square

FIG. 1

foot at ground level. It is entirely permissible to neglect the water pressure below ground. Even in poor soil, the resisting capacity of the earth surrounding the tank walls below ground can be taken at two tons per square foot, precisely as in foundations.

A pit is first dug, with plumb sides equal to the outside dimensions of the tank, and a footing or floor of concrete, about 9 inches thick, laid down. Next a box form of the inside dimensions of the tank is set up, and the space between it and the pit walls filled with concrete up to a foot below ground level. The overlapping rods for the above-ground section can now be set in place, and the work poured to ground level, securing the rods in position.

The design shown for the portion above ground, Fig. 1, makes a pleasing, strong, and economical construction. The pilasters are figured as beams to carry the whole load of the panels, and reinforced accordingly. The panels are treated as floor slabs figured on the pressure of water per square foot at ground level.

Constructing the Tank

The first carpentry work will be to set up the outside forms, Fig. 2, and nail the expanded metal to them, [illegible] strips of [illegible] flat strip steel being used to hold them off the surface of the forms. Another scheme is to drive two nails crossing at the intersection of the diamond meshes of the expanded metal. A single nail driven at the proper slant will also serve to hold the reinforcement about an inch off the forms, but is weak and liable to come out in the ramming and placing of the concrete. It is mentioned here because carpenters are too apt to discover this method themselves, and to work it with enthusiasm as being the easiest possible method.

A dense, impervious, rather [illegible] concrete should be used. The 1:2:4 mixture gave very good results in the tank illustrated. It will have no bad spots in it, nor will it leak or sweat. Rock concreting is not permissible. Remember that you are pouring into a thin shell, only 4 inches wide including the expanded metal. The actual space in which to pour is only 4 inches. Rock is sure to bunch and arch. [illegible] the expanded metal [illegible] the form. Of course, before pouring, the [illegible] be [illegible] in the lower section and raked to [illegible] the outside forms and the sheets of expanded metal which reinforce the [illegible] should be placed lapping down a foot or so into the wall forms; also the longitudinal reinforcing rods of the beams, which is figured as a grand beam like the pilasters.

[illegible]

[illegible]

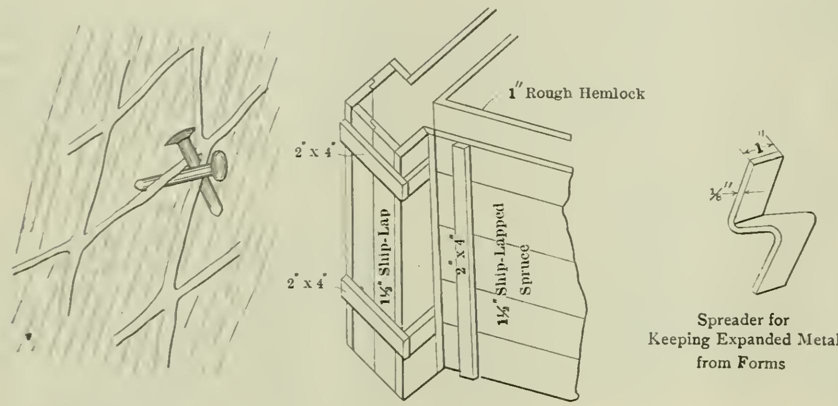
anthracite-cinder filling. The city water was led into it at ground level from a spur of the suction piping. When using the tank water, the meter valve was closed and the tank valve opened, when the feed-pump would suck it back through the same pipe.

It often occurs that there is exhaust steam. not otherwise condensable, which may be led into the feed-water tank. If a tee is left on the main exhaust pipe, and is well worth while, being inexpensive and in no sense a nuisance.

Tank Suitable for Water Softening, Also

A farther use for this tank is for water softening where the lime process is used. There is plenty of depth for settlement, and the large 24x24-inch manhole in the ceiling gives facility for handling the sludge. If boiler compounds are used, was charged with its quota of compound. To do this, the drip in the bottom of the charger was opened, and the feed water drained out of it. It was then filled by way of the funnel at the top with a saturated solution of the compound. The connecting nipple valves were then opened and the main feed gate shut, thus forcing the incoming feed water to pass through the charger driving along the compound before it. As only one set of boiler checks was left open, that particular boiler received the total charge intended for it.

The actual cost of the feed-water storage tank described was $482.26; the iron tank which it replaced cost $648.68, including $120.56 for a foundation of 10-inch I-beams cut into brick walls across a 14-foot alley between two buildings. This is the cheapest possible foundation. Supposing that the iron tank were to be placed on concrete piers on the site of the present tank, the tank being 12x12 feet, five piers would be required besides the footing. With the top of the piers 2 feet above grade and the bottom of the footings 4 feet below, the estimated cost of this foundation would be about $140. As the tank itself cost $528.12, set up, to replace the concrete storage tank with a

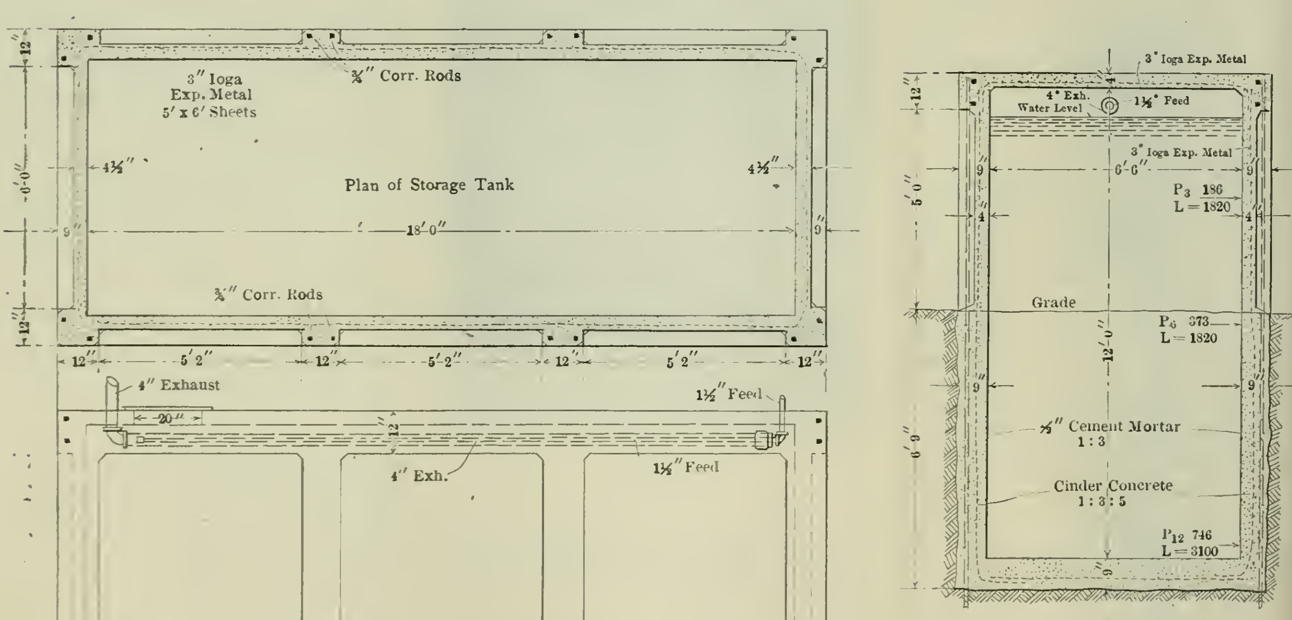


Crossed Nail Spreader

Sketch of Forms

Spreader for Keeping Expanded Metal from Forms

FIG. 2



Side Elevation

Cross-Section

FIG. 3

a suitable pipe led off to the tanks, much of this steam will be condensed and give a preliminary heating to the feed water. This pipe should run the length of the tank just above the water. Into the opposite end enters the water-supply pipe, about 1½ inches in size, and perforated all along the top with ⅜-inch holes. A large surface of cold, flowing water is thus exposed to the incoming steam, and a quantity of heat interchanged. This economy the writer prefers to introduce the charge directly into the feed line. For that purpose, a 4-inch nipple, capped at both ends, exactly held a charge for one boiler. This was by-passed around the main feed-line gate valve by attaching it above and below with ¾-inch nipples with a ¾-inch union and valve in each nipple. A drip valve was put into the bottom cap, and a feed valve and funnel tapped into the top. Just after blowing down, each boiler in turn steel one on the same site would cost $668.12. The cubic contents were identical.

When the terminal pressure of an engine cylinder is practically equal to the back pressure, as in some compound engines, the mean effective pressure formula reduces to

$$p_m = p_b \log R,$$

p_b being the back pressure.

Electric Dynamometers

By G. Everett Quick

Motors have often been rated from so-called power determinations in which the power was absorbed by crude devices or standard machines giving merely an estimated value, subject to wide variations. A true test worthy of the name, requires some means of loading by which observations may be made for accurately computing the power developed. The apparatus for doing this is called an "absorption dynamometer," while a transmission dynamometer is an apparatus by means of which the mechanical power delivered by one machine to another may be measured.

The simplest type of absorption dynamometer is the friction brake, which is made in various forms. In all forms of this brake, the force opposing rotation is obtained by the friction of a revolving pulley with a strap, disk, or wooden arm adjustably clamped to it. If these are clamped to the pulley and allowed to revolve freely with it, the load is zero, but if held stationary, the weight or spring required to hold the brake from revolving is a direct measure of the power absorbed by the friction. Fig. 1 shows an outline sketch of a prony brake, in which A is the friction wheel, L the horizontal distance of the weight from the center of the wheel, which is the radius of the circle which would be described by the suspended weight if it were allowed to revolve with the friction pulley. The imaginary speed, in feet per minute, which this weight would attain under these conditions, multiplied by the weight opposing this rotation, gives the power absorbed in foot-pounds per minute. The imaginary speed is obtained by multiplying the length L of the arm by 6.2832 and multiplying this product by the revolutions per minute made by the wheel A. In short,

6.2832 × *Rev. per min.* × *Arm length* × *Weight* = *Foot-pounds per minute*,

and

$$\frac{\textit{Foot-pounds per min.}}{33{,}000} = \textit{Horsepower}$$

By the use of a chart similar to that shown in Fig. 2, separate calculations for each reading may be avoided. A chart for each length of brake arm is required.

Electric Dynamometers

The well known prony brake is still used in the great majority of tests, and on account of its simplicity and low initial cost, and in spite of its inherent defects, it will no doubt always be widely used. However, other types, such as the Alden brake and the electric dynamometer have been developed which are practically free from the erratic and excessive vibrations characteristic of the prony brake, and mechanical power absorbed by these types may be accurately measured within a fraction of a per cent. Furthermore, the two classes of apparatus mentioned are not only used for loading small units, but may be made in single units capable of absorbing far more power than can be satisfactorily absorbed by a single prony brake.

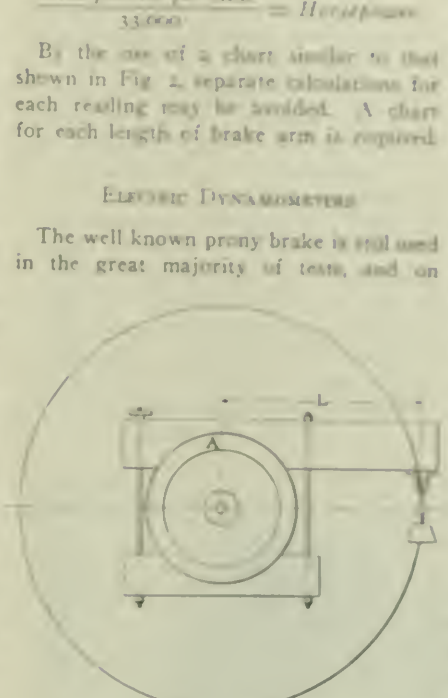


FIG. 1. SIMPLE PRONY BRAKE

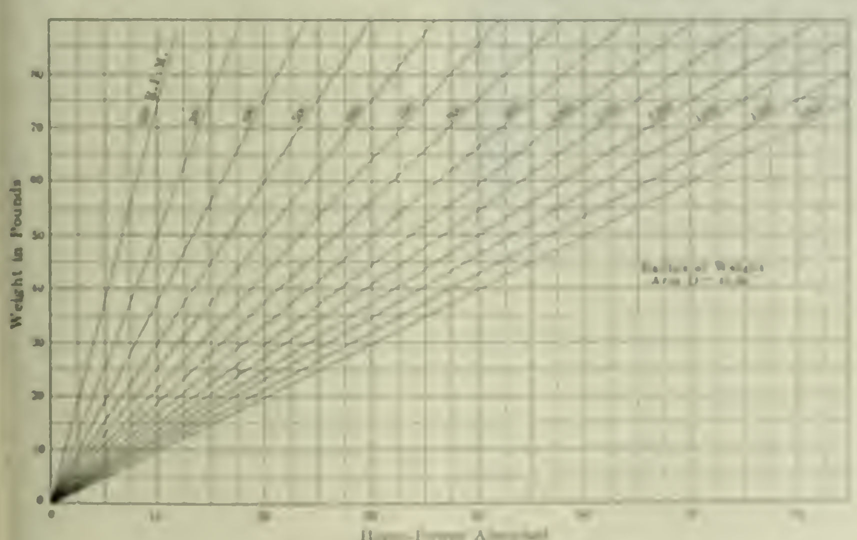


FIG. 2. REFERENCE CURVES FOR DYNAMOMETER

In all types of electric dynamometer, an electric generator, usually a direct-current machine, transforms most of the mechanical energy of the test motor into electrical energy, which in turn is dissipated as heat in an external circuit, or in the armature itself. Under certain conditions, the power ordinarily wasted in rheostats may supply useful power to other circuits.

The best known type of electric dynamometer, and in fact the only one which has been extensively used, is the standard electric interchangeable motor or generator connected by belt or flexible coupling to the test motor. When used to load motors of widely varying speed, the belt drive with different pulley ratios is necessary. Since the power absorbed is measured by the generator output in electrical units, the variable losses of the driving belt and armature resistance make a calibration curve very uncertain. With direct drive the curve is more reliable, although subject to variations due to the variable resistance of the generator conductors. The electric output and consequently the load on the motor, is controlled by passing the electric current through an adjustable rheostat. For small capacities a metallic rheostat, usually of the iron "grid" type, may be used, but for medium and large capacities the well known water rheostat is more practicable.

The so-called "cradle" dynamometer differs essentially from the above only by suspending and balancing the field frame of the generator on knife-edges or frictionless bearings and measuring the power by the torque between the field magnets and the revolving armature. It affords an easy, accurate and efficient means of obtaining instantaneous readings of the brake horsepower of an engine and also of putting full load on it for a continuous running test without excessive heating of the dynamometer. It may be used as a transmission dynamometer to give instantaneous indication of the power required to operate any particular machine by noting the pounds pull exerted at the end of the weight lever and the speed of the rotating armature. It affords a simple and accurate method for determining the horsepower required to operate the machines without the necessity of calculating efficiencies, reading electrical instruments, etc., as would be required with the usual method of testing with a standard electric motor. Owing to the simplicity of apparatus and calculations, the test may be made by comparatively inexperienced attendants.

The general arrangement of the electric dynamometer as manufactured by the Sprague Electric Company is shown in Fig. 3. The machine consists of a specially constructed direct-current generator of the familiar standard-yoke type, with compensating poles. The stationary part is supported on ball bearings in each a manner as to permit the field magnet to oscillate about the armature, remaining concentric, of course, in order that it may revolve freely under all conditions. Two arms extend horizontally from opposite sides of the field-magnet frame to which they are rigidly secured. The short arm or balance lever contains an adjustable weight to balance the complete dynamometer on its bearings. The long arm or weight lever is provided at its outer end with a hanger similar to that on an ordinary platform scale, on which slotted weights may be placed, or if preferred a spring scale may be used for measuring the pull exerted at the end of the lever when the dynamometer is in operation.

The torque exerted by the revolving armature on the field magnet tends to carry the frame around with the armature, and this torque acts in a similar manner to that of the frictional resistance of the friction brake, but without the objectionable vibrations.

Although the electric dynamometer is used more for absorbing a known mechanical power, it can also be employed as a combined motor and indicator, driving a machine and at the same time measuring the power required to do it, thereby serving as a simple transmission dynamometer.

The current for driving is obtained from any direct-current circuit of suitable voltage. The commutating poles afford a very wide range of speed control by varying the field strength with the rheostat connected in the shunt-field circuit of the machine.

Owing to the fact that this dynamometer can be used regularly as a power motor for driving shop equipment, comparatively little added capital is required to avail oneself of such a test outfit.

Eddy Current Dynamometer

A special form of electric dynamometer is the so-called eddy-current brake, which meets with a somewhat limited use as an absorption dynamometer for comparatively small powers when a continuous load is required. The field-magnet yoke and attachments are constructed and balanced essentially the same as in the previous type, although the field excitation must be obtained from a separate source. The armature, instead of having the customary winding and commutator with connections to an external circuit, is made up of copper disks or other short-circuited conductors in which currents are set up by rotation with the field and the heat thereby generated is dissipated to the atmosphere by radiation and connection without recourse to an external rheostat. However, a small rheostat is required in the field circuit for regulating the strength of the field magnet, and consequently the load absorbed.

The rotor of this dynamometer is very rigid and is not subject to electrical breakdown; there being no armature wiring, commutator or external circuit, the initial cost is less than that of the dynamo type. Obviously, the capacity of this type is limited to small powers as only a limited amount of energy can be dissipated in the form of heat by air cooling. However, the temperature of the rotor may be allowed to reach a much higher value than that allowed in the dynamo, since no combustible material need be used in its construction.

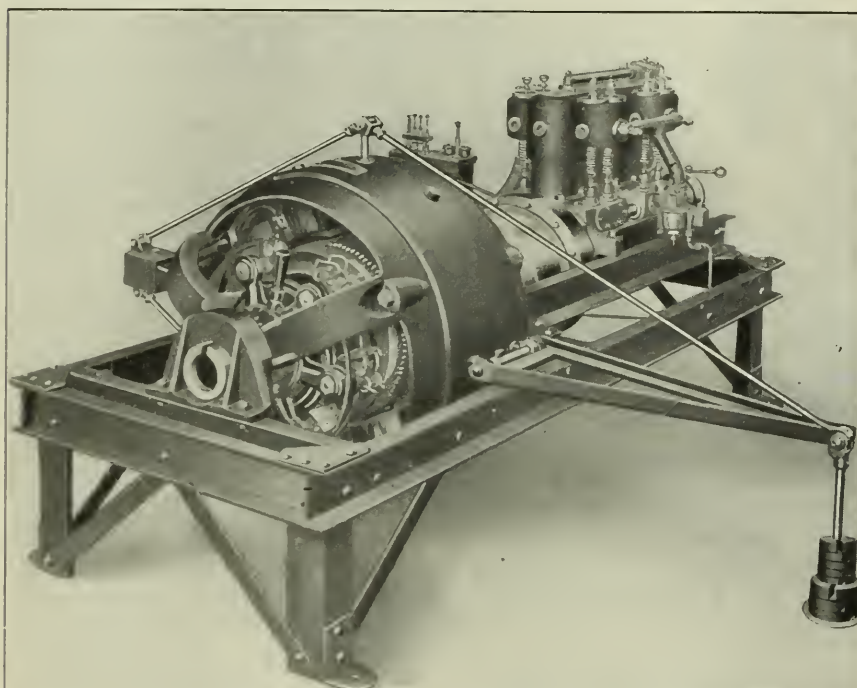


FIG. 3. ELECTRIC DYNAMOMETER COUPLED TO AN AUTOMOBILE ENGINE

Compound Cylinder Ratios for Equal Work

In the following is shown, step by step, the derivation of the formula by which was prepared the table of cylinder ratios, on page 215 of this number:

Let I = Initial pressure absolute,
t = Terminal pressure absolute,
b = Back pressure absolute,
R = Ratio total expansion,
r = Volumetric ratio of cylinders,
$M.P.$ = Mean pressure,
$M.E.P.$ = Mean effective pressure.

$$R : 1 + \log_\varepsilon R :: I : M.P.$$

$$M.P. = \frac{I\,(1 + \log_\varepsilon R)}{R} = \frac{I}{R}\,(1 + \log_\varepsilon R). \qquad (1)$$

But $\frac{I}{R} = t$ and

$$M.P. = t\,(1 + \log_\varepsilon R). \qquad (2)$$

$$M.E.P. = M.P. - b.$$

So that

$$M.E.P. = t\,(1 + \log_\varepsilon R) - b \qquad (3)$$

If the work is to be equally divided the mean effective pressure in the low-pressure cylinder will be

$$M.E.P._l = \frac{t\,(1 + \log_\varepsilon R) - b}{2} \qquad (4)$$

and the *mean* pressure in that cylinder

$$M.P._l = \frac{t\,(H \log_\varepsilon R) - b}{2} + b. \qquad (5)$$

By transposing formula (2) it is seen that

$$\log_\varepsilon R = \frac{M.P.}{t} - 1. \qquad (6)$$

Substituting for $M.P.$ the value given by formula (5) the $\log_\varepsilon$ of the ratio of expansion in the low-pressure cylinder (which is the same as the volumetric ratios of the cylinders, for the contents of the high- are expanded to the volume of the low-) is found to be

$$\log_\varepsilon r = \frac{\frac{t\,(1 + \log_\varepsilon R) - b}{2} + b}{t} - 1 =$$

$$\log_\varepsilon r = \frac{\log_\varepsilon R + \frac{b}{t} - 1}{2} \qquad (7)$$

when $\frac{b}{t} = 1$, i.e., when the diagram ends in a point this reduces to

$$\log_\varepsilon r = \frac{\log_\varepsilon R}{2}, \qquad (8)$$

and since halving a logarithm gives the logarithm of the square root, formula (8) simply means that for the condition cited

$$r = \sqrt{R}.$$

Heat in Steam

By Joseph H. Hart

The question of the amount of heat in steam under various operating conditions, the quantity of this heat available for transformation into work and the various relations of this heat quantity which produce condensation and superheating and other equally important changes in the steam content is a question of the greatest importance not only to the designing engineer, but to the operating and stationary engineer as well. As a general thing almost every man familiar at all with the operation of steam engines has a little information in regard to the subject of heat units and a number of heat changes and the amount of heat available under certain circumstances, but in regard to all the heat relations possible in steam under various conditions of operation they are not familiar. Thus such statements as the one that the quantity of heat in steam is approximately the same independent of its temperature is one not easily understood. Again, the statement that the specific heat of saturated steam is negative leads to an interesting situation and one not clearly understood by the average operator. These two examples will serve to illustrate the type of difficulties which arise, and it is the object of this article more fully to explain the connection of heat and steam, the variation of amount with temperature and the variability of the quantity available for transformation into work under various standard conditions and the causes of steam condensation under conditions not clearly understood.

Thus it is assumed that the average engineer or reader of this article is more or less familiar with the definitions of specific heat and latent heat and has a clear conception of what is known as heat quantity. Specific heat is defined as the quantity of heat required to heat one pound of material one degree Fahrenheit, measured in B.t.u., where a B.t.u. is the quantity of heat required to raise one pound of water one degree Fahrenheit. This heat quantity is referred to heat held by water under varying conditions, and the specific heat is often defined as the ratio of the heat under certain circumstances to that in an equivalent mass of water under the same circumstances. Latent heat is defined as the quantity of heat required to change the state of a body without change in temperature, and it is generally known that this latent heat is given out in condensation or solidification, but absorbed in liquefaction or vaporization. However, this definition is not general enough and often leads to considerable ambiguity, whereas a broader statement of the case would explain many difficult facts as they arise and will not complicate the conditions at the outset in any respect.

Latent Heat Potential Energy

A rise in temperature of a body is nothing more or less than an increase in the kinetic energy of the molecules. The temperature of a body measured by the absolute scale is directly proportional to the mean kinetic energy of the molecules, and these can best be regarded as little bullets flying around through space, in the case of a gas, and producing pressure by their multitudinous bombardments. In a liquid they are fastened together by some unknown bonds, probably similar to gravitation, but still free enough to possess a certain free path and hence capable of possessing kinetic energy. Thus, when a pound of water is heated one degree, a portion of the heat or energy, is used to raise the kinetic energy of the molecules and a portion used to cause expansion or a stretching of the bonds which tie the molecules together. Latent heat is in reality potential energy of the molecules or energy of position and the molecules of water changed into steam possess potential energy of position in exactly the manner that a ball thrown above the surface of the earth, until it escapes the influence of gravitation, possesses energy of position. The molecules of steam have possessed at one time sufficient kinetic energy to rise from the surface of the water due to their motion against the force of cohesion, losing a portion of their velocity exactly as a ball thrown into the air does in rising higher and higher.

When water is heated one degree, a certain amount of heat or energy is used in raising the temperature or kinetic energy of the molecules of the water, and a small fractional part is used up in producing the change of relative position and is apparent as potential energy. The molecules have a variable speed ranging over several thousand per second, and the average or mean velocity or energy only is considered. When the water gets to the boiling point some of the molecules possess sufficient speed to rise high enough above the mass of liquid to become practically free from their attractive power and they lose during this maneuver a large amount of their kinetic energy, possessing after separation approximately the same average kinetic energy as the average molecule in the liquid. The removal of the high-speed molecules causes a diminution in the average speed of the remainder, and hence a fall in temperature unless heat is supplied. This supply in reality is the latent heat of steam. After the water is changed to steam the steam then possesses practically nothing but specific heat, or further increase in temperature means an addition only to the kinetic energy of the molecule. This is actually the case in what is known as superheated steam, in which case the steam behaves as a perfect gas and obeys Boyle's law and Charles' law absolutely.

What Happens if the Pressure Above the Steam is Increased

If the pressure above the water is increased, with less space the molecules are crowded together and a great many more collisions occur among the molecules endeavoring to escape from the surface of the water, and thus a larger kinetic energy per molecule must exist for the evaporation to go on, or simply that the temperature must rise before evaporation occurs. This is the reason for the rise in temperature of the boiling point with increase in steam pressure. The molecules, however, lose a smaller percentage of their kinetic energy in escaping from the water and attaining their position with its corresponding potential energy as steam, and hence the latent heat or quantity of heat used up in potential energy is diminished, and hence the further phenomenon of a fall in latent heat of vaporization with rise in temperature of the boiling point. The fall in latent heat or potential energy required compensates largely for the increase in apparent heat or kinetic energy, so that the total heat in the steam is the same as the potential energy of position of the molecules plus their kinetic energy or energy of motion. The latter undoubtedly varies with rise in temperature, but the specific heat of steam at that temperature, or the quantity of energy required to raise the kinetic energy of the molecules the fractional amount required per degree, is so small a percentage of the total energy involved that it is often neglected.

It is possible under some circumstances at least theoretically to increase the pressure on steam to a sufficient extent to eliminate the latent heat of position entirely. If the molecules are sufficiently packed to prevent separation from the liquid, the energy of position practically disappears and the molecules increase their kinetic energy only, and this phenomenon occurs at what is known as the critical temperature, pressure and volume respectively.

Action of Steam in Contact with Water

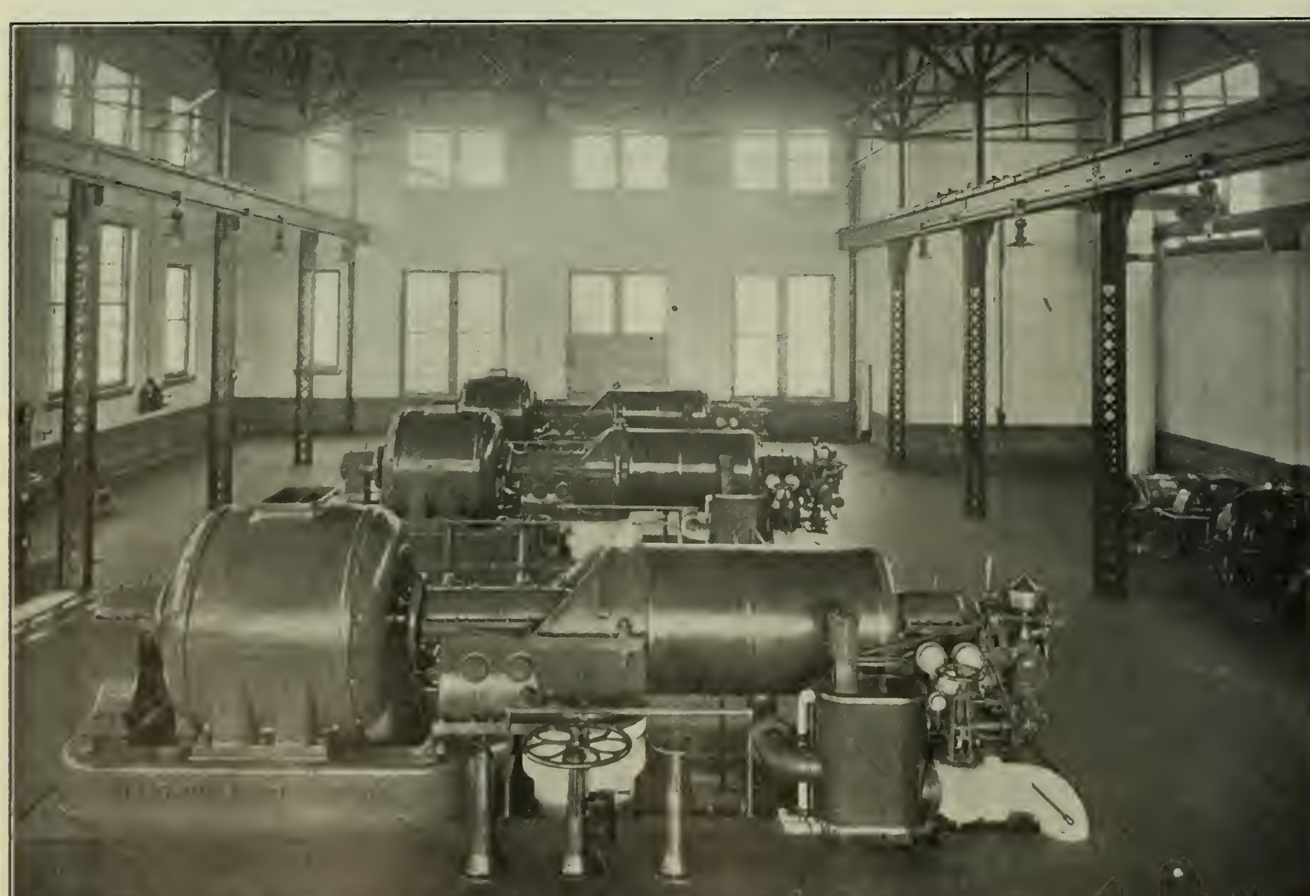
Steam in contact with water possesses anomalous behavior under varying conditions. The number of molecules in a given volume of steam at a given pressure, if the steam is saturated, that is at the temperature of the water in contact with it, is a certain definite quantity which [illegible] under [illegible] conditions. The best explanation of the phenomenon here is that there are as many molecules in the steam that [illegible] arise from the water and [illegible] from the steam into the water and are condensed as lose their energy of position and acquire an increased energy of motion due to the pressure exerted upon them. The molecules in the steam and water possess the same average kinetic energy. Since the same temperature, and only a certain number can exist in the steam, and the transfer of molecules to the steam from the water with the consequent loss in kinetic energy and production of potential energy of position, is exactly counterbalanced by the number of molecules of steam transferred from the steam to the water with their consequent loss of potential energy of position and equivalent rise in kinetic energy. Any increase in pressure on the steam or diminution in the volume of the same results in a crowding of the molecules from the steam into the water, with a corresponding increase in the average kinetic energy or temperature of the water and of the steam as well, since there are then less molecules in the steam and less potential energy in the system, with an increase in the average kinetic energy of all the molecules. This condition explains in reality what is known as the negative specific heat of saturated steam.

When steam in contact with water is heated one degree, the kinetic energy of the entire mass of molecules in both the water and steam is increased a certain definite percentage depending upon the absolute temperature of the system. The increase in kinetic energy of the molecules in the steam results in an increased pressure which means that a number of the molecules are transferred automatically to the water and give up their latent heat of position, which energy is apparent in increased average kinetic energy of the molecules. This energy results in a further rise in temperature. Hence when heat is added to a mixture of water and steam, or what is known as saturated steam, the amount of steam actually diminishes in quantity as determined by weight. The temperature of the water is raised a much larger amount than the heat put in would warrant according to the specific heat of the water, and the extra heat that is evolved in increased rise in temperature of the water and steam comes from the latent heat of condensation of the fractional part of the steam which disappears. Hence arises the statement of the negative specific heat or the production of heat with rise in temperature of saturated steam.

Cause of Much Difficulty in Design and Operation

This anomalous behavior of steam in contact with water is the cause of much difficulty in steam design and operation. Saturated steam, that is, steam in connection with the water in the boiler, changes in amount with every variation in pressure and volume of the same and does not behave as a normal perfect gas would under the circumstances. Thus with saturated steam entering the cylinder of a steam engine, the increase in volume which results from expansion in the cylinder and the transfer of a portion of the kinetic energy of the molecules into energy of the piston, results in a diminution in the kinetic energy of the molecules sufficient to cause a portion of the steam to change into water and to give up its latent heat, in order to maintain the temperature normal for saturated steam at this pressure and temperature. Hence, the phenomenon of cylinder condensation which is augmented greatly by the further radiation of heat through the walls.

Sufficient has been shown to warrant the statement that the behavior of steam under all conditions of operation and theory is a purely mechanical one, and the transfers of kinetic to potential energy and *vice versa* are responsible for all the anomalous conditions existing in the utilization of steam. Any difficulty or misconception or ambiguity that arises in the utilization of steam can be explained and clearly understood by a reference to the kinetic and potential energy of the molecules. This latter conception, known as the kinetic theory of gases, is the basis of thermodynamics and has suggested many possible developments of a mechanical nature which are used in practical applications to eliminate the more serious difficulties in power production in this field.



THREE ALLIS-CHALMERS STEAM TURBINES AND GENERATORS, EACH 750-KILOWATT 3-PHASE 60-CYCLE 2300-VOLT, INSTALLED IN THE NEW POWER PLANT OF THE PACIFIC MILLS, LAWRENCE, MASS.

Heat Losses in an Electric Power Station

At a recent meeting of the Institution of Civil Engineers, a paper was read on "An Investigation of the Heat Losses in an Electric Power Station," by F. H. Corson, of which the following is an abstract:

An inquiry, originating from Blackburn, in 1903, showed that the average coal consumption of 34 principal generating stations of the United Kingdom was about 7.7 pounds per unit generated. The figures ranged from 3.6 pounds to 15 pounds, Blackburn standing at 10 pounds. Rough tests on the various sections of the plant resulted in considerable rearrangement. The steam-pipe system was overhauled and more effectively drained, and steam separators and driers were in consequence dispensed with. Engine stop valves were, where possible, attached directly to the main steam pipes. The steam ring was discarded, and generally the effective heat-radiating surface was greatly diminished. Better-fitting boiler dampers were provided, the condition of the brickwork was improved, and the whole process of combustion was more thoroughly controlled by the institution of flue-gas analysis. These and similar alterations occupied about three years, and the fuel consumption fell during that time to about six pounds of the same coal per average unit generated, a reduction of 40 per cent. Further progress being imperative, it was decided to conduct tests covering the whole operation of the works, viewing the losses peculiar to each part of the plant in their relationship to each other and to the whole; and arrangements were made, and apparatus devised, for their prosecution. After isolated trials of the various types of apparatus had proved their reliability, simultaneous tests were arranged, of a duration long enough to embrace all conditions of operation met with in routine work.

The Blackburn undertaking comprises two adjoining stations of 2300 kilowatts capacity each, containing 12 mechanically fired Lancashire boilers, six fitted with superheaters; 15 high-speed engines driving generators from 60 to 775 kilowatts in size, controlled from three switchboards; steam piping 3 to 14 inches in diameter; ejector and jet condensers fed from an overhead water tank above the boiler house; low-speed steam-driven feed pumps; four batteries of economizers totaling 1504 tubes; two chimneys, 130 and 250 feet high, respectively. The test has covered during 168 consecutive hours the combustion of about 230 tons of coal, the evaporation of 3.176 million pounds of water, and the generation of 99,209 electrical units. The net results show a consumption of 5.15 pounds of coal, and a total evaporation of 33.9 pounds of water per average unit.—*Mechanical Engineer.*

Purchasing and Burning of Coal

By H. W. Richardson

The purchasing of coal for power plants of any great size should receive a great deal of consideration, as the economy of the plant depends much on the quality of the fuel which is burned. In not a few large concerns all coal is purchased by the company's purchasing agent, who in most cases does not understand the peculiar characteristics of coal and seldom, if ever, does he consult his engineer before making a purchase.

All coal companies sell the very best fuel obtainable, according to their agents, and the man who can show the purchasing agent a coal which is of high B.t.u. value and at a low price will invariably obtain the contract. The coal is then sent to the power plant and the engineer's troubles begin. The purchaser of the fuel understands that the coal contains a great many heat units, but he is generally ignorant of the conditions under which the coal is to be burned. What I wish to make plain is that the B.t.u. value does not show that the coal is just what is wanted for any particular plant. Every plant is, of course, equipped with certain grates or stokers, and these furnaces may be adapted to some fuels, but will not burn other grades economically.

The B.t.u. value of coal is determined principally by the amount of ash. One coal may show by analysis 15 per cent. volatile, 75 per cent. fixed carbon and 10 per cent. ash; another coal will show 25 per cent. volatile, 65 per cent. fixed carbon and 10 per cent. ash. The B.t.u. value of these two coals will be the same, but they do not burn equally under the same conditions. For a poor furnace the high volatile coal is unsuitable, and in many installations no adjustments are possible that will better the results. In this case, if a low volatile coal is tried, it will often solve the difficulty.

The coal dealer explains to the purchasing agent that his coal is high in heat value and offers it at a good figure, which will invariably attract the purchasing agent and cause him to purchase a large amount. He does not understand furnace peculiarities and it is then up to the engineer to burn the coal, and if results are not forthcoming he is sure to meet with severe criticism. In a particular case where conditions were as stated above, the excess amount of cheap fuel burned made it in reality quite expensive, simply because the fuel was not adapted to the plant. The adaptability of the coal is more necessary in stoker plants than in hand-fired plants. In practically all stoker furnaces it is absolutely impossible to use one fuel. Some fuels even among those of high heat values, will not burn properly unless they can be worked and stirred up frequently.

To determine which coal is adapted for a particular plant, most engineers will agree that it is good practice to sample and analyze all cargoes received. This procedure is proper to pursue in order that the purchaser may be assured that he is receiving coal of the quality he desires and it will determine whether or not the coal dealer is fulfilling his obligations. Simply knowing the B.t.u. value of the coal, however, is not an assurance that it is the coal wanted. To determine this it is necessary actually to burn the coal and carefully observe the evaporation of the boilers. It is preferable to make tests on all of the boilers, as merely trying the coal under one will not give general results. That these observations may be taken with any degree of accuracy, it is preferable to weigh the coal and use a meter of some kind in the boiler-feed line. If only the weight of the coal consumed had been determined, the economy can be checked quite closely by noting the wattmeter readings and obtaining the pounds of coal per kilowatt-hour. It is thus easy to determine the grade of fuel which will burn with the best economy in the plant, and all that remains to do is to analyze all coal of this grade that is received on any contract to make sure that the coal in each cargo is of the same quality.

The majority of engineers are not familiar with the sampling and the analysis of coal. It is generally considered that this is something beyond them and requiring the skill of a chemist. This is a wrong impression, as any engineer of ordinary intelligence can analyze his own coal. Two forms of analysis are made, one called the ultimate, which requires a chemist, as it determines all the different chemical elements. This is not of any great value to the engineer. The other form is the proximate analysis. This gives the percentages of volatile combustible, fixed carbon and ash, which are in fact the only elements which interest the average engineer, excepting sulphur, the percentage of which he can also easily obtain. All that are necessary to perform the proximate analysis are a platinum crucible, a set of balances, a bunsen burner and an assayer's muffle. As a general rule the coal dealer will be more careful in the selection of the coal if he is aware that an inspection is to be made.

Analysis of the flue gases must also be made. In plants of great magnitude the installation of a CO_2 recorder is the proper idea, but in smaller plants the management is generally adverse to the purchasing of expensive instruments. In this case the engineer can procure an Orsat apparatus, which is inexpensive and requires not a great amount of skill to operate. With this apparatus he can obtain the proper amount of air necessary to burn the coal economically and will get results which will enable him to increase the boiler efficiency.

There has been considerable agitation for the purchasing of coal on the B.t.u. basis, which is all right as far as it goes, but the best method is to find the proper coal and then contract for this particular grade and obtain it as long as possible, for generally if too many requisites are demanded for a particular coal the coal dealer will state his particular price, and in the end but little is gained.

Pipe Sizes Without Figures

By J. E. Bates

Frequently an inquiry or discussion is seen in the correspondence columns of mechanical journals as to how to get the proper size of a single pipe that will be required to carry the same volume as two or more pipes, and while it can be figured out very readily by getting the area of the pipes, there is a much quicker way of getting the same results which has the advantage of requiring no more knowledge than the ability to read correctly the figures on a rule.

Suppose there are an engine and pump to connect up and it is desired to know what size of pipe will be ample for both. Take a steel square or any true right angle and lay off the diameters of the pipes on the legs of the square; then measure across from the points representing these diameters, and this will be the diameter of pipe wanted.

Suppose the steam inlet to the engine is 3 inches and that on the pump 1½ inches; then the distance from the end of the 3-inch mark, Fig. 1, to the end of the 1½-inch mark would be about 3⅜ inches. which would mean the nearest commercial size, or a 3½-inch pipe. This is simply the solution of a right-angled triangle, in

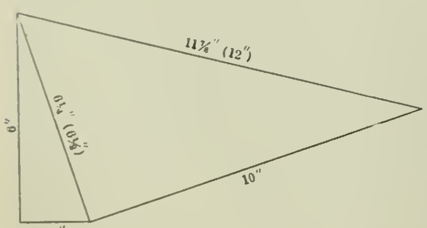


FIG. 4

which the diameter obtained is the hypotenuse.

Taking another case, suppose we have an engine with a 4-inch steam inlet, another engine with a 2½-inch steam inlet and a pump with a 1¼-inch inlet. Then a right-angled triangle, Fig. 2, with a base of 1¼ inches and a hight of 2½ inches, will have a hypotenuse about 2¾ inches long. Now take this resulting hypotenuse and use it as a base for another triangle, the hight of which will be equal to the inlet diameter of the other engine. The result obtained is 4⅞ inches, or a 5-inch pipe. This will mean that a 5-inch pipe will be run from the boiler to the 4-inch connection. a 3-inch pipe from there to the other engine, and a 1¼-inch pipe to the pump, assuming that the pump is farthest away from the boiler. If the engine with the 2½-inch opening is farthest from the boiler. the pump next and the engine with a 4-inch inlet nearest, it would require a 5-inch pipe from

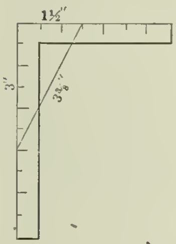


FIG. 1

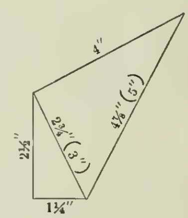


FIG. 2

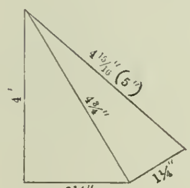


FIG. 3

the boiler to the 4-inch outlet, a 3-inch pipe on to the pump outlet and a 2½-inch to the other engine.

Taking it another way, if the engine with the 4-inch inlet was farthest from the boilers, the 2½-inch connection next and the pump nearest, the problem would be as represented in Fig. 3. In this event there would be a 5-inch pipe from the boilers to the smaller engine, with a 1¼-inch outlet to the pump and a 4-inch pipe on to the larger engine.

As a proof, the area of a pipe is the square of its diameter in inches times 0.7854, or to express it in a formula, where d represents diameter in inches, we have:

$$d^2 \times 0.7854 = A.$$

The area of an 1¼-inch pipe is 1.227 square inches; of a 2½-inch pipe, 4.908 square inches; of a 4-inch pipe, 12.566 square inches. The sum of these areas gives a total for the three pipes of 18.70 square inches. The area of a 5-inch pipe is 19.635 square inches, which is the nearest size.

Suppose the pipes are 10, 6 and 2 inches, respectively, the problem would work out as in Fig. 4, and a 12-inch pipe would be required. Reducing this to figures as a check, we obtain:

	Square Inches.
Area of 10-inch pipe	78.54
Area of 6-inch pipe	28.27
Area of 2-inch pipe	3.14
Total	109.95
Area of 12-inch pipe	113.10

To find the size of pipe required for any number of openings, begin at the opening farthest from the boiler and work toward the boiler. Suppose there are five different steam inlets to pipe to, which may be numbered 1, 2, 3, 4 and 5, No. 1 representing the opening nearest the boiler and the others numbering consecutively as to their relative distances from the boiler. For sizes take No. 1 to be 3½ inches in diameter; No. 2, 5 inches; No. 3, 2 inches; No. 4, 2½ inches; No. 5, 6 inches.

Beginning with opening No. 5 as the base and opening No. 4 as the hight, a hypotenuse of 6 7/16 inches is obtained. This would mean the use of a 6½-inch pipe between No. 3 and No. 4 openings, and a 6-inch pipe between No. 4 and No. 5 openings, the diameter of the opening farthest from the boiler always determining the size of the pipe to use between it and the next steam outlet. Taking the hypotenuse already obtained as a base, draw another triangle, the hight of which will be determined by the diameter of No. 3, or 2 inches. A resulting hypotenuse of 6¾ inches is obtained, and this means a 7-inch pipe between No. 2 and No. 3. Taking this last hypotenuse as a base and opening No. 2 for the hight, a hypotenuse of 8⅜ inches is obtained, or an 8½-inch pipe between No. 1 and No. 2 openings. With the hypotenuse last obtained as a base and No. 1 opening as the hight, the final resultant is 9 1/16 inches, which will determine the size of pipe to run between No. 1 opening and the boilers, or practically a 9-inch pipe.

By computation the following areas are obtained:

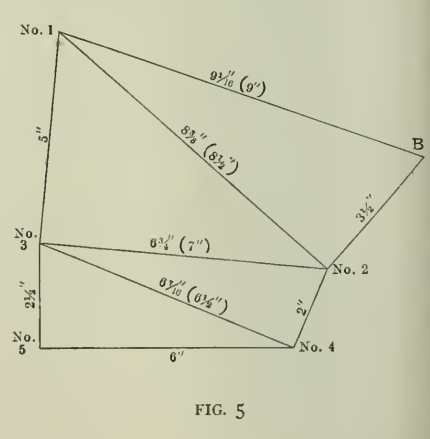


FIG. 5

	Square Inches
Area of No. 1 pipe	9.621
Area of No. 2 pipe	19.635
Area of No. 3 pipe	3.142
Area of No. 4 pipe	4.908
Area of No. 5 pipe	28.274
Total area	65.580
Area of 9-inch pipe	63.617

This is within 1.963 square inches of what the figures call for, which is certainly near enough for all practical purposes.

Cylinder Ratios for Compound Engines

The accompanying table gives the cylinder ratios which in two-stage compounds will produce an equal division of the work between the two cylinders, with no drop or free expansion in the receiver. It considers only the ideal diagram, unaffected by clearance, wire drawing, compression, etc.

Find the total ratio of expansion in the first column. If not given, it may be found by dividing the initial by the terminal pressure, both absolute.

Divide the back pressure by the terminal pressure, both absolute, and find the quotient at the head of the columns. If the terminal pressure is not given it may be found by dividing the initial by the ratio of expansion.

In the column at the head of which the quotient of the back pressure divided by the terminal pressure is found, and in the line opposite the given ratio of expansion, will be found the cylinder ratio which will produce an equal division of the load as represented by the ideal diagram.

EXAMPLE

What should be the ratio between the cylinders of a compound engine to work with an initial pressure of 120 pounds absolute, ten expansions and exhaust against an absolute back pressure of 3 pounds, in order that the work may be [illegible]

[illegible]

Cylinder Ratios for Compound Engines, with Equal Distribution of Load

Total Ratio of Expansion		0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00
6	1 1	1.52 1.23	1.56 1.25	1.60 1.26	1.64 1.28	1.68 1.30	1.72 1.31	1.77 [illegible]	1.81 1.34	1.86 1.36	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6.5	1 1	1.59 1.26	1.63 1.28	1.67 1.29	1.71 1.31	1.75 [illegible]	1.80 1.34	1.84 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	1 1	1.64 1.28	1.69 1.30	1.73 1.31	1.77 [illegible]	1.82 1.35	1.86 [illegible]	1.91 [illegible]	1.96 1.40	2.01 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7.5	1 1	1.70 1.30	1.75 1.32	1.79 1.34	1.84 [illegible]	1.88 1.37	1.93 1.39	1.98 1.41	2.03 1.42	2.08 1.44	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	1 1	1.76 1.33	1.81 1.34	1.85 1.36	1.90 1.38	1.94 1.39	1.99 1.41	2.04 1.43	2.09 1.44	2.14 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8.5	1 1	1.81 1.34	1.86 1.36	1.91 1.38	1.95 1.40	2.00 1.41	2.05 1.43	2.11 [illegible]	2.16 1.47	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	1 1	1.87 1.37	1.91 1.38	1.96 1.40	2.01 1.42	2.06 1.43	2.11 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9.5	1 1	1.92 1.38	1.96 1.40	2.01 1.42	2.07 1.44	2.12 1.46	2.17 1.47	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	1 1	1.97 1.40	2.02 1.42	2.07 1.44	2.12 1.46	2.17 1.47	2.23 1.49	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10.5	1 1	2.02 1.42	2.07 1.44	2.12 1.46	2.17 1.47	2.23 1.49	2.28 1.51	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	1 1	2.06 1.43	2.11 1.45	2.17 1.47	2.22 1.49	2.28 1.51	2.34 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11.5	1 1	2.11 1.45	2.16 1.47	2.22 1.49	2.27 1.51	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	1 1	2.15 1.47	2.21 1.49	2.26 1.50	2.32 1.52	[illegible]	2.44 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12.5	1 1	2.20 1.48	2.25 1.50	2.31 1.52	2.37 1.54	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	1 1	2.24 1.50	2.30 1.52	2.36 1.54	2.42 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13.5	1 1	2.28 1.51	2.34 1.53	2.40 1.55	2.46 1.57	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	1 1	2.33 1.53	2.39 1.54	2.45 1.56	2.51 1.58	[illegible]	2.64 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14.5	1 1	2.37 1.54	2.43 1.56	2.49 1.58	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	1 1	2.41 1.56	2.47 1.57	2.53 1.59	2.60 1.61	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15.5	1 1	2.45 1.56	2.51 1.58	2.57 1.60	2.64 1.62	2.70 1.64	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	1 1	2.49 1.58	[illegible] 1.60	2.61 1.61	2.68 1.64	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16.5	1 1	2.53 1.59	2.59 1.61	2.65 1.63	2.71 1.65	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	1 1	2.56 1.60	2.62 1.62	2.68 1.64	2.75 1.66	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17.5	1 1	2.60 1.61	2.67 1.63	2.73 1.65	[illegible] 1.67	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	1 1	2.64 1.62	2.70 1.64	2.77 1.66	2.84 1.68	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18.5	1 1	2.67 1.64	2.74 1.65	2.81 1.68	[illegible] 1.70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	1 1	2.71 1.65	2.78 1.67	[illegible]	[illegible] 1.71	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19.5	1 1	2.74 1.66	2.81 1.68	[illegible] 1.70	[illegible] 1.72	[illegible] 1.74	3.11 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20	1 1	2.78 1.67	[illegible]	[illegible] 1.71	[illegible] 1.73	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

(Column heading: Quotient of Back Pressure Divided by Terminal Pressure, Both Absolute.)

terminal is unity. The values in the body of the table are the volumetric ratios; the volume of the low-pressure cylinder divided by the volume of the high-. The second row of figures give the ratios of cylinder diameters when the strokes are the same. For example, in an engine using 13 expansions and with a back pressure one-half the terminal, the low-pressure cylinder must have 2.81 times the volume and 1.68 times the diameter of the high-. The derivation of the formula by which the table was computed is given in another column.

Marine Engines

About the reciprocating marine engine there is absolutely nothing new to record. The manufacture of such engines has become as simple and monotonous as the weaving of calico. Attention has been concentrated on the turbine. The position, so far as marine propulsion as a whole stands, has been made quite clear. The turbine, to be efficient, drives the propeller too fast for it to be efficient, except for speeds over 18 knots. Either the turbine must be sacrificed to the propeller, or the propeller to the turbine. It has come to be fully understood that the economy of the turbine lies at the low-pressure end. In the reciprocating engine steam cannot, as a rule, be expanded much below 7 pounds absolute in the low-pressure cylinder. This cuts off a large section of the toe of the diagram. But the turbine can work down to 1½ pounds absolute. The result is that, instead of exhausting direct from the low-pressure cylinder into the condenser, it is worth while to interpose a turbine and exhaust through it to a condenser fitted with special auxiliary air extractors. This turbine may be of fairly large diameter running at a reasonable speed. Three screws are then used to propel the ship. This system of propulsion has been for some time under discussion, and has at last been put to the test on a large scale. The first merchant steamer to be fitted is the "Otaki," the property of the New Zealand Shipping Company, Limited, London. The vessel was built by W. Denny Brothers, and engined by Denny & Co., Limited, Dumbarton. The "Otaki" is fitted with two sets of reciprocating engines in the wings, driving twin screws; between these two engines is interposed a low-pressure turbine of very large size, which drives a center screw. The turbine revolves only in the ahead direction, and change valves are fitted so that the steam may be either passed directly into the condenser or to the turbine. Hence in maneuvering the vessel becomes an ordinary twin-screw. The twin-screw engines are triple-expansion of the ordinary design, 24½, 39 and 58 by 39. The "Otaki" is virtually a sister ship to the "Orari," which was built and delivered in 1906 to the same company. The boiler installation is precisely the same as in the "Orari." The only alteration that was made by the builders was that the length was slightly increased to make up for the loss due to the three tunnels, as against two in the "Orari," and the stern post was so arranged that the third screw could be fitted in an aperture. The dimensions of the "Otaki" are 464x60x34 feet, or 4 feet 6 inches longer than the "Orari." Otherwise the vessels are the same. The economical results seem to be very good. During the trial trip of the ship, which were made in November, the consumption of water for all purposes came out at 12.3 pounds per indicated horsepower per hour, a consumption probably the best ever attained at sea.

The purpose of the combination we have just described is the attainment of the economy of fuel. It has not been adapted to get over the speed-efficiency trouble. During the last year a radically different scheme has attracted a good deal of attention. It is to let the turbine run at that number of revolutions which best suits it, and the propeller at its best speed, the reconciliation of conflicting conditions being effected by the interposition of transmission gear of some kind. When the screw propeller was first introduced it was found that it would have to be run too fast for the slowly revolving steam engines of those days. Therefore gearing was introduced, the screw making two or three turns for each one of the crank shaft. Now we find the conditions reversed, and it has been proposed to drive the screw by spur gearing. The circumstances are more favorable than those just mentioned, because a pinion will drive a spur wheel with less loss of power, less friction and vibration, than a spur wheel will drive a pinion. But electricity provides a better way out of the difficulty. The turbine drives a dynamo at one speed, and that drives motors at a much lower speed. All the arguments in favor of this plan were very ably set forth by W. P. Durtnall to the Institute of Marine Engineers on July 2 and dealt with in our impressions for July 24 and November 6.

Superheating enjoys a strictly qualified popularity. Used in moderation it promotes economy without drawbacks. Attempts to use very hot steam, however, have not been commercially successful. It would occupy far more space than we can spare to set forth the reasons why in any detail. Great benefit is obtained by drying the steam thoroughly in the superheater, and raising its temperature about 100 degrees in the valve chest above that normal to the pressure. With such steam, and a pressure of 160 pounds, and clearance reduced to a minimum, an indicated horsepower may be had for a pound of good coal per hour, and this may be regarded as the most that can be obtained from any commercial kind of steam engine whatever.—*The Engineer*, London.

Gas Power as an Aid to Electrical Industries

By Philip W. Robson

Most of the generating stations in our smaller towns find it difficult to show satisfactory financial results. This is not a prejudiced statement, for though personally I have long felt its truth, I am able to quote a prominent electrical engineer as its author. I refer to J. F. C. Snell, who dealt fully with this aspect of the matter in his paper read in the early part of last year before the Institution of Electrical Engineers. On account of their unsatisfactory financial position, Mr. Snell actually advised the entire elimination of independent electricity stations in the smaller towns in favor of central plants each supplying groups of towns. This drastic step is not at all necessary if gas power is adopted in lieu of steam, and this opinion is the result of the frequent opportunities I have had of making careful comparison in the actual running costs of the best steam engines as against gas engines. I will give one characteristic example of a new slow-speed vertical-mill steam engine fitted with surface condenser and all the latest steam-saving appliances:

COMPARATIVE COSTS.

	Steam.			Gas.		
Output of engine......	250 I.H.P.			250 I.H.P.		
Weekly working costs, 55 hours:						
Coal...............	£9	10	0	£	0	0
Coke...............	0	0	0	3	0	0
Wages..............	2	1	6	2	0	0
Oil................	1	5	0	0	6	0
Water..............	0	7	6	0	0	0
Sundries...........	0	15	2	0	5	9
	£13	19	2	£5	11	9
Weekly saving in favor of gas engines.......				8	7	5
Annual (52 weeks) saving in favor of gas engines............				435	5	8

In the above comparison both the steam engine and the gas engine are assumed to work on constant load, but in the case of the fluctuating load which is usually experienced in a generating station, the comparative saving would be still more in favor of the gas-power plant, while the standby losses with the latter would be practically negligible. For such reasons it is not too much to say that the running costs of a small station driven by gas engines will be only one-third of the present costs with a steam plant. In addition, it is not to be forgotten that with a gas-engine combination there is no boiler, and consequently no smoke, and few ashes, besides which the plant can be got on full load within 30 minutes from starting with everything cold.

It is pleasant to record that during the year several gas engines have been ordered for use in such generating stations, and I do not doubt that experience will justify a great extension of their adoption. I believe that gas power will prove to be the salvation of small stations.

LARGE UNITS FOR BIG STATIONS

The problem of large units is quite different. The large gas engine is still comparatively in its infancy, and the fiasco of the Johannesburg station is quite sufficient in itself to scare even bold minds from contemplating large gas units. Still progress is being maintained at a rapid rate, and an astonishing change of feeling has taken place in the year. In proof of this, the city of Birmingham is actually inviting proposals at the present time for 3000-kilowatt gas-driven sets. Confidence has been restored to a large extent by the organized visits which leading electrical engineers have paid to the Continent in the course of the year, when it was made possible for them to see many large engines successfully at work.

I think there is no doubt that the best types of large engine work well, and the fuel consumption is only about one half that of the best large steam engines, but in connection with their adoption I would like, if I may do so without being misunderstood, to utter a word of warning. There are two chief factors in making a new prime mover a success; it must first be made right, and it must afterward be worked right. Both require special knowledge, and, speaking from experience as an engine maker, I am bound to admit that I very often find our engines better looked after by the station engineers and attendants than by our own men. I think other engine makers will bear me out in this, and after all one of the essential elements in the successful application of gas power on a big scale in central stations is that station engineers shall in all cases be educated up to them. With this object in view I advise in such cases that a moderate-sized engine and gas plant be first installed, say a unit of from 400 to 500 horsepower. This would always be a useful set to have; it could work quite as economically as the larger units, and further would be an experimental set to make all concerned acquainted with the general behavior and management of gas units. The transition from this first set to a subsequent larger unit would be so easy and natural that there would be a complete absence of administrative anxiety.

Let me again emphasize that it is one of the features of gas power that units of 400 horsepower will work quite as economically as those of 2000 horsepower, so that apart from space consideration there is not at present a great gain in adopting the larger units.

STEAM TURBINES VERSUS GAS ENGINES

I am not aware of any reliable figures which will afford proper data for a comparison of the merits of the turbine with those of the large gas engine. There are frequently, however, special factors which must decide in favor of the latter. The turbine requires a high vacuum and consequently a lavish supply of cooling water for the condensing plant; the gas plant will work successfully with little water. Again, what is the cost of upkeep of these turbines? One hears rumors of the rapid disintegration of the blades, the renewal of which is a costly job, and there are many indications that the gas engine will not suffer from an upkeep comparison. Nor must it be forgotten that the only pressure in a gas-engine plant is that within the working cylinder. There are no high-pressure boilers, feed-heaters, feed and steam pipes, and all the other high-pressure fittings which are necessary in a modern steam plant. The absence of these is an important advantage.

THE USE OF BY-PRODUCT GASES

There has been a great extension during the year in the use of gas engines in conjunction with blast-furnace and coke-oven gases, which are by-products of the great iron works and collieries. In the majority of cases these engines drive dynamos, and the works are accordingly equipped for electric drive. This sphere of development is going to prove a most valuable and important one, not less for electrical engineers than for gas-engine builders. There are many inquiries out at the present time for engines and dynamos for this class of work, a great deal of which will be carried out in the course of the new year.

ISOLATED INSTALLATIONS

The past year has witnessed a continuance of the use of gas power in isolated plants. Particular location has little or no influence on the successful and economical working of gas engines and gas producers, and it is to them that the electrical engineer must turn to enable him to produce electricity with economy in such cases, especially in view of the growing tendency which exists to remove factories out of the large town areas. In addition to factories, there are asylums, schools, and large country houses which are gradually adopting gas power for generating electricity.

CONFLICTING INTERESTS

In those comparatively few districts where cheap current is available for power purposes from the public supply a feeling of competition undoubtedly exists between those interested in the sale of smaller gas engines and producers, and the electric supply. Whether it is really economically sound for the latter to sell current to power users at a price which cannot be remunerative, is a controversial subject beyond the scope of these remarks. I would, however, like to remind the electrical industries that the use of electrical energy in all isolated factories cannot be dispensed with, and hence if gas engines are put in, dynamos are also required. The electrical trades benefit here to at least an equal extent with the engine makers, and the attempts, often successful, which have been made in such cases to depreciate the use of gas engines, has also had the effect of shutting out an enormous number of contracts for dynamos and other equipment, to the serious disadvantage of the electric trade. This should be specially noted at present when many of the latter are unfortunately in a most depressed condition.—*The Electrical Times*, London.

New Swedish Peat Invention

In stating that considerable money has been expended on Dartmoor and the Great and Tregaron moors in England in attempts to convert peat into a marketable commodity on a large scale, Consul Joseph G. Stephens writes from Plymouth of a present apparently successful invention:

The peat is employed on the moor and its immediate vicinity as fuel, but the various processes hitherto tried with a view to adapting it for use as a fuel in rivalry of coal in the towns, or for putting it to other useful purposes, have hitherto ended in large losses. A new method is, however, being put forward according to a local journal under which, it is claimed, peat may become a very valuable commodity. The inventor is a Swedish scientist, who has been engaged in experiments for years and has now reached the stage when a large factory plant has been put in operation.

The process is very simple. The peat, as obtained from the bog, is first of all pulped into a homogeneous mass. It is then heated under pressure to a temperature above 150 degrees Centigrade, after which the water is pressed out by mechanical means. The residue is formed into briquets in the usual way. It is because of the heating of the mass to so high a temperature that the peat ceases to hold water in the same way as at lower temperatures. By mechanical methods it is almost impossible to eliminate water from peat at ordinary temperatures, but by this process beyond the important taken place quite easily. As to the commercial value of the peat briquets, it is claimed that 4 pounds will give as much heat as 4 or 5 pounds of good coal. It is held that the manufacture of fuel from peat by this process can be carried on commercially, may be sold near and that in the matter of price peat fuel would be much cheaper than coal.—*Monthly Consular and Trade Reports.*

The Technologic Branch of the United States Geological Survey is issuing, upon application, a copy of Bulletin [illegible] which has to do with the density of woods.

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Contents PAGE

Visiting

The engineer who has frequent opportunities to visit other plants than his own possesses a material advantage. To see other makes and types of apparatus, to exchange ideas with other engineers regarding methods and results, to discuss difficulties and swap experiences, can but make a man broader, better informed and capable of greater things.

Comparatively few engineers are so favored. The activity of the ordinary member of the craft is confined to a small sphere, and the condition that he shall be constantly within it is imperative. When he does get a day off he is naturally more inclined to spend it in some other way than in visiting other plants. And yet there are evenings when one might drop in at the power house or the electric-light station or some of the hotel and other plants which run at night.

Have you exhausted the possibilities for information of all the plants in your neighborhood?

Have you noticed that it is the man who devotes some of his spare time to visiting around in this way who gets on, and who is looked up to and sought when something of importance is up?

The next best thing to visiting oneself is being visited. An intelligent and interested caller can be made a fertile source of information, and in return for your courtesies to him will gladly be drawn upon for any knowledge which he may possess about the things in which you are especially interested. The men who knew two or three things about engineering and hugged them to themselves, have been swept aside (they never were engineers) by men who by a free exchange of knowledge have learned more in weeks than the niggards would acquire in a lifetime.

And finally for the man who has neither the chance to make visits to nor receive visits from his kind there is the weekly or monthly arrival of his technical paper. Here he will find accounts of the visits of the editors to different remarkable and interesting plants. Photographs of the different features of the plant will be reproduced, so that the reader who follows the article closely and intelligently may know how the plant looks and how it is put together almost as well as though he had been over it himself. These articles are not simple enumerations and catalog descriptions of the proprietary articles and machinery which go to make up a power plant, but seek to answer the questions that an intelligent engineer would ask and to point out the things which would interest and attract him if he were visiting the plant himself. In your paper also those who have had exceptional opportunities for observation or have devoted study and thought to some particular subject come to talk to you upon the things with which they are especially qualified to deal, and if you do not catch their meaning and require some point straightened out, they or the editors are always glad to be called upon for an explanation. If you do not agree with them, there are the correspondence columns where you can argue it out with them and other contributors to your own satisfaction, besides making a little cigar or book money by your trouble.

The next time you have a caller, try to make it worth his while to have called, and do not let him go until you have profited by all that he is able and willing to tell you.

And the next time your paper comes see if you have been getting out of it all the good which it is capable and willing to do you.

Failure of a Butt Joint

On another page of this issue will be found a description of the failure of a triple-riveted butt double-strapped boiler seam. (Two other similar cases are known to the writer of the article.) From the description of this failure it would appear that it was caused by an action similar to that supposed to produce a like defect in the lap form of seam. It has generally been assumed that this defect in the lap seam was caused by the ends of the sheets being out of line, and the circumferential stresses produced by internal pressure causing the plates to bend along the outer line of rivet heads, this action being repeated with each change or pulsation in the steam pressure.

While this explanation is doubtless in the main correct, it does not explain why these lap cracks invariably start on the under side of the outer lapping sheet and never on the top of the under lapping sheet. As far as the foregoing theory of their formation is concerned, they should be as likely to occur on one side of the lap as the other. It is not impossible that the form of the seam is not the only factor to be held responsible when failure occurs to a lap joint.

While the record of a single failure of the butt form of joint would not justify speculation as to the probability of other failures of a similar character, it does not require a great stretch of the imagination to picture this type of joint being made so that the true cylindrical form of the boiler would not be maintained at the joint, and as a consequence bending of the sheet might take place in operation.

It has been previously suggested in these columns that there is an apparent need for further investigation of riveted joints and it would seem that there is an interesting and profitable field of investigation open to some institution of learning, to determine by actual experiment on boilers under pressure just how deformation occurs at the seams when made true to form and otherwise.

The State of Massachusetts is spending, directly and indirectly, a vast sum of money annually in an endeavor to insure as far as possible that steam boilers in its bounds be immune from explosion. Why would not a careful investigation of what actually happens to boiler joints under working conditions be of advantage in accomplishing the desired result?

If maintaining the true cylindrical form of the shell at a butt-strapped seam is of equal importance to the type of joint in rendering it safe for continued use, the sooner the facts are known the better. Safety of boiler construction is of the greatest importance to the public, and no feature should be guessed at or surmised that will admit of direct proof by experiment. The number of extremely dangerous cracks that have recently been discovered in boilers, before they have actually caused explosions, would seem to point to a need for a periodical examination of old boilers under hydrostatic pressure, with all the longitudinal seams uncovered so that every facility may be afforded to detect such defects.

The fact that the boiler did not explode is evidently due to the fact that the sheet, although split nearly across, was retained in position by being riveted to the flange of the head on one side and to the round sheet on the other.

The Actual Cost of Power

In the great majority of cases where power costs are figured from the records of operating plants, the total expense per horsepower or per kilowatt-hour is calculated without taking into account the fixed charges of the installation. It is usually sufficient from the point of view of the plant operator to determine what his power costs him month by month, as manufactured under the local conditions of his station. He can ordinarily do little or nothing to reduce the fixed charges, except by properly maintaining the plant to offset its depreciation; the operating costs, pure and simple, are the facts he must deal with, and upon which he must base his work in the interests of economical production.

It is important for the engineer to be able to figure power costs including the fixed charges, however, when occasion arises, and to appreciate the influence of the annual interest, depreciation, insurance and taxes on the unit cost of power produced. It is evident that the greater the output that can be obtained in a plant, the less will be the fixed or annual charges per unit. In some cases these charges are quite high, in others low. An example of what power actually costs in a modern oil-engine station in the past year may be cited. This station contained two American Diesel engines of 225 horsepower each, with triple 16x24-inch cylinders, direct-connected to alternators running 164 revolutions per minute.

The total cost of the station was about $105,000, or $234 per horsepower of normal rating. The manufacturing cost of the plant was made up of the following items: Fuel oil, $3,160; water, $88; oil and waste, $247; wages, $3,913; station repairs, $5; oil-plant repairs, $663; electric-plant repairs, $73; total, $8,149. The energy delivered at the switchboard was 817,000 kilowatt-hours. The operating cost was thus about 1 cent per kilowatt-hour. The total cost of the power, however, included the interest on the total cost of the plant, assumed as six per cent., depreciation, taken at seven per cent., taxes, one per cent., insurance, one per cent., total fixed charges, fifteen per cent. The plant cost was made up of: building, $39,288; real estate, $17,057; oil plant, $38,500 ($85.50 per horsepower); electric plant, $9,500. The total fixed charges were, therefore, fifteen per cent. of $105,000, or about $15,700 per year. The manufacturing cost at the station per kilowatt-hour figures about half the fixed charges per kilowatt-hour, the latter coming to about 1.92 cents. Thus the total cost of producing power in this plant is not far from 2.92 cents per unit generated, and the influence of the initial investment in the station becomes clearly important.

In making the choice of station equipment, it is, of course, necessary to consider the features of operating convenience and reliability, safety, probability of heavy repairs, overload capacity, the reliability of the makers, the accessibility of the equipment for repairs and adjustment and similar points, in addition to the simple question of cost. The economy of production may be excellent, as in the case illustrated, oil costing from 3 to 4 cents per gallon; the repairs are far from alarming, also; but the initial cost of the station is high. It must be borne in mind, in considering a case of this kind, that the load factor of the plant exerts a powerful influence on the ultimate economy of production. The output of the station for the year was about one-third its maximum possible output for a three-hundred-day year at full load for twenty-four hours. If the company succeeds in increasing the load on the plant, the cost per kilowatt-hour due to the fixed charges will rapidly go down. If the plant could be operated at full load for every business day of the year, doubtless impracticable under the local conditions, but sometimes feasible with electrochemical loads, the fixed cost per kilowatt-hour would drop to about 0.7 cent, and it is probable that a load nearer the machinery rating would result in still better fuel economy, probably carrying the total cost of power production down to 1.5 cents at the most.

A moderate initial cost of plant is exceedingly important if it can be obtained, but in cases where it is high it will not do to assume that it will not pay to install expensive apparatus, provided the operating economy and service reliability are all that could be desired. The point is, not to overlook the fixed charges in making estimates of the values of different equipments.

Furnace Arches

It has been said, and rightly, that in the future the greatest economy to be made in the steam plant will be in the boiler room, rather than in the engines, which have arrived at a fair state of perfection. Stress has lately been laid upon the matter of preserving the coal supply, but even setting aside the fact that this is desirable, the standpoint of economy in dollars and cents demands not only that the furnace of a boiler shall be constructed so that the coal will be burned to the best advantage, but that a low grade of cheap fuel can be burned successfully.

That the down-draft furnace is the best type, so far as known, is a matter of fact, and that it has not become more popular is not that its merits have not been recognized, but that in most cases the necessary space for its installation is lacking. The down-draft furnace is efficient because in it the gases are heated to a temperature sufficient to cause their consumption before reaching the cooling surfaces of the boiler tubes or shell, as the case may be; the top of the lower grate, which is constructed of [illegible], bringing about this result. This idea is being carried out in the shape of brick arches in the ordinary furnace, which gives the same economical result regarding the consumption of gases freed from the fuel.

The brick arch is a fuel saver not only because it consumes the gases liberated from the coal, but because it produces a longer flame than obtained in furnaces not so designed, thus making the heating surface of the boiler more efficient. A furnace having the lowest temperature will have the highest amount of CO, due to imperfect combustion, and tests have been made with furnaces with and without the fire-brick arch which have resulted in a saving of more than fourteen per cent. in CO over the furnace not fitted with the brick arch.

The matter of burning the smaller sizes of coal is becoming of considerable importance and the brick arch plays no small part in its consumption, especially in cities where a smoke ordinance prohibits the making of smoke to any great extent.

It is necessary to take into consideration that the [illegible] furnace, at the rate of about [illegible] per cent. This includes the heat escaping out of the stack, radiation from the boiler and setting, which may be greatly varied depending upon the manner in which the brick-work is kept in repair, and the loss due to coal which drops through the grates into the ashpit.

Coal and Coke Production in the United States

The following table has been compiled largely from data communicated by the several State mine inspectors, estimates having been made only where no such statistics were available, but in all cases upon the basis of good information:

PRODUCTION OF COAL IN THE UNITED STATES.

States.	1907. Short Tons.	1908. Short Tons.
Bituminous:		
Alabama	14,417,863	11,950,000
Arkansas	1,930,400	1,750,000
California and Alaska	45,300	55,000
Colorado	10,920,527	9,773,000
Georgia and North Carolina	365,300	275,000
Illinois	(c)51,317,146	48,000,000
Indiana	11,692,072	12,000,000
Iowa	(a) 7,568,424	7,050,000
Kansas	6,137,040	5,600,000
Kentucky	10,207,060	9,526,000
Maryland	5,529,663	5,000,000
Michigan	(b) 1,898,446	2,000,000
Missouri	4,350,000	3,900,000
Montana	1,810,000	1,800,000
New Mexico	(a) 2,302,062	2,725,000
North Dakota	268,300	250,000
Ohio	32,465,949	30,000,000
Oklahoma	3,450,000	3,250,000
Oregon	51,600	25,000
Pennsylvania	149,759,089	118,309,000
Tennessee	6.760,017	5,009,000
Texas	1,300,000	1,250,000
Utah	1,967,621	2,000,000
Virginia	4,570,341	4,000,000
Washington	3,713,824	3,000,000
West Virginia	47,205,965	44,091,000
Wyoming	6,218,859	6,100,000
Total bituminous	388,222,868	338,688,000
Anthracite:		
Colorado	45,113	30,000
New Mexico	17,000	10,000
Pennsylvania	86,279,719	80,240,000
Total anthracite	86,341,832	80,280,000
Grand total	474,564,700	418,968,000

(*a*) For the fiscal year ending June 30.
(*b*) For the 12 months ending November 30, 1907.
(*c*) As reported by the U. S. Geological Survey

PRODUCTION OF COKE IN THE UNITED STATES.

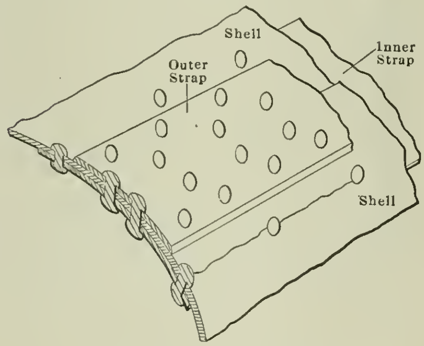
States.	1907. Short Tons.	1908. Short Tons.
Alabama	3,096,722	2,800,000
Colorado	1,097,051	854,000
Georgia and North Carolina	71,460	70,000
Illinois	372,697	270,000
Kentucky	77,055	60,000
Montana	31,400	30,000
New Mexico	203,437	260,000
Ohio	310,640	250,000
Oklahoma	57,600	50,000
Pennsylvania	23,516,309	11,287,000
Tennessee	495,200	250,000
Utah	324,692	290,000
Virginia	1,622,734	1,200,000
Washington	61,400	48,000
West Virginia	4,078,222	2,978,000
Other states (*c*)	1,650,000	2,000,000
Total	37,066,619	22,697,000

(*c*) Includes output of by-product coke for Massachusetts, Maryland, Minnesota, New York, Michigan, Wisconsin, New Jersey.

If the production of coal in 1908 had shown as large an increase as in 1907, the long predicted half-billion total would have been reached. To satisfy our fuel demands during the last 12 months, we have exhausted about 61 square miles of our available coal lands. If our production should remain stationary, at this total, in future years, it would require over 6000 years to exhaust our coal beds; if, however, the future production should increase at a rate equal to that shown in 1907, the available coal seams would last only about 200 years.—*Engineering and Mining Journal.*

Hidden Crack in a Strapped Butt Joint

The triple-riveted butt-strapped joint has been assumed to be a complete remedy for the hidden crack to which the lap joint is liable. The following account of the failure of a butt joint in this manner will, therefore, be of exceptional interest. It is written by T. T. Parker, chief boiler inspector of the Fidelity and Casualty Insurance Company, and will appear in the bulletin issued by that company. Mr. Parker says that this is the third instance



WHERE THE FAILURE OCCURRED

of the kind which has come to his attention:

A recent failure of a horizontal tubular boiler by rupture through the double pitch of rivet line of the longitudinal seam is of more than usual interest. The boiler was 72 inches in diameter and of $\frac{7}{16}$-inch shell plate. It was about sixteen years old. The inner and outer straps were each ⅜ inch thick. The joint was triple-riveted, the single pitch being 3⅜-inch, the double 6¾-inch and the rivet holes $\frac{15}{16}$-inch. This represents standard practice for this thickness of plate and the calculated efficiency of the joint is 86 per cent. of the solid plate, the weakest section of the joint being the net plate in the double pitch or outer row of rivets, at which point the failure occurred.

The boiler had been cut out and thoroughly cleaned and steam had been raised to 80 pounds preparatory to cutting the boiler in with others, when the engineer noted steam escaping through the brickwork at the rear sheet on top. Removing some of the brickwork disclosed a crack extending for five rivets, a distance of 33¾ inches, the rupture being from $\frac{1}{16}$-inch to ⅛-inch. The main valve had not been opened. The engineer quietly pulled the fire and, pumping up, reduced the pressure to zero.

The removal of the straps resulted in finding the plate cracked on the inside from rivet to rivet from the rear-head seam to the circular seam. This condition, of course, had been hidden by the inside strap and was not revealed until the crack had broken through and leaked. The rivet holes had been punched and the burs were not removed. There were slight marks in the plate along the double-pitch line, indicating the usual bending action when the sheet entered the cold rolls. The plate at the fracture was full size and showed no reduction in area, which is significant of segregation of carbon at the end of the sheet.

Multiplying the 80 pounds pressure by the radius gives a pressure of 2880 pounds per square inch on the shell. This multiplied by 33 inches gives 95,040 pounds on a strip the length of the fracture. According to all calculations this condition should have resulted in a terrible explosion, as there was nothing to hold the ruptured sides of the sheet together save the frictional resistance of the rivet heads to the severed plate. It is impossible to determine how long the crack existed under the strap prior to showing through the sheet, but there is no doubt it first started from the inner side and worked outwardly. Had the boiler been made with lap seams unquestionably an explosion would have occurred, as the strength of the inner strap in connection with the frictional value o the rivets on this strap would have bee lacking. The accident leads one to believ that a test piece should be cut from *eacl end of each sheet* and subjected to th usual chemical and physical requirement and that the rivet holes in such seams, i punched, should be reamed out at least ⅛ of an inch, with a view to removing th evil effects of the punch.

The conduct of the engineer in charg was truly admirable. First, there was hi carefulness in noting and examining th defect; second, his courage in staying wit the boiler (a dynamite bomb with the fus burning) until the pressure had been car fully removed. Such devotion to duty i the moment of danger stamps the eng neer as a hero in the highest degree an reflects great credit on the profession.

The entire sheet was condemned, course, and a new boiler was ordered.

The twenty-fourth anniversary of Ne ark Association No. 3, N. A. S. E., will held at the new Auditorium, 81 and Orange street, Newark, N. J., Februa 12 next.

The next meeting of the National G and Gasolene Engine Trades Associati will be held at the Auditorium hot Chicago, Tuesday, February 9.

Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

Center Crank and Crosshead Pin Oiler

The accompanying illustration, Fig. 1, represents a device for oiling the crank pin of a high-speed center-crank engine. It is manufactured by William W. Nugent & Co., 18 to 30 West Randolph street, Chicago. The object of this oiler is to provide a continuous tube from a stationary oil supply to the crank pin when the engine is in motion. The tubes telescope and are self-lubricating.

Fig. 2 shows a method of oiling a center crank and crosshead pin on a vertical trunk engine, such as vertical gas engines, etc. The oil is fed under pressure and must go to the parts to be oiled. This device will stand high speeds.

The illustrations show how the oil is distributed to the parts to be oiled by means of the Nugent steel oil-tight knuckle joints. This method prevents short circuiting of generators, in direct-connected units, due to splashing oil, and the danger from trouble in the brasses, due to grit, is eliminated almost entirely.

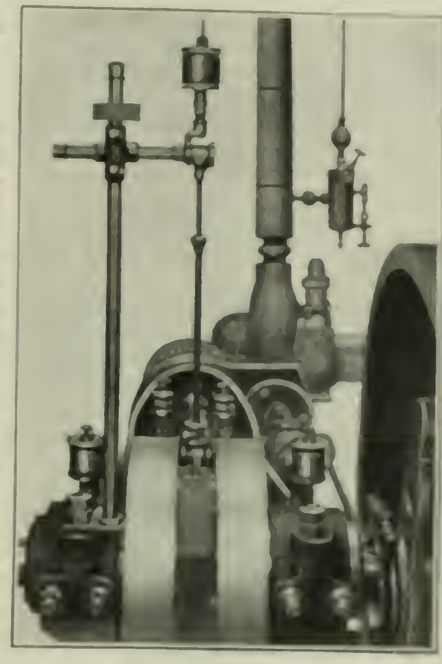


FIG. 1 THE NUGENT CRANK-PIN OILER

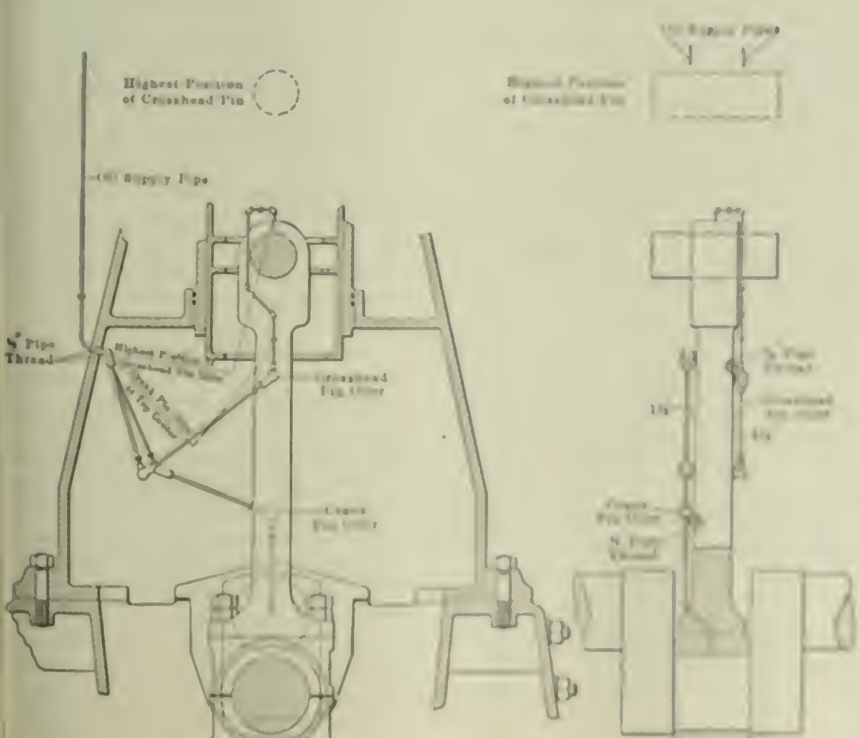


FIG. 2. DETAILS OF CRANK-PIN OILER

Simplex Blowoff Valve

In Fig. 1 is shown the exterior of a valve without a seat or a tapered plug, known as the Simplex blowoff valve.

The sectional drawings, Figs. 2 and 3, show the interior construction of the valve in open and closed positions. The two sets of packing rings C, Fig. 2, surround the plug valve D, and are compressed when the valve comes to a closed

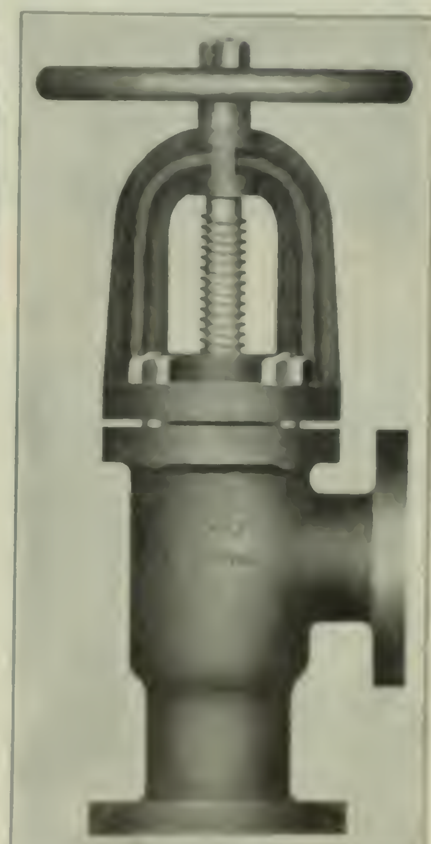


FIG. 1

position, thereby insuring a tight valve. The packing box [illegible] to take up the [illegible] ground plug valve D is moved, operating the handwheel, which revolves [illegible] of the valve.

The valve plug is prevented from turning by guides in the yoke and the packing is compressed by the [illegible] the plug valve. When opening the valve [illegible] compression is released from the packing, allowing a free and

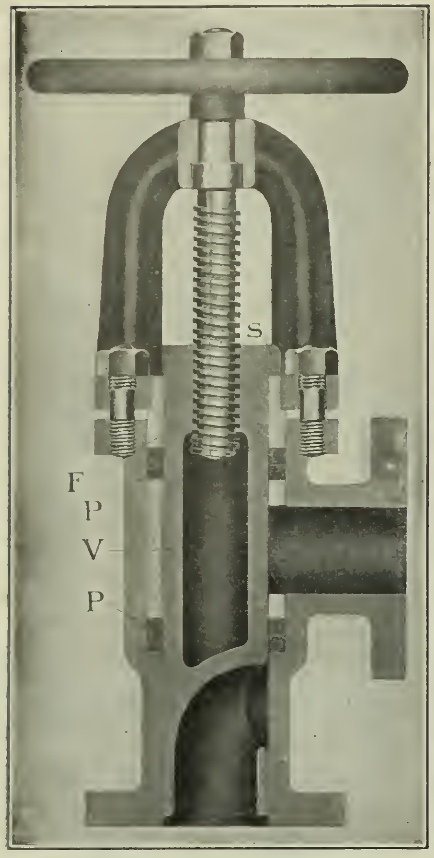


FIG. 2

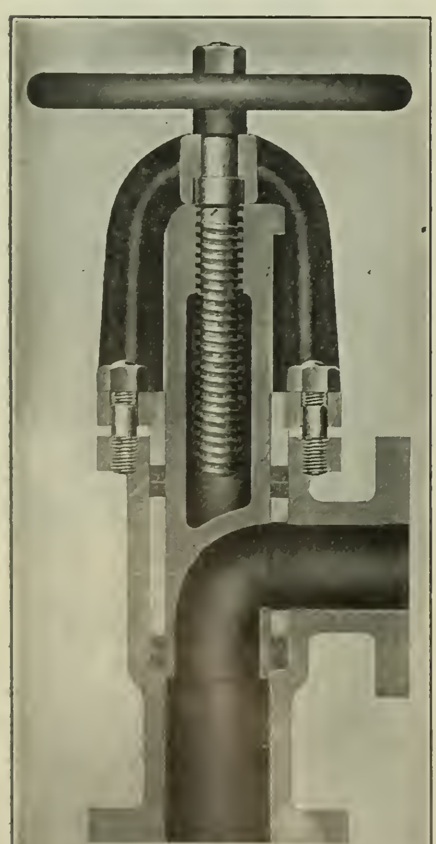


FIG. 3

easy movement to the valve, at the same time reducing the wear and tear on the packing, giving a free, unrestricted blow-out through the port (which is curved). See Fig. 3. This removes severe strains from the valve body.

The valve has no seat nor projection on which scale, sediment, etc., can accumulate, in either the closed or open position. The operation of the plug valve *V* is exposed to view, as well as the means of preventing the rotation of the plug valve, and the means of adjusting the packing. The valve is also made in the globe or Y-valve shape and with special connections and flanges as ordered. It is manufactured by the Simplex Engineering Company, Philadelphia, Penn.

Emergency Non-return Stop Valve

Referring to the drawing, the flange *A* is attached to the nozzle of the boiler, and the flange *B* is attached to the main steam line. The seat *C* has an extending flange which fits in a groove cut in the flange *A*, and the lower face, fitting against the flange of the boiler, is held in position by the bolts *D*, to prevent the seat from working loose. No screw threads are employed to hold the seat in position, therefore it is easy to remove. The method of guiding the valve disk *E* on the long stem held in position to the valve seat *C* dispenses with the stem projecting from the valve, and is also intended to assist in preventing hammering and chattering of the disk. Also, attached to the valve disk *E* is a piston *F* provided with piston rings *G* which take up the wear inside the dashpot *H*. A drain is provided to remove the water of condensation which might collect on top of the valve seat.

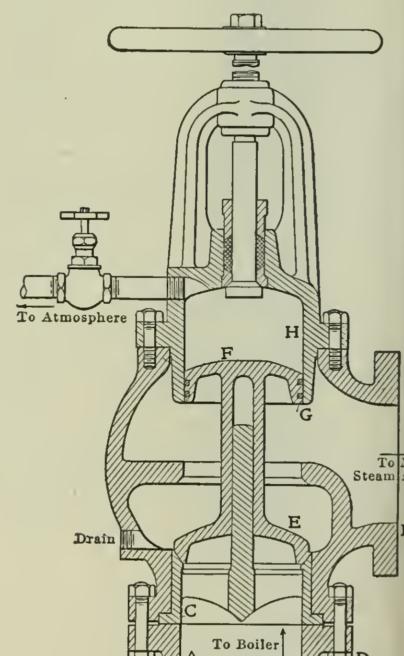
When attached to the boiler and steam header, with the stem and handwheel opened full, the valve is in operation, subject to the conditions existing in the pipes to which the valve is attached. With the main header pressure 150 pounds, the valve disk *E* is expected to remain on the seat *C* until the individual boiler has attained a pressure of 150 pounds, or the same pressure as the header, before steam can pass into the header. This feature points out a lazy boiler, so that one boiler cannot have the pressure of all the other boilers when the individual boiler pressure drops.

The opening and closing of the valve being subject to the pressures above and below the valve disk *E*, the valve cannot be opened into a boiler out of use, in which men may be working. Should a tube blow out in an individual boiler, that boiler alone is crippled, as the valve disk *E* closes on its lower seat automatically by the drop in pressure.

When desiring to discontinue using a boiler it is only necessary to stop firing and the valve will close without hand manipulation. To insure the certainty o the valve being closed, the handwheel t which the stem is attached is screwe down its full stroke.

In the event of a header explosion, th valve disk *E* is thrown wide open o account of the drop in the steam pres sure on the header or outlet of the valv and, coming in contact with the uppe seat in the valve body, shuts off th steam flow from each boiler to which thi valve is attached.

If an accident to the engines occur this valve may be closed from a distanc by opening the small pilot valve which re leases the steam on the upper piston an allows the boiler pressure beneath th valve disk *E* to close the valve against th upper seat without manipulating the hand



EMERGENCY NON-RETURN STOP VALVE

wheel. It will be noted this valve ha but one moving part, a valve disk t which is attached a piston. It is manu factured by John V. Schmid, 1823 Wes Allegheny avenue, Philadelphia, Penn.

Personal

J. E. Woodwell, of L. B. Marks & J. E Woodwell, New York City, has been re tained by McKim, Mead & White, arch tects, as consulting engineer for the en tire mechanical and electrical equipmen including the heating and ventilation, ele tric lighting and power, mail-handling de vices, etc., of the new United States po office to be erected at the Pennsylvan terminal station in New York City. Th cost of this installation will be upward $500,000. The firm has retained Prof. H. Woodbridge, of the Massachuset Institute of Technology, as associate co sulting engineer for the heating and vent lation of this building.

Inquiries

Questions are not answered unless they are of general interest and are accompanied by the name and address of the inquirer.

Comparative Evaporative Power

In J. G. McIntosh's book, "Technology of Sugar," I find the following paragraph: "The comparative evaporative power is not increased by adding more units (in speaking of double and triple effects)." Will a quadruple effect cut in two double effects give nearly double evaporation? If a plantation has a standard double effect and adds to it another cell, making it a triple effect, will this increase its capacity for evaporation, or will it be better to run the third cell as a single effect to be able to evaporate more liquid?

E. H.

Compared with the compound or triple-expansion engine, if the evaporating conditions are analogous to comparing the power capable of being developed by the whole three cylinders of a triple engine to the power capable of being developed by the low-pressure cylinder, the paragraph quoted is right, as the low-pressure cylinder with the same initial pressure will easily develop the same power as the whole three, but with less economy of steam. In the triple-effect evaporator the economy of steam will be greater when compared with single effect than it will be in a triple engine compared with a good single engine, and the economy will be due to a different principle than that of the triple engine.

Any one of the units of a triple-effect system of evaporators will evaporate the same quantity per hour as the whole three units, provided the initial steam pressure and the vacuum in the condenser are the same when used single or triple, but, of course, there will be three times as much steam used in the single effect.

Quadruple effects cut into two double effects will give double the quantity of evaporation, provided the pressure of steam in the two first effects of the two doubles is the same as that in the first effect of the quadruple (vacuum in the condenser must, of course, be the same in either case). As triple effects are ordinarily designed, the comparatively large amount of heating surface in each unit prevents them being used to their full capacity as single effects, for if the full steam pressure were used on a single unit, that is, used on the first of the whole three, the single cell would prime or foam to such extent that much valuable concentrate would be lost by entrainment.

Of course, triple effects could be designed with a smaller quantity of heating surface in proportion to the volume of the evaporator, so that the entrainment would be small when used as single effects.

With the same amount of heating surface in the new as in one unit of the double effects, it will not increase the evaporating capacity unless the steam pressure is also increased; although adding a larger third unit to the two units would somewhat increase the capacity provided the larger unit is used to evaporate the heavier or more concentrated liquor, which circulates with more difficulty and therefore needs more heating surface for a given rate of evaporation.

Run as a single effect to get the most liquor evaporated where economy of steam does not count.

By separating the two units of the double and making two singles, there is no need of installing another new one, provided economy is no object and foaming does not result.

Book Reviews

SHAFTING, PULLEYS, BELTING AND ROPE TRANSMISSION. By Hubert E. Collins. Hill Publishing Company, New York. Cloth; 157 pages, 4½x7 inches; illustrated. Price, $1.50.

This is another of the Power handbooks, made up largely of material which has appeared in the columns of Power, and has thus had the advantage of previous presentation, discussion and revision. It contains practical directions for the putting up, lining and leveling, and the care and maintenance of shafting, belting and rope transmissions, splicing of ropes and belts, etc. It treats the subject from the practical rather than the academic standpoint and should furnish the man who uses it hints which will be worth many times its cost.

MODERN POWER GAS PRODUCER PRACTICE. By Horace Allen. The Technical Publishing Company, Ltd., London, Eng. Cloth; 233 pages, 5x7 inches; 130 illustrations. Price, $[illegible].

This little work is one of the most satisfying that the reviewer has ever read. With the exception of some typographical slips, left in doubtless by careless proofreading, there are no inaccuracies that are discernible from reading the text without a slide-rule—and the reviewer has not skipped a paragraph. The names of [illegible] and [illegible] are spelled "[illegible]" and "[illegible]," the second table on page 213 is not arranged so as to be intelligible at first glance, the material forming the body of the book is rather [illegible] [illegible] [illegible] the [illegible] of [illegible] is disproportionately [illegible]. [illegible] [illegible] the book is [illegible] [illegible]. The author knows his subject thoroughly and [illegible] [illegible] till the reader [illegible] [illegible] [illegible] and clear, the English [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] "[illegible]." The book should be [illegible] [illegible] by everyone interested in the subject.

BOILERS. By Hubert E. Collins. Hill Publishing Company, New York. Cloth; 160 pages, 4½x7 inches; illustrated. Price, $1.

This book, which is one of the Power handbook series and was compiled largely from POWER AND THE ENGINEER, starts with a description of what goes on in a boiler as seen by watching a glass model of a water-tube type. Then follow simple talks on the Efficiency of Riveted Joints; the Bursting Strength of Boilers; the Bracing of Horizontal Tubular Boilers; Directions for Calculating the Strength of Riveted Joints and for Finding the Area to be Braced in Boiler Heads; a Graphical Determination of Boiler Dimensions; the Safety Valve; Horsepower of Boilers; Boiler Appliances; Care and Management of Boilers; Setting Return-Tubular Boilers; Removing Boiler Tubes; Use of Wood; Boiler Rules, and Mechanical Tube Cleaners. The presentation is in the simple style which has made the matter popular with practical men as it has appeared in our paper from time to time.

Books Received

"The Girl and the Motor." By Hilda Ward. The Gas Engine Publishing Company, Cincinnati, O. Cloth; 111 pages, 4½x7 inches; illustrated. Price, $1.

"Oil Motors." By G. Lieckfeld. J. B. Lippincott Company, Philadelphia, Penn. Morocco; 272 pages, [illegible] inches; [illegible] illustrations; indexed. Price, $[illegible].

"The Design and Construction of Ships." By John Harvard Biles. J. B. Lippincott Company, Philadelphia, Penn. Morocco; [illegible] pages, [illegible] inches; [illegible] illustrations; [illegible] folding plates; tables; indexed. Price, $[illegible].

Personal

F. C. [illegible], widely known [illegible] [illegible] [illegible] [illegible] [illegible] [illegible], manufacturers of "[illegible]" packing, was recently appointed [illegible] [illegible] of the company, with headquarters at [illegible] Lake street, Chicago, Ill.

Business Items

[illegible]

power boiler for the Pilgrim Laundry Company, of Philadelphia, two 122-horsepower boilers for the Southern Pacific hospital at San Francisco, and two 234-horsepower boilers for George W. Clayton College, Denver, Colo.

The Power Specialty Company, 111 Broadway, New York, builder of the Foster superheater and Heenan refuse destructors, recently received orders for 16,500 horsepower of superheaters, including those placed in boilers and separately fired units. They have also just been advised that the proposal to the city of Portsmouth, England, covering two Heenan destructors, each of 100 tons daily capacity, has been accepted.

The fact that equipment for power plants and industrial works is taking the lead in the resumption of business is well brought out by a list of recent sales comprising 80 fans, blowers and exhausters issued by the Green Fuel Economizer Company, of Matteawan, N. Y. These fans are to be used for such purposes as mechanical draft, heating and ventilating, hot-blast drying, etc., and their number indicates that many mills and other plants are being put into shape in anticipation of manufacturing operations on a large scale.

Henry W. Hess, chemist of the Toledo Gas, Light and Coke Company, Toledo, Ohio, made an examination of the liquid removed from a boiler by a Buckeye boiler skimmer and reports that he found the suspended solid to have been composed of calcium and magnesium carbonates mixed with a small amount of clay. In this particular case, the skimmer removed one hundred gallons of such liquid containing solids to the amount of 0.9259 pound per gallon, or 92.59 pounds per hundred gallons, each day. This skimmer is made by the Buckeye Boiler Skimmer Company, South End, Toledo, Ohio.

The Dearborn Drug and Chemical works reports that the general business of the company for the last six months of 1908 was larger than for any other six months in its history, indicating the quick return of prosperous business conditions. The percentage of increase the past few months, and especially for January, in the Eastern department of the company is particularly gratifying. Grant W. Spear, vice-president and Eastern manager, at the general Eastern offices, 299 Broadway, New York, who has been for years vice-president of the Dearborn company, at Chicago, ably assisted by Herbert E. Stone, as general sales manager, P. H. Hogan, manager of the Boston office, and Paul T. Payne, manager of the Philadelphia office, with P. G. Jones as special representative in the Philadelphia district, together with such popular and able representatives out of the New York office as Messrs. McConnaughty, Mitchell and others, constitute a most effective organization, which is an assurance of the high-grade manner in which the affairs of the Dearborn company will be handled in the Atlantic coast States.

An announcement of interest in the fan and blower business has just been given out—the consolidation of the American Blower Company, of Detroit, and the Sirocco Engineering Company, of New York. S. C. Davidson, of the parent Sirocco works, Belfast, Ireland, is financially interested in the deal. The factory of the Sirocco Engineering Company, at Troy, N. Y., and the plants of the American Blower Company, at Detroit, will continue in full operation under one management, and the home office will be at Detroit. In anticipation of a general improvement in business, also the necessity for increased foundry facilities, and the consummation of the "ABC"—Sirocco consolidation, the American Blower Company purchased outright during 1908 the complete foundry and plant formerly operated by the Northwestern Foundry and Supply Company, Detroit. The large triangular-shaped property, owned and occupied by the American Blower Company since about 1881, being entirely covered by buildings by the completion in 1907 and 1908 of a large steel-plate fan shop and office addition, the company recently purchased a large tract of land across the street, upon which it is expected new buildings, covering approximately 175x300 feet, will be erected. All business of the Consolidated companies will hereafter be transacted under the style and name of American Blower Company. The personnel of the management of the new company is as follows: James Inglis, president, who has been at the head of the American Blower Company; William C. Redfield, vice-president, who was president of the Sirocco Engineering Company; Charles H. Gifford, treasurer, who was, until a year ago, manager of the B. F. Sturtevant Company; Mr. Still, the secretary, is well known, especially among engineers, as chief engineer of the American Blower Company.

New Equipment

The Ozone Ice Company, Bogalusa, La., has awarded contract for the erection of ice plant.

The Athens (Wis.) Electric Light and Power Company contemplates installing larger generators.

The Idaho Power and Transportation Co., Idaho Falls, Idaho, is planning to double its output.

The Lebanon (Ky.) Light, Ice and Power Company is contemplating increasing output of plant.

Water-works at a cost of $20,000 will be constructed at Swink, Colo. E. G. Ritchie, city clerk.

It is reported that the Osceola (Ia.) Light, Heat and Power Company is planning to install an ice plant.

It is reported that water-works will be erected at Kearney, Neb., at a cost of $100,000. G. E. Ford, city clerk.

The citizens of Albion, Neb., voted to issue bonds for the construction of a municipal lighting and heating system.

The Chicago & Northwestern Railroad Company has commenced construction of power house at Clinton, Iowa.

The Jefferson (Texas) Ice, Light and Power Company is contemplating the installation of a producer gas plant.

It is reported that the Blackwell (Okla.) Electric Light and Power Company contemplates installing gas engines in plant.

The Keokuk (Iowa) Gas and Electric Company has been incorporated by Frederick Sargent and associates. Capital, $300,000.

The citizens of Sapulpa, Okla., voted to issue $65,000 bonds for extending and improving water-works. S. N. Hurd, city clerk.

The City Council, Hugo, Okla., will receive bids until February 2 for construction of water-works plant. W. T. Echols, city clerk.

The Sorento (Ill.) Electric Light Company will enlarge its plant. Will need a 150-horsepower engine and 100-kilowatt generator.

The Fowler (Ind.) Utilities Company contemplates installing new equipment, including engine and generator, meters, transformers, etc.

The Citizens Electric Company, Williamsport, Penn., contemplates installing additional equipment, including engines, generators and boilers.

The Union Central Light and Ice Company, Hubbard City, Texas, contemplates the erection of a new electric light plant and an addition to ice plant.

It is said about $40,000 will be expended for reconstruction of municipal electric-light plant at Topeka, Kan. H. K. Goodrich, superintendent.

The Savannah (Ga.) Ice and Storage Company has been organized to establish ice and cold-storage plant. J. G. Nelson, and others, organizers.

The village of Bergen, N. Y., has been authorized by the Public Service Commission to construct a municipal electric-light plant and water-works system.

The Scholl Engineering Company, Youngstown, Ohio, has been awarded contract for constructing water works at Girard, Ohio, and will receive all sub-bids.

Plans are being made to increase the output of the municipal electric light plant, Bethany, Mo. A new generator will be installed. J. F. Slinger, superintendent.

Plans are being considered for the installation of a 500-kilowatt steam turbine in the municipal electric light plant at Jamestown, N. Y. Chas. G. Sundquist, manager.

The West Penn Electric Company is said to be planning the erection of another power house at a cost of over $1,000,000. L. H. Conklin Connellsville, Penn., is general superintendent.

Plans are being considered for improvements at the municipal electric light plant at Elberton, Ga. These will include a new alternator, turbine pump and 50-horsepower motor. G. W. Hubbard, superintendent.

The Pasadena Rapid Transit Company has been incorporated to build an electric line between Pasadena and Los Angeles. Capital, $3,000,000. Incorporators, E. J. Sheehan, W. H. Smith, E. H. May, of Pasadena, and others.

New Catalogs

Hancock Inspirator Company, 85 Liberty street, New York. Catalog. Valves. Illustrated, 40 pages, 6x9 inches.

Thos. H. Dallett Company, Philadelphia, Penn. Catalog No. 100. Air compressors. Illustrated, 24 pages, 6x9 inches.

The M. W. Kellogg Company, 50 Church street, New York. Catalog. Piping and chimneys. Illustrated, 48 pages, 8½x11 inches.

American Steam Gauge and Valve Manufacturing Company, Boston, Mass. Catalog. Valves, Illustrated, 90 pages, 6x9 inches.

Wm. A. Harris Steam Engine Company, Providence, R. I. Catalog. Harris-Corliss engine. Illustrated, 80 pages, 7x10 inches.

Western Electric Company, 463 West street, New York. Bulletin No. 5370. Steam turbines. Illustrated, 12 pages, 8x10½ inches.

Wagner Electric Manufacturing Company, St. Louis, Mo. Bulletin No. 82. Polyphase motors. Illustrated, 16 pages, 8x10½ inches.

Walch & Wyeth, 87 Lake street, Chicago, Ill. Booklet. Erwood straightway swing gate valve. Illustrated, 16 pages, 6½x7 inches.

Ridgway Dynamo and Engine Company, Ridgway, Penn. Bulletin No. 20. Single-valve side-crank engine. Illustrated, 14 pages, 8x10½ inches.

Lathrop Engineering Company, 126 Liberty street, New York. Pamphlet. Lathrop system, of "Equalized Draft" for steam boilers. Illustrated, 16 pages, 4x7½ inches.

Help Wanted

Energy in a Pound of Steam

Net Energy of Expansion from 150 Pounds down to Atmospheric Approximates Energy from Atmospheric down to 27 1-2 Inches of Vacuum

BY FRED R. LOW

A correspondent writes: "In your issue of October 26, page 675, the following statement appears:

> When it is remembered that there is as much power in the steam from atmospheric pressure down to 27½ inches as there is from 150 pounds down to atmospheric pressure, it is easily seen that the power of a noncondensing plant can be doubled by the addition of an exhaust-steam turbine and condenser.—Gerald Stoney, before the British Association.

I would like very much to see this example worked out in full, so that I might follow it step by step."

The energy is proportional to the area of a diagram in which, as in that made by the steam-engine indicator, vertical distances represent pressures and horizontal distances volumes. Fig. 1 is such a diagram, plotted upon the assumption that the product of the pressure and volume remains constant. A volume *o 1* of steam at 120 pounds absolute pressure is expanded to twice that volume *o 2*, and in so expanding generates energy represented by the space *B C 2 1*. It is started with one volume at 120, and since the product of the volume and pressure remains constant the pressure at two volumes *C* must be 60. Notice that this area is made up of a triangle *A B C* and a rectangle *A C 2 1*, each 60 pounds high and one volume wide.

Suppose this steam at 60 pounds to be again doubled in volume. Its pressure would be reduced to 30 pounds and an amount of energy proportional to the area *C D 4 2* would be developed. This area consists of a triangle *C D E* and a rectangle *E D 4 2*, each 30 pounds high and two volumes wide, and since the area *1 B C 2* is twice as high, but only half as wide as *2 C D 4*, their areas must be equal, and since the work performed is represented by the area the work is the same. If the diagram is followed along it will be seen that the successive areas into which it is divided are equal, and that the last expansion from 15 to 7½ pounds results in the development of as much energy as that from 120 to 60. The energy developed depends upon the number of times the steam is expanded, i.e., the "ratio of expansion," the final volume divided by the initial volume. The energy is the product of the mean pressure during expansion and the increase in volume. In the early part of the diagram the pressure is high and the volume correspondingly small. In the later part of the diagram the pressure is small, but the volume is correspondingly great, and their product (the energy) is equal for the same ratio of expansion.

This much by way of simple illustration, but unfortunately steam does not expand in this way. A perfect gas would expand according to this mode if its temperature were kept constant. Steam cools as it expands and its volume would increase less rapidly than the expansion curve in Fig. 1 shows, dropping the pressure. The expansion line of the ordinary indicator diagram follows the line of Fig. 1 quite closely, because there is enough evaporation in the cylinder as the pressure is reduced to make up the shrinkage due to cooling, but this means that the diagram deals with a varying quantity of steam.

Let us get at the problem in another way. Every pound of the working fluid carries into the engine a number of heat units, and in passing out carries away a lesser number. The difference has been converted into work, and if it can be found how many heat units each pound of the fluid carries in and how many it takes out, the difference will be the number of heat units that have been converted into work, for the ideal case at least, for each pound of steam used. As each heat unit is equivalent to 778 foot-pounds the work can be expressed in those units by simple multiplication.

There are reproduced herewith a couple of fragments from Peabody's "Tables of the Properties of Steam." The second line gives the properties for steam of 2 pounds absolute pressure, the pressure *p* being given in the first column. In the second column is given the Fahrenheit temperature at which water will boil under that pressure, in this case 126.1 degrees. In the third column is given the "heat of the liquid" *q*, that is, the number of British thermal units which are required to raise a pound of water from 32 degrees to the above temperature.

Let the line *O X*, in Fig. 2, represent the absolute zero of temperature, 459.2 degrees below the zero of the Fahrenheit scale. On the line *A* [illegible] erected to any convenient scale of vertical distances, representing temperature, the freezing point, 32 degrees, which is the base from which

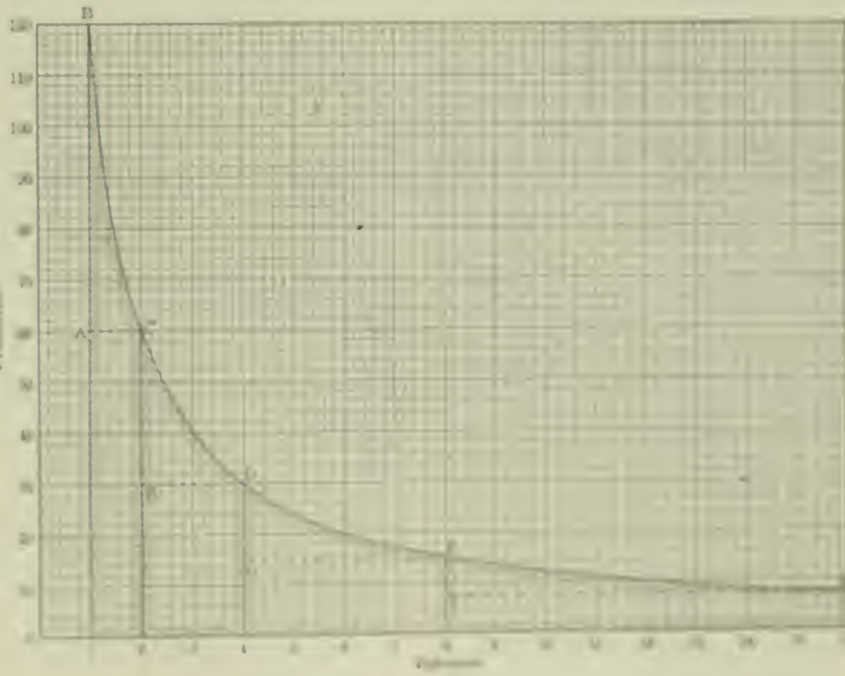


Fig. 1

most of the values of the steam table are reckoned. Locate the point *B* at the hight corresponding to the temperature, 126.3, to the chosen scale, and at such a distance from the line *I J* that the area *A B H I* will be proportional to the 94.3 B.t.u., which the table says it has required to bring the water from 32 degrees to this point. In other words, to bring the pound of water from 32 to 126.3 degrees has required 94.3 B.t.u. of energy in the form of heat, and the area *A B H I* represents that energy just as the area of the diagram from a steam-engine indicator represents energy.

Now look at the line of the table for 120 pounds pressure. The temperature here is 341 degrees, and the heat of the liquid is 312 B.t.u. Imagine the point *C* to be located at a vertical distance corresponding to 341 degrees Fahrenheit, and at such a distance horizontally from the line *J I* that the area *A C G I* will represent 312 B.t.u. If a number of points were located for different temperatures in this way the change would be found to occur along some such curve as *A B C*.

At 341 degrees the water under 120 pounds pressure would be ready to boil, and any further addition of heat would go to making it into steam, which process will take place at constant temperature. In the fourth column of the table it will be seen that the "heat of vaporization" *r* of 120-pound steam is 874 B.t.u., i.e., that

$$874 \times 778 = 679{,}972$$

foot-pounds of energy in the form of heat are required to tear the molecules of that pound of water at 341 degrees apart and convert it into dry-saturated steam of the same temperature. Of this energy 822 B.t.u., as shown in the sixth column, are required to push back the surroundings as the water expands into steam, to perform external work *A p u*, while the rest,

$$874 - 82.2 = 791.8$$

B.t.u., are required to overcome the attraction of the molecules for each other, to do internal work ρ, as shown in the fifth column.

FRAGMENTS OF PEABODY'S "TABLES OF STEAM PROPERTIES."

1	102.0	243	70.0	1043.1	981.1	62.0	0.1332	1.8574	335.3	161.3	0.00298	277	1
2	126.3	153	94.3	1026.2	961.9	64.3	0.1756	1.7519	174.0	55.4	0.00575	268	2
3	141.6	115	109.6	1015.5	949.6	65.9	0.2012	1.6895	118.6	28.0	0.00843	261	3
4	153.1	92	121.1	1007.5	940.6	66.9	0.2201	1.6447	90.60	17.22	0.01104	259	4
5	162.3	78	130.3	1001.2	933.4	67.8	0.2351	1.6100	73.38	11.56	0.01363	255	5
6	170.1	68	138.1	995.7	927.1	68.6	0.2478	1.5815	61.82	8.32	0.01618	251	6
118	339.8	6	310.8	874.8	792.8	82.1	0.4902	1.0946	3.776	30	0.2649	21	118
119	340.4	6	311.4	874.4	794.3	82.1	0.4911	1.0931	3.746	29	0.2670	21	119
120	341.0	7	312.0	874.0	791.8	82.2	0.4919	1.0918	3.717	28	0.2691	20	120
121	341.7	6	312.7	873.5	791.3	82.2	0.4927	1.0903	3.689	28	0.2711	21	121
122	342.3	6	313.3	873.0	790.7	82.3	0.4935	1.0889	3.661	28	0.2732	21	122
123	342.9	6	313.9	872.6	790.2	82.3	0.4943	1.0875	3.633	28	0.2753	21	123

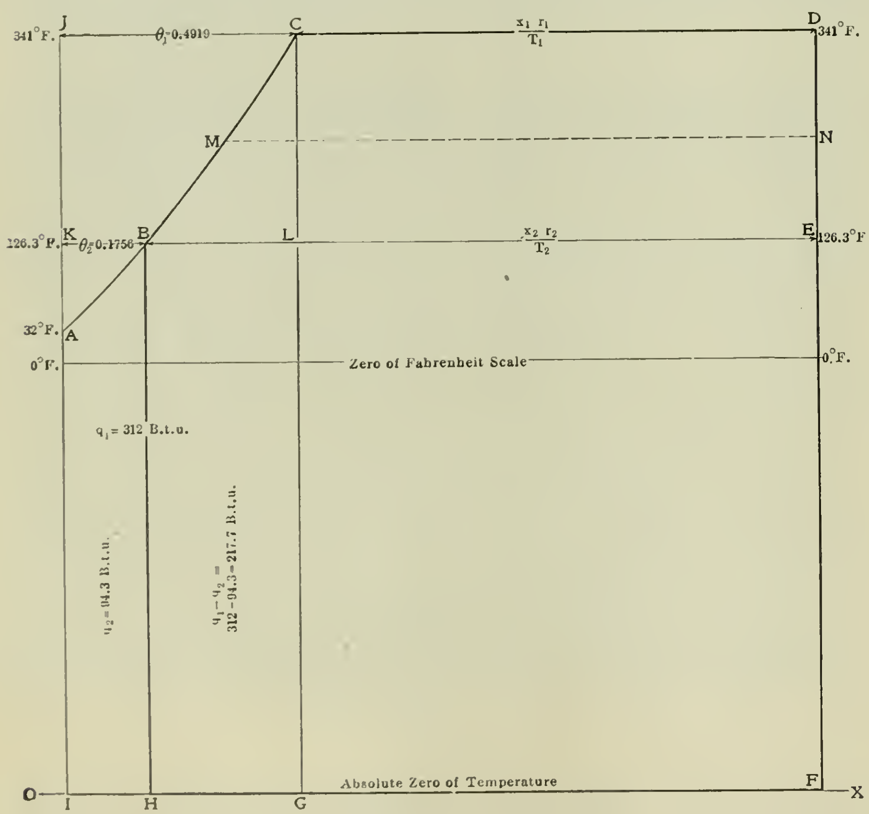


FIG. 2

At *C* the pound of water is about to change into steam. As the process takes place at constant temperature the change of state will be represented by a horizontal line *C D*. If the pound of water is all changed to steam the line *C D* must be of such length that the area *C D F G* will be proportional to 874, the heat of evaporation, on the same scale as the rest of the diagram. If only 0.98 of the water is changed to steam, i.e., if there is 2 per cent. of moisture it will take only

$$0.98 \times 874 = 856.52$$

B.t.u. to make the change, and the area *C D F G* would be drawn to represent that number of units. Similarly, to produce a mixture of steam and water of any quality *x* (the quality being the fraction of the mixture which is steam, 0.98 in the above case), will require *x r* heat units, *r* being the heat that would be required to evaporate the whole pound.

To convert the pound of water from 126.3 degrees, at *B*, into the pound of steam at 120 pounds, or 341 degrees, has taken an amount of energy in the form of heat proportional to the area of the diagram *B C D F H*, made up of *B C G H*, which is the difference between the heats of the liquids *q* at 341 and 126.3 degrees, and *C D F G*, the heat of vaporization of the mixture and equal to *x r*, or to *r* if *x* is unity and the steam is dry saturated. Therefore, the heat put into the pound of steam is

$$q_1 - q_2 + x_1 r_1,$$

the subscripts, or little figures below the letters, meaning at the higher temperature for 1 and at the lower for 2.

Now, suppose expansion to take place without any heat being either added to or taken from the mixture. In Fig. 2 addition of heat has resulted in movement to the right; abstraction of heat would be represented by movement to the left. As the steam expands its temperature falls, and as no heat is added or abstracted the change of state would be represented by a vertical line, as for instance *D E*, if the expansion occurred between 341 and 126.3 degrees. This would result in a pound of mixed steam and water at 126.3 degrees, for even if the steam were initially dry-saturated, there has been condensation due to the conversion of heat into work. The area *B E F H*, therefore, represents the heat of vaporization of that part of the pound of working fluid which is still steam, or $x_2 r_2$. The heat of vaporization r_2 at 2 pounds or 126.3 degrees may be taken from the table. How shall x_2, the quality after expansion, be found?

The area *CD F G* is proportional to $x_1 r_1$. Its hight $C G = T_1$, the absolute temperature at 120 pounds. Then its length CD must be its area divided by its hight or

$$\frac{x_1 r_1}{T_1}.$$

The horizontal distance of any point from the line JC, which passes through the point of 32 degrees, is proportional to the "entropy of the liquid" θ, at the temperature corresponding to the vertical position of the given point. For example, the distance JC of the point C is 0.4919, the entropy of the liquid θ, at 341 degrees (see seventh column of the table opposite 120 pounds).

The line $JD = CD + JC$ is proportional, therefore, to

$$\frac{x_1 r_1}{T_1} + \theta_1.$$

Similarly the line KE is proportional to

$$\frac{x_2 r_2}{T_2} + \theta_2.$$

And since these lines are equal,

$$\frac{x_1 r_1}{T_1} + \theta_1 = \frac{x_2 r_2}{T_2} + \theta_2. \quad (1)$$

All of these quantities with the exception of x are obtainable from the steam tables, and if one of the x's is known the other can be easily determined.

The heat remaining after expansion is $x_2 r_2$.

Then the number of heat units converted into work is

$$x_1 r_1 + q_1 - q_2 - x_2 r_2 \quad (3)$$

And if each heat unit is equivalent to 778 foot pounds, the net energy E_n developed by making a pound of water into steam and expanding it (the energy represented by a pressure-volume diagram like Fig. 3) would be

$$E_n = 778\,(x_1 r_1 + q_1 - q_2 - x_2 r_2). \quad (4)$$

For dry-saturated steam expanded from 120 to 2 pounds absolute these quantities become:

$x_1 = 1.$	$x_2 = 0.8038$
$r_1 = 874$	$r_2 = 1015.5$
$q_1 = 312$	$q_2 = 94.3$
$\rho_1 = 791.8$	$\rho_2 = 961.9$

and

$E_n = 778\,(1 \times 874 + 312 - 94.3 - 0.8038 \times 1015.5) =$ 214,294 foot pounds.

The area $b\,e\,f\,a$ of Fig. 3 is the product of the pressure and volume of the steam (or mixture) at the lower temperature. It is proportional to the external work found by subtracting $x_2 \rho_2$ instead of $x_2 r_2$ in formula (4), ρ being the heat equivalent of the internal work and the difference between r and the external work, so that subtracting ρ_2 instead of r_2 leaves in the result the external work at the lower pressure, the area $b\,e\,f\,a$ of Fig. 3. The formula for this case becomes:

$$E_t = 778\,(x_1 r_1 + q_1 - q_2 - x_2 \rho_2). \quad (5)$$

778 (874 + 312 − 94.3 − 0.8038 × [illegible]) = [illegible] foot pounds.

If the total energy of expansion, Fig. 5, is desired, the area $a\,b\,c\,d$ of that figure must be subtracted from Fig. 4. That is the external work of the steam at the higher pressure. To push a pound of steam into the cylinder of an engine and make the line $a\,b$, Fig. 5, on an indicator diagram, a pound of water would have to be evaporated in the boiler and the work done by that water in changing into steam is proportional to the area $a\,b\,c\,d$. This can be subtracted by changing the r_1 of formula to ρ_1, because ρ_1 is just this much less than r_1, and this makes the formula for the total energy developed during expansion:

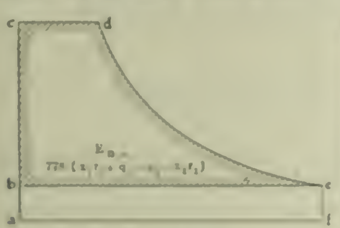


FIG. 3

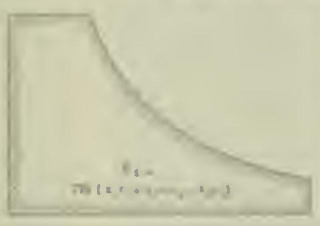


FIG. 4

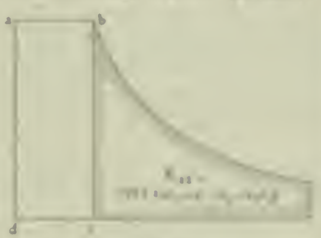


FIG. 5

FIG. 6

Transposing formula (1):

$$x_2 = \frac{x_1 \dfrac{r_1}{T_1} + \theta_1 - \theta_2}{\dfrac{r_2}{T_2}}. \quad (2)$$

The values of $\frac{r}{T}$ are given in the eighth column of the table. If you try to calculate them, remember that T is the absolute temperature, i.e., the Fahrenheit temperature plus 459.5.

Assuming dry-saturated steam to start with, $x_1 = 1$, and the following quantities may be found in the table:

$$\frac{r_1}{T_1} = 1.0918. \qquad \frac{r_2}{T_2} = 1.7519.$$

$$\theta_1 = 0.4919. \qquad \theta_2 = 0.1756.$$

Substituting these values in formula (2):

$$x_2 = \frac{1 \times 1.0918 + 0.4919 - 0.1756}{1.7519}$$

This is only common arithmetic:

```
        1.0918
             1 Multiply
        ------
        1.0918
        0.4919 Add
        ------
        1.5837
        0.1756 Subtract
        ------
1.7519) 1.4081 Divide
        ------
        0.8038 = x2
```

The heat put into the pound of steam was

$$B\,C\,D\,F\,H = x_1 r_1 + q_1 - q_2$$

done by a pound of water in changing to this mixture. If the working fluid were all steam, this value reduced to B.t.u. would be the $A\,p\,u$ of the sixth column of the table. For x per cent. of a pound still in the condition of steam it would be $x_2\,A\,p\,u$. And this is the amount of work which would have to be done upon the steam to expel it against the 2 pounds back pressure. It would have to be subtracted from the total energy represented by Fig. 4 to get the net energy represented by Fig. 3, but this has been done in formula (4), and in this way. The heat of evaporation r is the sum of the internal energy ρ and this external energy, and when $x_2 r_2$ was subtracted in formula (4) it included this external energy at the lower pressure. Of the [illegible] B.t.u. making up the heat of evaporation at the lower pressure, [illegible] would be used in pushing back the surroundings, in making room for the steam, in helping to push the piston away, if the expansion takes place in a cylinder, or in accelerating the mass if in a nozzle, so that they are a part of the energy available by the expansion, and should not be subtracted unless it is desired to take out the equivalent work of overcoming the back pressure in expelling the steam.

If the total energy represented by diagram Fig. 5 were desired it could be

$$E_{te} = 778\,(x_1 \rho_1 + q_1 - q_2 - x_2 \rho_2). \quad (6)$$

778 (791.8 × 1 + 312 − 94.3 − 0.8038 × 961.9) = [illegible] foot pounds.

And, finally, to get the net energy due to expansion, that represented by Fig. 6, the energy to expel the expanded steam must be deducted, which can be done by adding it to the amount to be subtracted in formula (6) by changing the ρ_2 to r_2:

$$E_{ne} = 778\,(x_1 \rho_1 + q_1 - q_2 - x_2 r_2). \quad (7)$$

778 (791.8 × 1 + 312 − 94.3 − 0.8038 × 1015.5) = [illegible] foot pounds.

Applying these formulas to the cases quoted by our correspondent the results would be as follows, showing that it was the net energy of expansion which Mr. [illegible] had in mind in making the statement quoted.

	[illegible]	[illegible]
[illegible], Fig. 3	[illegible]	[illegible]
[illegible], Fig. 4	[illegible]	[illegible]
[illegible], Fig. 5	[illegible]	[illegible]
[illegible], Fig. 6	[illegible]	[illegible]

*[illegible]

from Peabody's Temperature - Entropy Table. On the first follow the line for 358 degrees (the temperature in even degrees most nearly corresponding with 150 pounds) to the quality nearest unity, which will be in the triple column on one side or the other of the broken line extending zigzag across the table. To the right of that line the figures in the column marked quality mean degrees of superheat, while to the left they mean the fraction of the pound converted into steam, the x of the foregoing calculations. The quality nearest unity lies in the triple column under No. 1.56, and gives the heat contents as 1185.

On the other page in the column bearing the same number, 1.56, and opposite 212, find the heat contents (after expansion to that temperature) of a pound of steam (having the initial quality given at the higher temperature) to be 1018. table says that steam at 212 degrees and 99.89 per cent. dry has a heat content of 1145.6 B.t.u. This same steam expanded to 108 degrees would have 987.5 B.t.u. (found by locating the value for the lower temperature in the same column of entropy) and

$$778\ (1145.6 - 987.5) = 123{,}000$$
foot-pounds.

Numerous diagrams have been devised from which these values can be measured. Of such are those by H. F. Schmidt and W. C. Way, on page 524 of POWER for August, 1907, and one by R. M. Neilson, which will appear soon.

It is the heat which develops (or reappears as) work in falling from one temperature level to another, and it is the temperature range rather than the pressure range which should be compared when the relative amount of work is in

Temperature, Degrees Fahr.	Pressure, Pounds per Square Inch.	1.56			1.57		
		Quality.	Heat Contents.	Specific Volume.	Quality.	Heat Contents.	Specific Volume.
372	177.9	7	1200	2 596	21	1208	2 654
371	175.7	5	1198	2 620	19	1207	2.680
370	173 6	4	1197	2 646	18	1206	2 706
369	171.5	3	1196	2.672	17	1205	2.732
368	169.4	2	1195	2.700	16	1204	2.760
367	167.3	1	1194	2.725	14	1203	2 786
366	165.3	9997	1193.3	2.752	13	1202	2.814
365	163.2	9988	1192 3	2 782	12	1201	2.842
364	161.2	9979	1191 2	2 812	11	1200	2 870
363	159.2	9971	1190.2	2.843	10	1199	2.899
362	157.2	9963	1189.2	2.874	8	1198	2 928
361	155.3	9955	1188 1	2 906	7	1197	2.957
360	153.3	9946	1187.1	2.938	6	1196	2.986
359	151.4	9938	1186.1	2.971	5	1195	3.017
358	149.5	9929	1185 0	3 004	3	1193	3 047
357	147.6	9921	1183.9	3.037	2	1192	3.079
356	145.8	9913	1182.9	3.070	1	1191	3.108
355	143.9	9904	1181 9	3 105	9998	1190 0	3 135
354	142.1	9895	1180.8	3 141	9989	1189.0	3 170
353	140.3	9887	1179.8	3.176	9980	1187.9	3 206
352	138.5	9878	1178.7	3.211	9971	1186.8	3.242

Temperature, Degrees Fahr.	Pressure, Pounds per Square Inch.	1.56			1.57		
		Quality.	Heat Contents.	Specific Volume.	Quality	Heat Contents	Specific Volume.
228	20.02	8809	1037.7	17.56	8881	1044.6	17.70
227	19.64	8800	1036.5	17.86	8872	1043.4	18.00
226	19.28	8791	1035.3	18.17	8863	1042.2	18.32
225	18.91	8782	1034.1	18.48	8854	1041.0	18.63
224	18.56	8774	1032.8	18.79	8845	1039.7	18.95
223	18.21	8765	1031.6	19.12	8836	1038.5	19.27
222	17.86	8757	1030.4	19.44	8828	1037.2	19.60
221	17.52	8749	1029.2	19.78	8820	1036.0	19.94
220	17.19	8740	1028.0	20.13	8811	1034.8	20.29
219	16.86	8731	1026.7	20.48	8802	1033.5	20.65
218	16.53	8721	1025.4	20.84	8792	1032.2	21.01
217	16.21	8713	1024 2	21.21	8783	1031.0	21.38
216	15.90	8704	1022.9	21.58	8774	1029.7	21.75
215	15.59	8695	1021.7	21.96	8765	1028.5	22.13
214	15.29	8687	1020.5	22.35	8756	1027.2	22.53
213	14.99	8678	1019.3	22.74	8748	1026.0	22.93
212	14.70	8669	1018.0	23.11	8739	1024.7	23.30
211	14.41	8660	1016.8	23.48	8730	1023.5	23.67
210	14.12	8652	1015.5	23.90	8721	1022.2	24.10
209	13.84	8643	1014.2	24.34	8712	1020.9	24.53
208	13.57	8634	1013.0	24.78	8703	1019.7	24.98

SECTIONS OF PAGES FROM PEABODY'S TEMPERATURE-ENTROPY TABLES

If the difference between the heat contents at the two conditions be multiplied by 778 to reduce it to foot-pounds, it will be found that

$$778\ (1185 - 1018) = 129{,}926$$
foot-pounds,

which is the total net energy, Fig. 3, for one pound of steam in that initial condition expanded adiabatically through that range.

Under the same column (1.56) and opposite 108 the heat contents are given as 879.7, so that if this same pound of partially condensed steam is further expanded down to 108 degrees the energy developed will be

$$778\ (1018 - 879.7) = 107{,}597$$
foot-pounds.

But starting over again with practically dry steam at atmospheric pressure the question. The temperature of steam of 150 pounds absolute is 358.3 degrees, and of steam at 27½ inches vacuum about 108 degrees, so that the ranges compare as follows:

358.3	212
212.0	108
146.3	104

A glance at Fig. 2 will show that the energy represented by a diagram like Fig. 3 will not be the same for the same range of temperature; *B C D E* of Fig. 2 is equivalent to *b c d e* of Fig. 3. The dotted line *M N* divides the temperature range equally, but the energy, equivalent to the area *M C D N* developed by the fall through the first half of the range, is less than that, equivalent to *B M N E*, developed by the fall through the second half. If the cycle were changed to *C D E L* it is plain that equal falls in temperature would produce equal amounts of work. Just as the vertical line *D E* represents expansion without reception or loss of heat (adiabatic or isentropic expansion), so the line *L C* represents compression by the same mode. The diagram then consists of a line *C D*, representing expansion at constant temperature (the expansion of the water into steam represented by the steam line of the pressure-volume diagram *c d*, Fig. 7), a line *D E*, Fig. 2, representing adiabatic expansion (*d e* in Fig. 7), a line *E L*, representing compression at constant temperature (the line *e l* of Fig. 7, during which the steam is being reduced to its original volume at the constant temperature of the condenser), and the line *L C*, representing adiabatic compression to the original temperature (*l c* in Fig. 7). This is called the Carnot cycle, and from steam worked in this way the energy produced and represented by a diagram like Fig. 7 will be directly proportional to the temperature range.

A Dangerous Omission

By W. H. Wakeman

POWER for October 20, 1908, contained a short article under the above title, and the illustration is herewith reproduced for reference with the following explanation (see Fig. 1): A direct-acting steam pump *A* is used to operate hydraulic elevators. It discharges water through *B* into the pressure tank *C*. A relief valve is shown at *D*, which opens and allows water to flow into the surge tank *E* when the safe limit of pressure is reached. A power pump *F* was installed and is driven by an electric motor. It was connected to the system by inserting the cross *G*. The relief valve *D* was removed and connected at *H*, while *I* represents a stop valve.

The original article called attention to the fact that *I* might be closed and *F* started, thus causing trouble and expense by creating a very high water pressure from which there would be no automatic relief.

This is exactly what did happen about midnight a short time ago, since the original article appeared. There was no engineer in charge, but the fireman on duty heard an unusual noise in the pump room. On going in to investigate the matter he found that the heavy cast-iron air chamber that formerly was located at *J* had leaped upward, making a large dent in the ceiling above it, and had then fallen to the floor, while water was coming out of an irregular hole that was left when the air chamber failed. The switch was pulled out and the pump stopped.

The air chamber is illustrated in Fig. 2. The break occurred in the lower part of

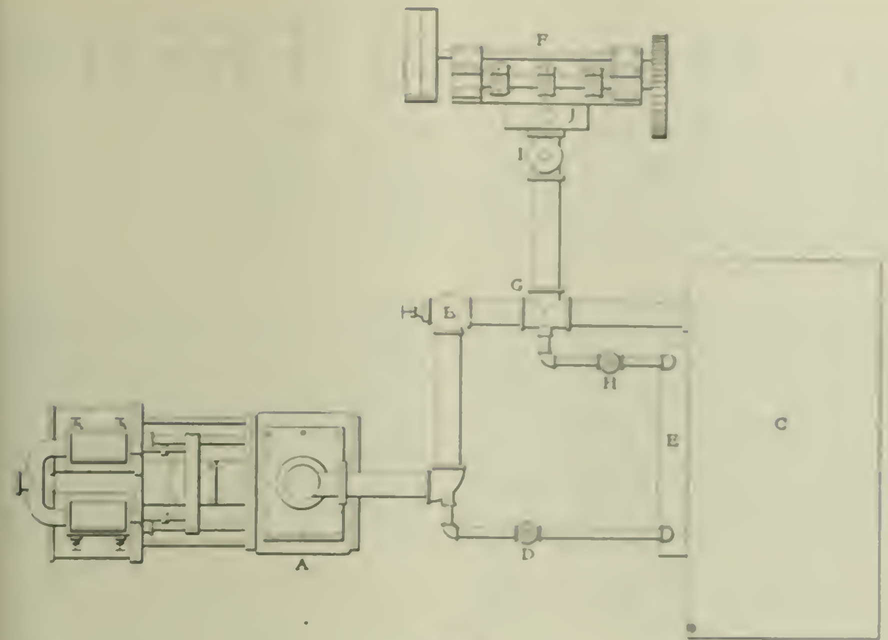


FIG. 1

the neck, which is 5 inches in diameter, while the head above it is 12 inches. It is about 31 inches high above the break, and the flange below is 14 inches. Fig. 3 is a plan of the broken flange, showing a rupture of very irregular form. The iron is from $\frac{13}{16}$ to $\frac{15}{16}$ inch thick; its appearance indicates that the break was new, and the metal was free from air holes, etc.

It is morally certain that the immediate cause of this so-called accident was the fact that the valve *I*, Fig. 1, was closed, and as this prevented the relief valve *H* from opening, a very high pressure accumulated in a short time, especially as it could not find even partial relief by starting seams in the tank *C*, as it did on a former occasion. The automatic electrical apparatus evidently failed to work properly.

Fig. 4 illustrates the pressure gage that is connected to this pump. The pointer evidently made a complete circle on the dial and was forced against the pin with sufficient force to loosen it from its pivot; consequently, it gave up in despair the effort to indicate the great pressure resulting from this mismanagement and hung idly on the pivot, point downward.

The following facts should be taken into consideration in this connection: The power pump *F* was installed a few months ago by two well informed engineers. They advised the superintendent, who has had no previous experience with steam and electrical machinery, to install a relief valve between *I* and *J*, and offered to supply the valve and install it complete for $30, but he replied that it was unnecessary; therefore, it was omitted, with the stated result, which is what would be expected by any practical engineer.

Less than 10 days previous to this failure the night engineer, who held a license the night previous to the date of disaster, under the city government, was kept on duty for 36 hours, because nobody was provided to release him, and then discharged for some trivial fault a few days later. He finished his labors at this plant therefore, it occurred the first night that a new man was operating the machinery. The new man had not secured a license for this plant, as the law allows one week in which to secure the necessary papers. The trouble could not have been caused by the discharged employee, as the day fireman operated the plant for 12 hours after he left, and the night man had been on duty for several hours when the failure occurred. While the night fireman could have kept the valve *I* open while the pump was either in active operation, or else liable to be started automatically at any time, and thus maintain communication with the relief valve *H*, the superintendent, who allowed such a dangerous state of affairs to exist after he had been informed of it and warned of what might happen at any time, is directly responsible. A relief valve, which is only another name for a safety valve, should never be located where an ignorant or careless fireman can prevent it from operating by closing a valve, and any man who does not understand this principle, or is not sufficiently impressed with its importance to apply it rigidly, is not qualified to have charge of a steam plant located in one of the largest buildings in the central part of the city of which it forms a conspicuous part.

FIG. 2

FIG. 3

FIG. 4

The Plunger Hydraulic Elevator

Construction and Operation Details of the Highest Type of Passenger Elevator Made by the Standard Plunger Elevator Company

BY WILLIAM BAXTER, JR.

For the highest type of passenger elevator the Standard Plunger Elevator Company uses the system shown diagrammatically in Fig. 302. In this arrangement it will be noticed that the discharge tank *G* is located several floors above the top of the lifting cylinder. The hight of the discharge tank varies according to the car speed, and ranges from about 40 feet for

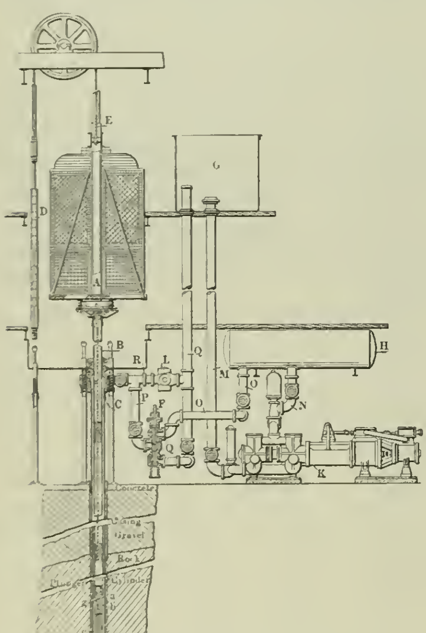


FIG. 302

moderate car speed to double this hight for speeds of 500 or 600 feet per minute. In addition to setting the discharge tank at an elevation, the discharge pipe *Q* is connected with the inlet pipe *P* through a branch *R* in which is inserted a check valve *L*. The object of this pipe connection is twofold; first, it prevents drawing the plunger away from the water in making stops on the upward trips and, second, it saves a considerable quantity of pressure water, and thereby increases the efficiency of the apparatus. The valve *L* permits water to flow freely from the pipe *Q* into the cylinder, but prevents water from passing through it from the cylinder to the pipe *Q*. The operation of the system is as follows: Suppose the elevator is running up at full speed and that the operating valve *F* is closed quickly; then the momentum of the counterbalance *D* will carry the car upward and draw the plunger away from the water, as explained in previous articles. This would be the effect if the pipe connection *R* were not provided, but with this connection, as soon as the plunger begins to draw away from the water, the vacuum developed, assisted by the pressure due to the elevation of the tank *G*, will cause water to run down through the pipe *Q*, the valve *L* and the pipe *R* into the cylinder and keep the latter full. When the plunger comes to a state of rest there is no empty space under it, and as a result the car will not drop down as would be the case if water could not enter the cylinder.

To avoid drawing the plunger away from the water by too rapid a valve closure on the upward trips when the simple pipe arrangement of Fig. 301 is used, the pilot valve is adjusted so that the main valve cannot close too rapidly. With the arrangement of Fig. 302 it is immaterial how quickly the main valve is closed, providing the discharge tank is placed high enough to develop as much pressure as may be necessary to cause water to flow in through the pipe *R* and follow up the plunger as fast as it moves until its motion is arrested by the greater weight of the car. All the water that is drawn into the cylinder through the pipe *R* in making stops represents energy saved, because it reduces the amount of water drawn from the pressure tank *H*.

It is not practicable in all buildings to set a discharge tank at the desired elevation, and in such cases the elevated tank *G* must be replaced by a pressure tank located in the basement. A system of this kind is shown by Fig. 303, which is far more elaborate than Fig. 302 and shows every detail of a high-class passenger-elevator system. Of the two tanks shown, the top one is the pressure and the lower one the discharge tank. The pipe *Q* leads to an inverted U consisting of two legs, as shown, the function of

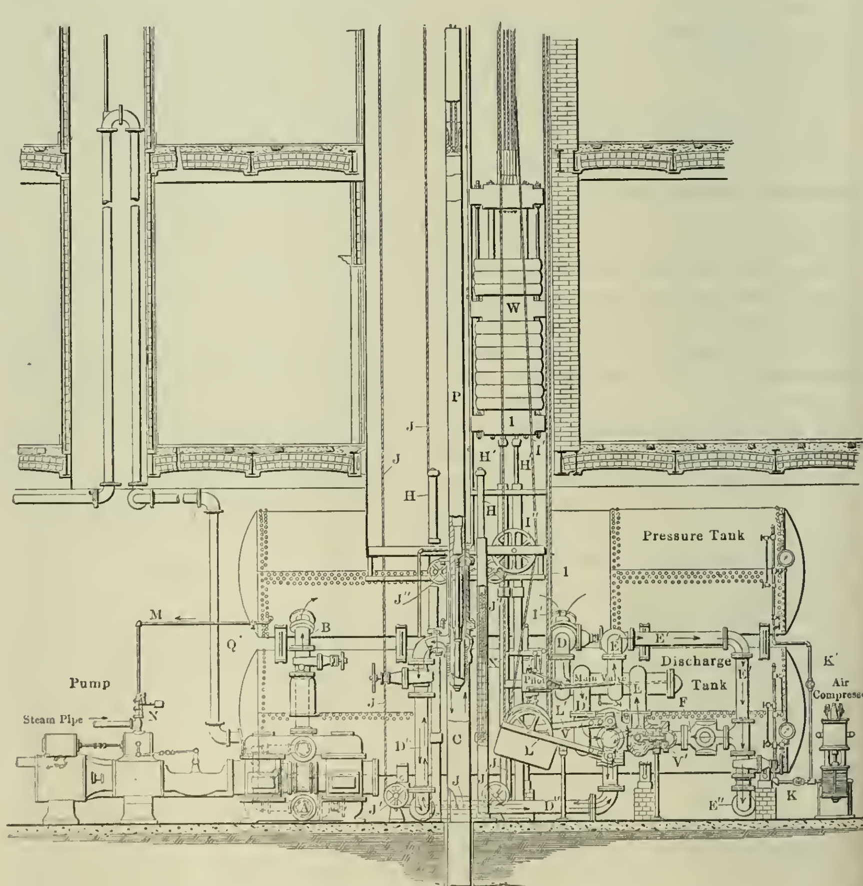


FIG 303

which is to maintain a uniform pressure in the discharge tank. This U-pipe is extended up to whatever hight may be necessary to develop the required pressure. At the bend at the top a short vent pipe is provided, which is open at the upper end, so as to prevent the inverted U from acting as a siphon and drawing the water out of the tank. The pilot valve lever X is actuated by the rope J which runs under stationary sheaves J' at the bottom and over and under the two sheaves J'' at the top of the pit at the bottom of the shaft. At the top of the building the rope J runs over other sheaves, as shown in Fig. 304 which represents all the apparatus at the upper end of the elevator well, and also the elevator car. The lever L of the top automatic stop valve V' is actuated by the rope I, and the lever L' of the down automatic

through the suction pipe A and delivers into the pressure tank through the pipe B. The air compressor forces water into the discharge tank through the pipe E and into the pressure tank through pipe K'. Each tank is provided with gages to show the pressure and the water level. The compressor is run only occasionally, when the air supply runs low. The operation of the main pump is controlled by a pressure regulator N which is connected with the pressure tank by the pipe M. This regulator controls the valve in the steam pipe and thus stops and starts the pump whenever required by the variations of pressure in the tank.

The operation of the elevator is as follows: To start on the up trip the pilot-valve lever X is depressed, causing the main valve to be moved to the left; this allows water to pass out of the pres-

is running upward the valve V' is open so that water coming from the discharge tank through the check valve U can pass through it freely. When the car is descending [illegible] the down stop valve V'' is open until the lower floor is reached; consequently, the discharge water returning from the cylinder C can pass from the pipe D'' to the connection E, thence through the main valve to the pipe E' and to the discharge tank through the pipe E''.

The automatic stop valves shown in Fig. 3[illegible] are arranged slightly different from those presented in Fig. 3[illegible], the arrangement being in the position of the shafts upon which the operating levers are mounted. The main valve also is provided with a safety feature not shown [illegible] other drawings. These points of difference can be understood by inspection of Fig. 3[illegible], which is an enlarged sec-

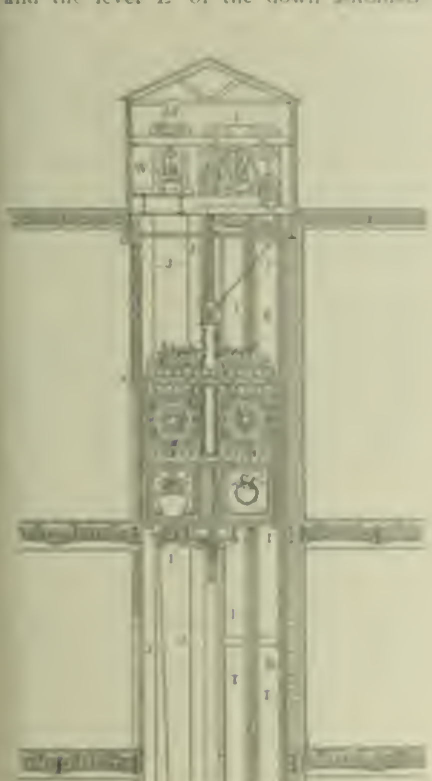


FIG. 304

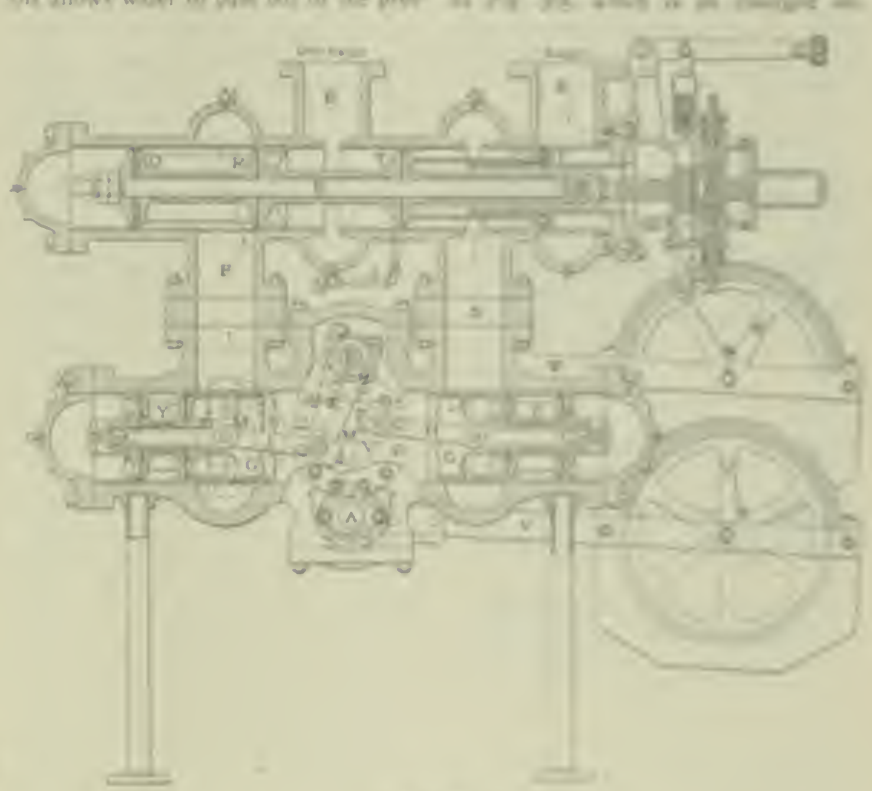


FIG. 30[illegible]

stop valve V'' is actuated by the rope I'. The points of attachment of these ropes to the car and the way in which they are supported at the top of the elevator well are shown in Fig. 304.

The construction of the car buffers is shown in Fig. 303 at H H. The counterbalance buffers are of similar design but are not generally provided with the rubber cushions shown below the spiral springs in the car buffers. If either the car or the counterbalance strikes the buffers running at a high speed, the latter are pushed down until the compression of the springs arrests the motion. The stroke of the buffers depends on the speed of the elevator, being made greater as the speed increases. The pump on the right draws water from the discharge tank

sure tank through the pipe D and the main valve to the connection D', thence through the top stop valve V' to the pipe D'', and to the cylinder C, forcing the plunger P and the car upward. If the car is stopped on the up trip, the flow of water through this path is arrested by the closing of the main valve, and if the latter closes so rapidly that the plunger tends to run ahead the water in the cylinder, then the water in the lower discharge tank flows upward through the pipe E'', to and through the check valve U and into the chamber of the down stop valve V'', as indicated by the dotted lines back of the valve, from here it [illegible] into the cylinder until the car stops. In [illegible] [illegible] the check valve U is the same as the valve L of Fig. 3[illegible]. When the car

[illegible] view of the main and stop valves of Fig. 3[illegible]. The advantage of placing the shafts S and S' [illegible] the wheel is that the levers W and T can be attached directly to them, while in the construction shown by Fig. 3[illegible] one of the levers swings on the shaft of the opposite lever, and requires connection to its own shaft through [illegible] segments. In Fig. 3[illegible] the operation of the stop valves does not appear to be practicable because it looks as if a very small movement of the crank T'' to the left would move it past the center S''. This difficulty will be fully cleared up by the aid of Fig. 3[illegible], which is a vertical section at right angles to the view in Fig. 3[illegible] and passing through the centers of the shafts S and S'. Looking at this drawing it will be seen that the crank

V'' and W'' are made so that they can swing past each other. This view also shows the way in which the bearings of the shafts A and B are made water-tight by the use of the cup packings a' and b'. The shafts are incased in brass tubing $a\,b$ to prevent corrosion.

The safety device attached to the main valve in Fig. 303 is clearly shown in Fig. 305; it consists of the small pipe connection a, and its operation is as follows: Suppose the car is running upward; when it reaches the upper floor the top stop valve Z will close, and at the same time the main valve piston T' will move to the left, thereby locking pressure water in the space S' between the main valve and the stop valve. This pressure will force the cup packings of the stop valve Z out so as to develop possibly sufficient friction to prevent the lever V and the weight of the sheave V' from shifting the valve to the open position when the car starts on the down trip. When the pipe a is

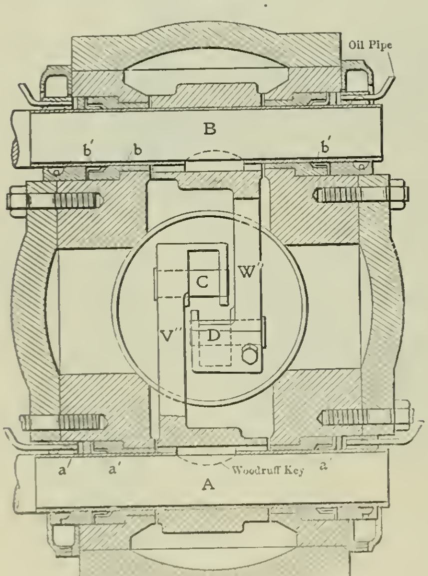


FIG. 306

provided this cannot happen because in order to run the car down the main valve has to be moved to the left so that the piston R may be carried beyond the port and thus open communication between E and E'. As soon as the main valve moves far enough for the piston T to pass to the left of the inlet of the pipe a, the pressure in S' drops to equality with that in E' and then the friction of the cup packings of the valve Z is so reduced that the valve cannot stick. It might be said that this samê result could be accomplished by putting additional weight on the lever V, but this would increase the tension on the operating rope, which is objectionable.

Professor Rateau has granted a license to the British Westinghouse Company for the manufacture of his steam turbine and the company has sold two units of 5000 kilowatts capacity each to London city.

Coal Specifications and Tests

By A. V. Doane

The practice of buying coal by specification, rather than by trade name or other time-honored methods, is rapidly increasing among large purchasers of fuel, and while this tendency is undoubtedly in the right direction, it is by no means a simple matter to write satisfactory specifications or properly to enforce them when written.

It is practically impossible to draw any general specification which shall be universally applicable, for the reason that coal is a natural product varying widely in composition from lignite to graphite. The great variety of purposes for which coal is used and the conditions under which it is burned make it necessary to select the kind best suited to the particular work to be done, if the best results are to be obtained. The most that could be done in the way of general specifications would be to formulate requirements suited to the different classes of service.

As by far the greater part of the bituminous coal mined is used for generating steam, specifications for coal to be used for this purpose have naturally been given the most attention. Even in this special use of fuel there are wide variations, as the quality and composition of the coal which can be economically obtained in different sections of the country vary considerably.

The types of boiler and furnace in use should be considered in specifying the quality of coal desired. For instance, vertical boilers do not give as good results with coal containing a high percentage of volatile matter as the horizontal type, while even a gas coal can be burned smokelessly and efficiently in a properly designed and proportioned furnace.

If more care were given to selecting the coal best suited to the particular case under consideration, and to the training and supervision of firemen, the smoke nuisance would be largely abated, with considerable saving in the fuel charges.

There is generally, at first, considerable opposition on the part of coal dealers to bidding according to specifications. There are several reasons for this: The opportunity for selling inferior coal at a good price is much diminished; there are more bother and detail about delivering and billing; also, a quite general fear that, owing to rejections or onerous requirements, they will sustain losses, which fear often leads to an increase in the price bid as a precautionary measure.

Ill-advised and too severe specifications or lack of judgment and tact in enforcement have sometimes caused a prejudice against this method of purchasing coal, also, but as a rule, if the dealer is treated fairly and the matter is properly explained, he soon becomes accustomed to the change. The honest dealer is protected by the specification method, as unscrupulous competitors who under the old system might have bid on furnishing some well known high-grade coal, intending to substitute an inferior and cheaper grade when making deliveries, will hesitate about playing this trick if they know that the coal will be tested and that they will be held strictly to the terms of the contract.

Writing Specifications

In writing specifications the properties which the coal should possess must be carefully considered, having in view the types of boiler, furnace, stoker, etc., methods of handling, storage and disposal of ashes, character of the load on the engines and the characteristics of the coals which can be readily obtained in the locality.

The amount required, place and time of delivery, mechanical condition of the coal and allowable proportion of slack should be specified. The maximum percentage, based on dry coal, of ash, volatile matter and sulphur and the minimum of B.t.u. per pound should be defined. Also, the coal should not heat dangerously when stored in large piles, nor cause an undue amount of smoke when fired with reasonable care.

In some cases the bidder is allowed to submit his own specifications covering the properties which he guarantees the coal shall possess, and the payment is based on the success of the contractor in delivering coal up to the standard he has set. If the price paid is based on the B.t.u. contained and the coal is weighed when received, the determination of the heating effect may be based on the coal as received, thus correcting for moisture.

The methods of sampling and testing should be described and in case of disagreement between the contractor and purchaser some way should be provided, generally by calling in a disinterested expert, of settling the controversy.

The basis of payment is, of course, one of the most important features of the contract. It is usual to pay the price per ton quoted by the successful bidder, deducting a specified amount as penalty for failure to deliver coal up to the standard, and adding a stated sum as premium for exceeding the requirements. The amount of B.t.u. per pound and the percentage of ash are generally the items on which premiums are paid or penalties deducted, but in some cases the amounts of volatile matter and moisture are included. In some instances, too, any variation from the specified standard makes a change in the price.

Another method, and one which, considering the unavoidable errors in sampling and testing, seems more equitable, is to allow a small variation, perhaps 1 or 2 per cent., above and below the standard before the premium or penalty becomes operative. The amount to be deducted or paid as premium should be given careful consideration in order to protect the interests of both parties to the contract. The purpose should be to deduct enough from the price bid to make good any loss sustained by the purchaser through failure to receive coal of the specified quality and to add enough to reward and encourage the contractor if the standard is exceeded.

It may be said that if the required B.t.u. per pound are received it is hardly fair to make a deduction for excess percentage of ash, but aside from payment for inert matter there are other important considerations: In using a coal having a high ash content more coal must be handled by the fireman to produce a given result, the ash must be heated to the temperature of the furnace and much of this heat is lost. The ash clogs the fire, requiring more draft; the fire must be sliced or shaken more frequently, resulting in a loss of unburnt coal through the grates, a greater tendency to form clinkers and increased expense in handling and disposal of ashes. If the ashes have to be carted to a considerable distance, this item alone may make it economical to buy a higher priced coal with a small percentage of ash, rather than a cheaper coal with high ash content.

In the case of Government, State or municipal contracts, the bidder is usually required to make a deposit with his bid, which may be retained if he fails to execute the contract, if it is awarded to him, and the successful bidder is also required to give bonds to insure the satisfactory carrying out of his obligations.

Tests

It was formerly the custom to calculate the heat units in the coal from the results of an ultimate analysis. This method has been largely superseded by the calorimeter test which is more accurate and can be made rapidly and conveniently, especially if a simple and easily manipulated calorimeter is employed.

In addition to the heat units, determinations of moisture, volatile matter, sulphur and ash are commonly made.

The moisture test is a difficult one to make with accuracy as, if an attempt is made to drive off all the water by heating the coal, some of the combustible volatile is very likely to go with it.

In the same manner the test for volatile matter shows that there is no well-defined line between combined water and combustible volatile matter on the one hand and between the latter and so-called fixed carbon on the other. In order to minimize the error it is customary to heat the coal in a platinum crucible for a definite time over a standard flame.

The test is an important one, as the percentage of volatile matter plays an important part in the heating effect, and while a high volatile coal may give a satisfactory result in the calorimeter, it does not follow that it will make an equally good showing under the boilers, unless the plant is particularly adapted to burn coal of this kind. If anthracite screenings, buckwheat or some of the other small sizes of hard coal are mixed with the bituminous coal the percentage of volatile in the soft coal may be considerably higher than would be desirable if it were to be used alone. It is much more difficult to secure smokeless combustion with a high volatile coal than with one containing only a moderate amount.

It is customary in reports on boiler tests to state the evaporation per pound of combustion or coal free from moisture and ash regarding the residue, after subtracting these constituents, as entirely combustible. This assumption has been shown to be erroneous, as in some coals, particularly those from the western part of the country, a large proportion of the supposed combustible volatile is in reality water of composition. This error ranges from 3 or 4 per cent. for Eastern coals to 14 or more for Western, so that if a true basis of comparison is desired an ultimate analysis is required.

The test for sulphur is of considerable importance with some coals, particularly those from the West, which contain from 1 to 5 per cent. While sulphur is combustible, it has only about one-quarter of the calorific value of carbon. It makes a fusible ash, especially when combined with iron or iron pyrites. The melted ash runs into the air spaces, stopping the air supply and often ruining the grate.

The hot gases containing sulphur are commonly supposed to attack iron, but it is doubtful if the comparatively cool boiler shell is injured; but highly heated ironwork in smoke stacks, etc., may be attacked, and if the sulphurous products of combustion combine with moisture, an acid is formed which rapidly corrodes ironwork exposed to its action.

It is popularly supposed that so-called spontaneous combustion of coal is caused by the sulphur present, but investigation has shown that while the oxidation of pyrites in a coal which has a tendency to heat may play some part in starting the action, the true cause is the capacity of the coal to absorb oxygen, which seems to depend on the molecular condition.

Some coals low in sulphur heat dangerously, while others with a high content of this element give no trouble. Great care should be taken to avoid getting a dangerous coal, as a large mass of coal on fire in the storage bins or pile is an expensive and dangerous proposition.

There appears to be no reliable test which will give absolute information about the heating tendency, although coal which retains considerable moisture when air-dried is said to be more likely to heat. Freshly mined coal containing a large proportion of dust is more liable to heat, especially if wet when stored.

In making coal tests one of the most important operations is the collection of the sample, as it is evident that if this is not truly representative of the coal, the care and refinement with which the tests are carried out are of little use.

If the coal is delivered by carts or hoisted to bunkers a small quantity may be taken from each load or from the tubs or conveyors at convenient intervals and put in a pile, from which the sample is taken. If necessary to obtain the sample from a pile or car, small portions should be taken from different parts, not only on the surface but at some distance below, as there is a tendency for the heavier lumps, which contain the most slate or bone, to settle to the bottom, particularly in railroad cars.

Enough coal should be taken to make a pile containing about one bushel. This should be spread out flat on a clean, dry surface and all large lumps broken. The pile should then be divided into quarters and a section rejected. The lumps should then be broken finer and the coal shoveled over thoroughly to mix it, and again quartered and a section rejected, repeating the operation until there remains but a small quantity, containing no lumps larger than a pea, from which the sample for analysis is taken and placed in an air-tight can or jar holding about one quart. A tin can with a friction top, such as is used for paints or varnish, is convenient.

In order to identify the sample a brass label holder, such as is put on drawers or cases, may be bent to fit the outside of the can and soldered at the corners to hold it in place. A card is then slipped into the holder with the necessary information written on it. The card is changed when the can is used again.

The sample should be taken by a representative of the purchaser and little dependence should be put on tests of sample lumps or of samples sent in by bidders. It is common practice for dealers to send a carefully selected sample to some well known chemist for analysis and then make use of his report to show the high quality of the coal. It is more than probable that a test of a sample of the coal as received by the purchaser will fail to equal the figures given in the report.

In making contracts it is usual to specify that the tests are to be made in accordance with the methods adopted by the American Chemical Society. Experience has shown that if the specifications are so drawn that the purchaser gets the coal which is best suited to his plant and requirements, if the tests are made by a competent person and the interests of both parties to the contract are properly protected, bidding in accordance with these specifications is the best and fairest way to obtain a satisfactory supply of coal.

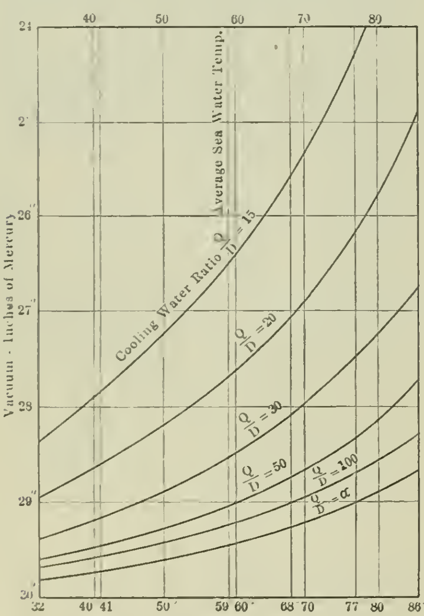
[illegible]

Surface Condensation for Steam Turbines*

Coefficient of Heat Transference, Influence of Air Leakage, Condenser Pumps, Temperature of Air and Water and Contra vs. Ordinary Flow

BY PROFESSOR E. JOSSE

On shipboard surface condensers are always preferred because the condensed water should be fit for use as boiler feed. Even in stationary-turbine plants preference is often given to the surface condenser over the more economical jet condensers for three reasons: (1) the surface condenser produces a good vacuum more easily than the jet condenser; (2) the condensed water is free from oil and can be reused; (3) there is danger that the cooling water of the jet condenser might flow back into the turbine. Messrs. Tosi, of Leghorn, are installing an air-operated nonreturn valve to obviate this difficulty. As a rule surface condensers



Ratio of Cooling Water to Feed - Degrees F.

FIG. 1

are insisted upon for turbines and they may cost from 30 to 60 per cent. of the whole turbine-plant cost. On board ship the large dimensions and weight are factors of importance.

An investigation was made of the effect of increasing vacuum on the thermal efficiency of the prime mover, bringing out the facts that the available heat increases considerably as the vacuum increases above 21 inches. The reason is that the specific volume of the steam augments rapidly as the condenser pressure is reduced, and the cylinders of reciprocating engines cannot for practical reasons be enlarged to accommodate this volume. It is well known that reducing the vacuum below 26 inches does not increase the efficiency of steam engines. In turbines there is ample steam space for large volumes and the lower condenser pressures can be fully utilized. These investigations proved that the engineer is on the right track when he endeavors further to improve the condenser vacuum. What can be achieved by enlarging the condenser dimensions has already been done and it is no good to go farther in this direction. Other ways must be found.

The attainable vacuum depends on the temperature and mass of the available cooling water. Given an unlimited amount of cooling water at 60 degrees Fahrenheit, the steam pressure can be reduced to half an inch absolute, or a 98 per cent. vacuum. With warmer circulating water, the vacuum will, of course, be poorer. In Fig. 1 are plotted the possible vacua with various ratios of circulating water to condensed steam and various initial temperatures. On board ship a ratio of 50 to 60 can generally be managed and an excellent vacuum should hence be realizable, if other considerations did not complicate the problem.

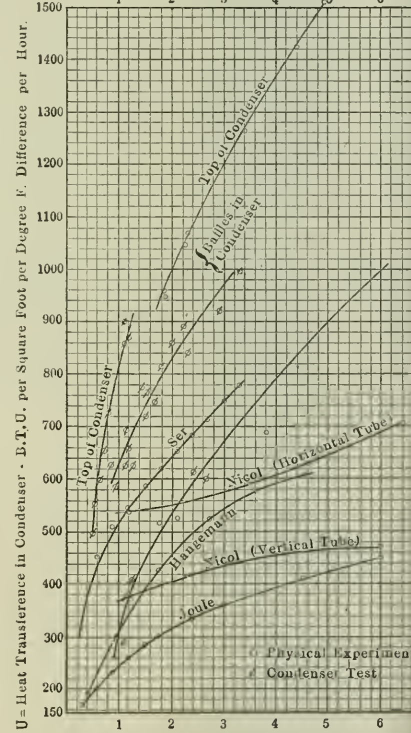
Coefficient of Heat Transference

In order that the steam may give off its heat to the cooling water, the heat has to pass through the metallic wall of the condenser tube and may be considered in three stages: in the transference from the steam to the metal; in the metallic wall of thickness d and thermal conductivity L; and in the transference from the metal to the water. The coefficient of transference U, the number of heat units transferred per hour through 1 square foot of metallic condenser wall when the temperature of the steam is 1 degree Fahrenheit higher than that of the water, can be deduced from the formula

$$\frac{1}{U} = \frac{1}{A_1} + \frac{d}{L} + \frac{1}{A_2},$$

d being the usual thickness of condenser tubes (1 millimeter or 0.0393 inch). For this thickness the value of L is fairly well known and may be given as 18,430 for brass, 61,500 for copper, 11,270 for iron, 5740 for zinc, 11,050 for tin and 2660 for aluminum. The middle term $\frac{d}{L}$ would have the value of $\frac{1}{18{,}430}$ and be of comparatively little importance.

The term $\frac{1}{A_2}$ is the most importan[t] and has been investigated with the aid o[f] two concentric tubes, water being sen[t] both through the inner tube and the annular jacket. The values of various experimenters differ greatly. Professo[r]



Rate of Flow of Cooling Water - Feet per Second

FIG. 2

Josse agrees best with Ser, who gave th[e] approximate formula

$$A - 2 = 510\sqrt{V},$$

where V is the velocity of water throug[h] the tubes in feet per second. This velo[city] is the decisive factor; far more im[portant] than the material of the con[denser] tubes and their thickness, and als[o] of greater consequence than the velocit[y] of the steam, about which, or, rather, th[e] term $\frac{1}{A_1}$, there is even less agreemen[t]. The coefficient A_1 is generally suppose[d] to be about 2085, although Ser give[s] a much higher figure. From an analysi[s] of Ser's figures and his own experiment[s]

*Abstract of paper read before the summer meeting of the Schiffsbautechnische Gesellschaft at Berlin, June 16 to 18, 1908, by Prof. E. Josse, director of the department of engineering at the Technical High School at Charlottenburg.

Professor Josse concludes that 3900 is a more correct value. The velocity of the steam has its influence, but the whole term does not count for much. For water flowing at the rate of 1.64 feet per second Josse's formula would be:

$$\frac{1}{U} = \frac{1}{3900} + \frac{1}{18{,}430} + \frac{1}{653} = \frac{1}{445}$$

and

$$U = 445.$$

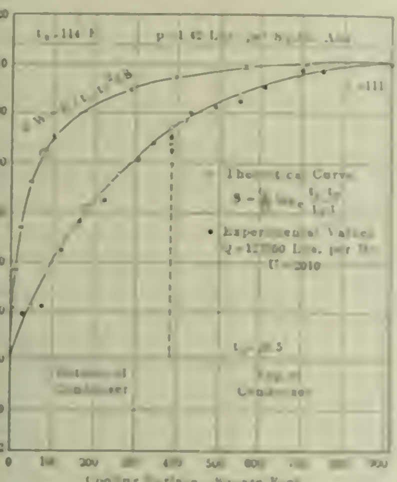


FIG. 3

If A_1 be increased to twice its value U would rise only to 475, and if the tube thickness be increased to 2 millimeters U would hardly be affected. An increase, however, in the rate of flow from 1.64 to 5 feet per second would raise U to 625. As an increase of the steam flow is undesirable the best plan is to accelerate the flow of the circulating water and by introducing the baffle strips or retarders of Pape, Henneberg & Co., of Hamburg, into his condenser tubes, in order to break the water currents up into vortices, he raised the U at a velocity of 3.28 feet per second from 614 to 922. The results of Professor Josse's experiments conducted with condensers and of experiments made by others with physical apparatus are plotted in Fig. 2, the curves showing that in condenser tests better results are obtained than in experiments conducted in the physical laboratory.

Opinions differ concerning the increase of U with greater differences of temperature. According to some the heat transferred should increase proportionately to the difference; according to Weiss and others, proportionally to the square of the temperature differences. His investigations were conducted by placing thermocouples in different portions of the condenser tubes. If the heat transferred increases as a linear function of the difference then the rise of the temperature in the cooling water should follow an exponential law and it was found to be so.

The curves in Fig. 3 are in equally close agreement with the formula

$$Surface = S = \frac{Q}{U} \log_e \frac{t_s - t_1}{t_s - t},$$

where t_s is the saturation temperature and t_1 the temperature of the cooling water at entrance, t being the discharge temperature. It will be seen that the quadratic formula of Weiss does not conform at all with the theoretic curve.

Influence of Air Leakage

Before proceeding to a calculation of suitable condenser dimensions the influence of air leakage must be studied. Air enters into the condenser with the exhaust steam, the temperature of the air being that of the steam; the pressure of the mixture will be the sum of the partial steam pressure and of the partial air pressure. The air must be withdrawn by the air pump. If the withdrawal takes place at the temperature corresponding to the condenser pressure the partial steam pressure would be equal to the condenser pressure; that is, the partial air pressure would be zero and the pump would have to deal with an enormous air volume. The air pressure should, therefore, not be re-

FIG. 4

duced to zero and the temperature be lowered, at the spot where the air is withdrawn, below the saturation temperature of the condenser pressure. The condenser is to cool the air as well as the steam, for while the heat transference from steam to metal takes place readily, the respective coefficient U being in round numbers 4100, air is known to be a good thermal insulator and its U is of the order of 1.

Experiments on the heating of air when passing along pipes have been made by Ser. He noticed that the U improves with the diameter of the pipes, and also with the velocity of the air (the pipe diameters range from 16 to 40 millimeters), but he did not introduce a diameter term in his empirical formula, and all his experiments were conducted at ordinary air pressure.

In the condenser vacuum the heat transference should obviously be smaller than at atmospheric pressure and Professor Josse investigated this problem by carrying air at different speeds and pressures through a pipe of 25 millimeters internal diameter and 1500 millimeters in length placed in a steam bath at 212 degrees Fahrenheit. The air was drawn by a pump through a meter, its volume determined and its pressure adjusted by means of a valve inserted between the meter and the pipe. The heat transmission from the steam through the pipe wall to the air was deduced from the heat of the air and checked by determining the amount of condensation taking place in the steam space.

Figs. 4 and 5 and the accompanying table show the results in a striking manner, the experiments indicating that the rate of flow of the water which is decisive for the cooling of the steam will be of little consequence for the cooling of the air, which will essentially depend upon the rate of flow of the air, in consequence of which large air-cooling surfaces should be provided.

The curves of Fig. 6 illustrate the rise in the temperature and the cooling water resulting when different amounts of air enter the condenser. In both cases, the first portion of the curve is horizontal, i.e., there is no temperature rise at first. In the lower curve about 40 per cent. of the total condenser surface seems to have essentially served for cooling the air, since if the exhaust were free of air the curve would at once rise.

In steam turbines it is more easy to keep air out than in reciprocating engines. In turbines air can only gain access, as a rule, through the shaft glands, which are packed with water, oil or steam. Steam turbines are, however, as liable as reciprocating engines to air contamination through the feed water, if the pipes are leaky or the pumps do not work well.

FIG. 5

For well constructed turbines the amount of air leakage should be very small. Experiments with a 3000-kilowatt Parsons turbine show that not more than 11 pounds of air was delivered per hour when 3000 pounds of steam was used per hour.

Condenser Pumps

Turning to the condenser pumps, Professor Josse points out that the wet and condensed water may either be removed separately, by a so-called dry-air pump, or both together, by a wet-air pump. As dry-air pumps have to deal with high compression ratios, with high vacua and single-stage pumps, the clearances must be small. When the clearance amounts to 5 per cent. the vacuum cannot be maintained at more

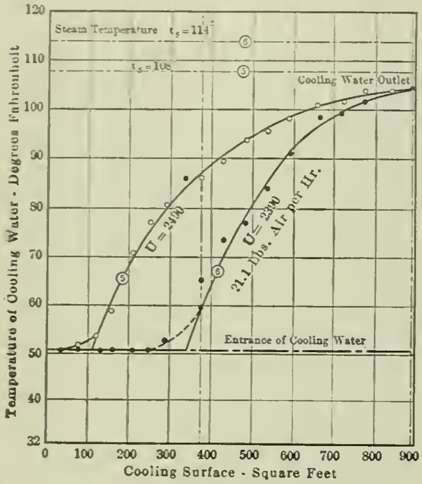


FIG. 6

than 95 per cent. and the clearance must be reduced, or other expedients adopted. Three are mentioned: (1) the air pump may be built in two stages; (2) the pump may be fitted with an equalizing pipe so that the two sides of the piston are connected near the end of each stroke, the volumetric efficiency is raised by this expedient, but considerable more power is absorbed to accomplish the result; (3) with the wet-air pump the clearance space is made to receive the condensed water which will fill at least part of it.

Fig. 7 illustrates the construction of these double-acting wet-air pumps. It will be noted that means are provided in the upper valve deck to allow the noncondensable vapors to enter above the piston on each down stroke, together with the water which flows in through the center ports passed over by the piston.

A pump of this design, 20 inches in diameter, 6.3 inches stroke and running at 250 revolutions per minute, for a plant condensing 22,000 pounds of steam per hour with a vacuum of 28 inches, was also illustrated. It is important in this pump that the valves should be very light in weight.

Temperature of Discharged Air

Returning to the temperature at which the mixture of condensed water and air should be withdrawn, the case represented

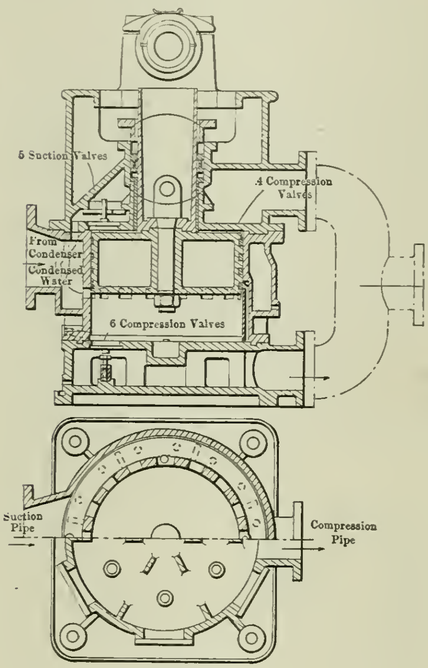


FIG. 7

in Fig. 8 is that of a 28½-inch vacuum, one kilogram of air entering per hour, and the air-pump capacity is 50 cubic meters, 1765 cubic feet per hour. The abscissas are the temperatures at the condenser outlet. If the pump is merely to remove the dry air the flow of air would be little influenced by the temperature, as the straight line in the upper part of the diagram indicates, but the partial pressure of the air at saturation temperature dwindles to zero and the air volume becomes very great.

In the case represented the volume to be removed would equal the pump capacity of 50 cubic meters at 25.6 degrees Centigrade, when the partial air pressure will be 0.017 atmosphere. If the pump had a capacity of 2800 cubic feet, or 80 cubic meters per hour, then the temperature might rise to 29 degrees Centigrade. If, on the other hand, two kilograms of air should leak into the condenser instead of one, the cooling would be carried down to 15 degrees Centigrade.

The temperature of the discharged air is a criterion as to the fitness of the con-

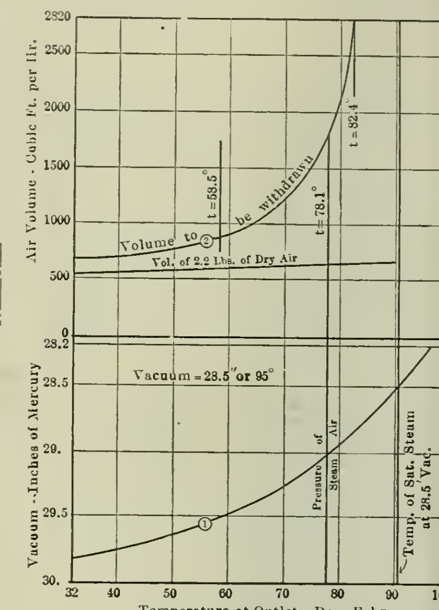


FIG. 8

denser plant, but caution should be exercised in forming an opinion. A claim that the condenser must work the better the lower the temperature of the discharged air is unjustified. The air temperature may be low because there is much air leakage, or because the pump delivery is poor. Air leakage becomes a serious factor when a high vacuum is to be utilized and the air must be cooled whether a dry- or wet-air pump be used.

Temperature of Condensed Water

As regards temperature of condensed water the two systems differ. When the air is separately withdrawn the condensed water need not be cooled. When a wet-air pump is used extra cooling of the condensed mixture is necessary, lest an after escape of air ensue; Professor Josse first cools the liquid, then the air, by bringing it into contact with the liquid, as the cool-

HEAT TRANSFERENCE COEFFICIENTS FOR AIR.

Length of pipe, 52 inches; internal diameter, 0.91 inch; air-flushed surface, 148 square inches.

Experiment.	1	21	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Inches of vac. =								14.4	14.4	14.5	14.6	14.4	26.8	26.75	26.8	26.8	26.8
Air pressure, lb. abs.	14.95	14.95	14.95	14.95	14.95	14.95	14.95	7.57	7.57	7.54	7.50	7.57	1.56	1.53	1.56	1.56	1.56
Steam temp., deg. F.	Always 212°																
Air temp. at entrance, deg. F.	62.1	62.4	65.1	67.5	68.6	70	67.5	67.5	67.1	67.3	68	68	80.5	86.4	87	90.5	97.8
Air temp. at discharge, deg. F.	138	144.5	156.2	160.8	164.3	161	171.1	149.7	165.2	164	174.6	183	161.7	183.8	184	189	184.1
Air temp., mean, deg. F.	100.5	104.1	110.3	114.9	116.7	114.9	119.4	108.5	116.7	117.6	121.2	125.7	122.1	134.8	136.4	140	141.9
Air wt. per hr., lb.	70.8	'65.9	24.4	16.7	12.9	9.16	5.4	34.2	19.6	15.3	8.7	4.82	3.8	2.75	1.79	1.46	0.53
Air vol. per hr., cu.ft.	1000	656.5	351	242.2	187.2	132.9	79.1	986	572	451	268.1	142.9	543	409.5	262.1	215	77.7
Air speed in pipe, no. ft. per sec.	62.2	40.8	21.8	15.1	11.64	8.27	4.92	61.4	35.6	28	16.03	8.9	33.8	25.5	16.3	13.38	4.82
B.t.u. transferred, per hr.	1282	906	530	371	295	198	134	670	458	366	221	132	73.5	64.	41.3	34.4	10.8
Heat transferred, coeff. = U	10.52	8.56	5.51	4.02	3.29	2.17	1.59	6.67	5.15	4.22	2.72	1.79	0.85	0.955	0.62	0.565	0.172

ing of the water requires much smaller surfaces than the cooling of the air. This arrangement is said to save surface space. The extra cooling of the liquid is [illegible] far undesirable, as the cold feed water has afterward to be reheated with modern high vacua which generally do not require a cooling of more than a few degrees below saturation temperature. This loss of heat will not amount to more than 1 or 1½ per cent. of the heat of the feed water. The wet pumps are, on the whole, simpler, occupy less space, absorb less power than dry-air pumps. Another point is that the steam withdrawn, together with the air, has to be compressed; for this purpose injection is sometimes resorted to. In the wet pump the steam will condense again as soon as compression is begun.

A Series of Condenser Tests

Professor Josse's experiments have extended over three years, during which his improved condensers have been working satisfactorily.

The first series of tests concerns the 300-kilowatt Parsons turbines of the engineering laboratory at Charlottenburg, which a vertical pipe of ample dimensions connects with the surface condenser below. The wet-air pump of Professor Josse is driven by belting from an electric motor at 300 revolutions. The chief dimensions are as follows:

Cooling surface	968	sq. ft.
Tubes, diameter	0.79	in.
Tubes, thickness	0.04	in.
Tubes, length	[illegible]	in.
Number of tubes (upper set)	316	
Number of tubes (lower set)	242	
Total	[illegible]	
Surface (upper set)	[illegible]	sq. ft.
Surface (lower set)	[illegible]	sq. ft.
Total surface	[illegible]	sq. ft.
Total cross-section (upper tubes)	[illegible]	sq. in.
Total cross-section (lower tubes)	[illegible]	sq. in.

The average duty of the condenser was 35 kilograms of steam condensed per hour per square meter (7.15 pounds per square foot) of cooling surface. The excess of cooling over the theoretical at the highest vacuum was 16 per cent., with a 27-inch vacuum, which went down to 5 per cent. The difference in temperature between the temperature of the condenser and the discharged cooling water was generally less than 2 degrees Centigrade.

The average coefficient of heat transference was high to 600, even 800, although the rate of flow of the cooling water was, as a rule, only 0.4 of a meter per second (16 inches). This high efficiency is ascribed to the good services of the baffles. The cooling water was very pure and baffles had not required any cleaning in three years.

The second condenser experimented with was that of the 200-kilowatt turbine of the laboratory built at the Allgemeine Elektricitats Gesellschaft. This condenser was built for experimental purposes and is of peculiar construction. It consists of [illegible] tubes, disposed in an upper and lower condenser, [illegible] of the tubes of the upper condenser run crosswise, their length being 558 millimeters (22 inches). The three sets of longitudinal tubes have each a length of 1200 millimeters (47 inches), a common internal diameter of 15 millimeters (0.59 inch), and a total cooling surface of 28.52 square meters ([illegible] square feet). This small area is to condense 2000 kilograms (4400 pounds) of steam per hour, 65 kilograms per hour per square meter (13.3 pounds per square foot), nearly twice as much as the first condenser. The best vacuum reached was 96.4 per cent., and nearly 50 per cent. more than the theoretical amount of cooling water was needed for this performance. The wet pump was also too small. The heat transference was very good, the coefficient rose to 1470 in the case of the top tubes. For the condenser as a whole the heat transference was 786, when the cooling-water ratio was 50. The cross tubes were added to see whether vortices set up in the steam would raise the efficiency; no such effect was observed.

Contraflow and Ordinary Flow

Professor Josse then discusses the piping system connecting the pumps to the condensers, the main case being where a cooling-water ratio of only 21 could be obtained, in consequence of which the vacua were much lower than what they should be. He questioned also the justification of the general distinction between contraflow and ordinary flow. For the greater portion of the condenser there is a rise of temperature only on the water side, the temperature of the steam side remains that of the saturated steam and the term "contraflow" should, strictly speaking, only be applied if there is a temperature fall in the one direction and a corresponding temperature rise in the opposite direction. As far as the condensation is concerned, it is immaterial in which direction the water flows. The con[illegible]

[illegible]

Increasing the Efficiency and Capacity of Large Gas Engines by Cooling the Charge

By F. E. Junge

Professor Junkers, of the Technische Hochschule of Aachen, Germany, has been conducting a long series of investigations to ascertain the influence of charge temperature on both the capacity and the

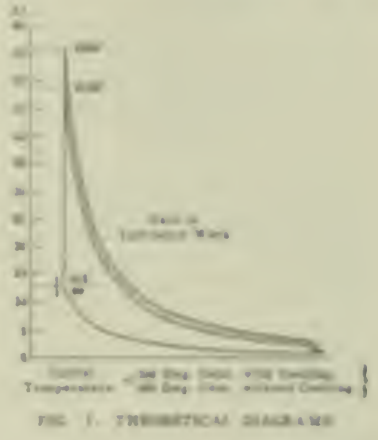


Fig. 1. Theoretical Diagrams

reliability and economy of gas engines. Fig. 1 shows the theoretical difference in the internal working process of the same gas engine operated with and without cooling the charge. According to the figure, there is a gain in work output attainable as represented by the small area along the expansion line, and as a further result of all-round reduction of temperatures in the cyclic process is realized.

The Junkers experiments were made on one of the Oechelhaeuser two-cycle engines of the Hörder Verein, at Hörde, Westfalia. Fig. 2 gives a schematic view of the engine, which was described in detail in Power in 1906. The operation here [illegible]

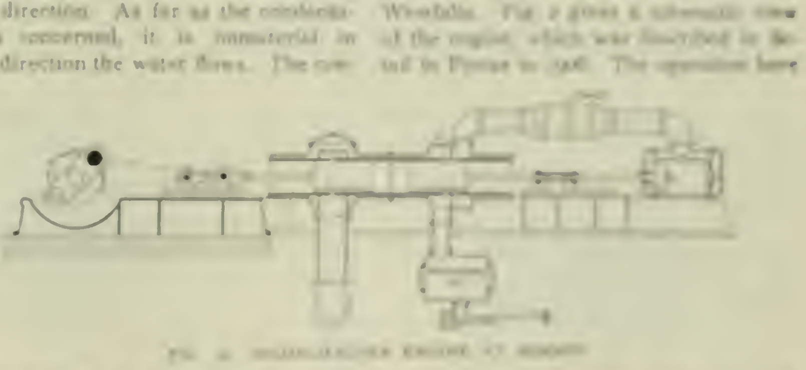


Fig. 2. [illegible]

[illegible]

pipe above, which is provided with a cooler, as shown in the sketch.

In the first trial the engine ran, without cooling the charge, at its maximum capacity, yielding a mean pressure in the working cylinder of 4.55 atmospheres and developing 395 indicated horsepower. The charge temperature was 90.5 degrees Centigrade. In the second trial the engine ran with cooling of the charge and yielded a mean pressure of 5.29 atmospheres, or 460 indicated horsepower in the working cylinder. The cooler reduced the charge temperature from 90.5 to 30.5 degrees Centigrade, the difference or refrigeration amounting, therefore, to 60 degrees Centigrade. From this follows a theoretical increase of capacity, with cooling, of 0.198 of the amount attained without cooling. The practical increase was 0.165 of the ordinary result. In other words, when cooling the charge the engine showed an increased output of 17 per cent. beyond what was attainable without cooling.

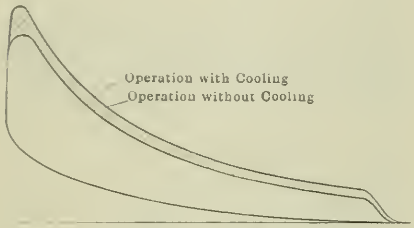


FIG. 3. ACTUAL DIAGRAMS TAKEN AT HOERDE

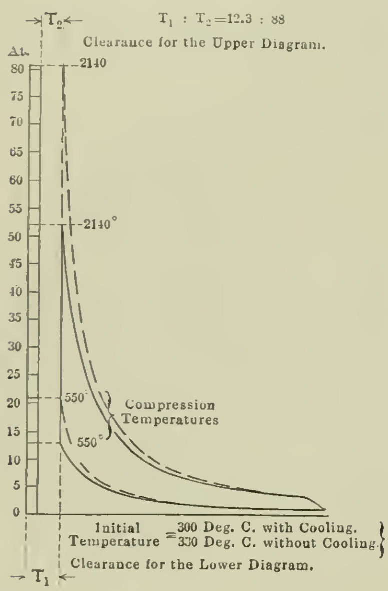
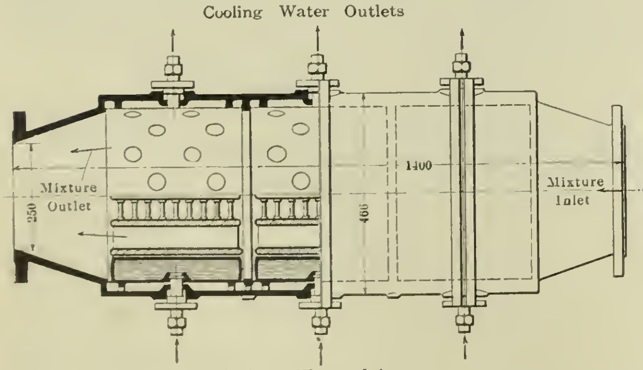


FIG. 4. DIAGRAM SHOWING EFFECT OF MIXTURE COOLING ON COMPRESSION RATIO

Fig. 3 gives two diagrams plotted one above the other, the one taken without and the other with cooling. The pump work amounted to 55 indicated horsepower in the first and to 51 indicated horsepower in the second instance. But this difference is probably due to the fact that the charging pump was too large for ordinary operation and its intake had to be throttled, while, owing to the larger free volume taken when cooling, the throttle was opened and its resistance diminished. The cooler carried away approximately 38,500 heat units per hour from the charge. A comparison of heat absorption by cooling water with and without mixture cooling, respectively, gives the following results, it being assumed that 700 heat units per horsepower-hour were being carried away by the cooling water: Output without intercooling = 395 indicated horsepower; loss to cooling water of cylinder = 700 × 395 = 276,500 heat units per hour. Output with intercooling = 460 indicated horsepower, and it was ascertained that the heat loss to the cooling water for the cylinder was not larger than before, 276,500 heat units per hour. In addition, there were wasted 38,500 heat units for cooling, making a total of 315,000 heat units per hour. An engine not equipped with the cooling device would lose, for the same output of 460 horsepower, 460 × 700 = 322,000 heat units per hour. It follows that the cooling also has a favorable effect on the total heat carried away per unit of power developed.



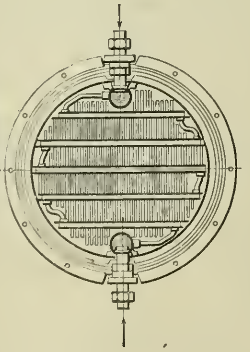
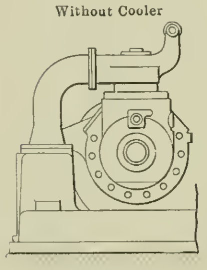


FIG. 5 COOLER OF OECHELHAUSER ENGINE AT HOERDE FIG. 6

Among other advantages of the Junkers system may be mentioned that the number of misfires is reduced, whereby the average mechanical efficiency of the engine is increased. Also, part of the water vapor of the charge is separated out by the cooler, by condensation, which must have a favorable effect on the combustion process. But these advantages are not all that can be realized by the innovation of mixture cooling. If, instead of reducing the temperatures of the whole cyclic process, cooling is used for increasing the compression pressures, then a far greater capacity may yet be obtained. For instance, cooling the charge by only 30 degrees Centigrade allows an increase of compression pressure from 13 to about 21 atmospheres to be used, without thereby increasing the cylinder temperature above



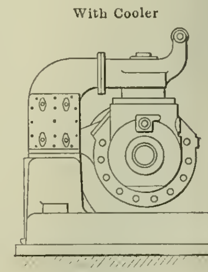
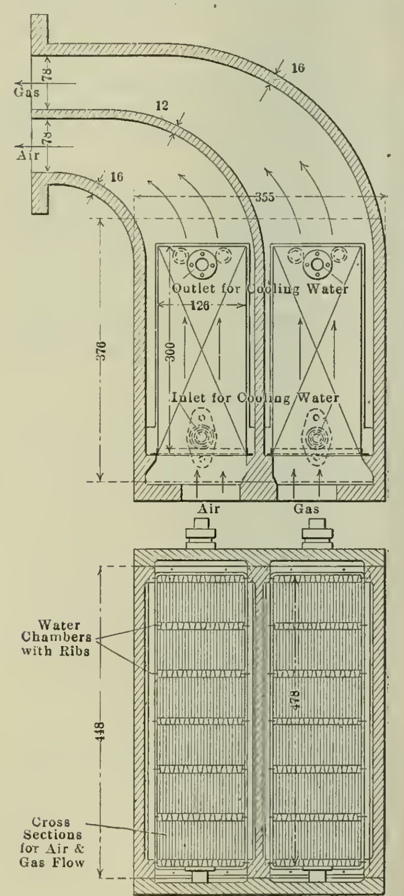


FIG. 7 FIG. 8

200-HORSEPOWER KOERTING ENGINE WITHOUT AND WITH COOLER



FIGS. 9 AND 10. EXPERIMENTAL COOLER FOR 200-HORSEPOWER KOERTING ENGINE

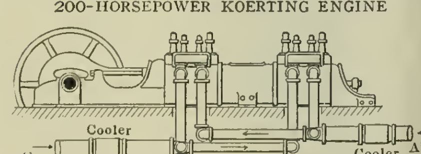


FIG. 11. FOUR-STROKE TANDEM ENGINE WITH COOLER

that of ordinary engines. A Korting engine running on producer gas and driving an electric generator showed thus an increased capacity of 12 per cent. at the switchboard. The fact was also confirmed that preignition, which had been a weak feature of the particular installation, disappeared entirely when cooling the mixture.

As to the construction of the cooler, those surfaces which absorb the heat of the gases must bear the correct proportion to the others which conduct their heat to the cooling water. The coolers are made of copper and are tinplated. They are mounted in solid cast-iron casings in such manner that the reciprocating movements, which accompany the operation of large engines, do not impose unfavorable stresses on the cooling system. The coolers allow the gases to pass through without change of direction, and the path of their travel is short, so that the friction resistance is small.

Figs. 5 and 6 show the cooler used at the Horde Verein. Figs. 7 and 8 show an arrangement of coolers used in connection with Korting engines. It will be evident that the appearance or floor space of the engine is not changed at all. The coolers are put in place from one side, like drawers, and can be removed for inspection and cleaning in a few moments after loosening the cover. Fig. 11 gives a schematic view of a tandem four-stroke engine with coolers built in both the air- and the gas-intake pipes. They show very favorable results, especially in summer; of course, it is impossible to realize such a considerable increase of capacity as with two-stroke engines, because the air is not compressed before it passes to the engine cylinder and the temperature differences are therefore smaller.

According to a contemporary, the turbinal tubeless boiler is made of concentric annular conical vessels with narrow water spaces and narrow flame spaces, heated by a liquid-fuel burner from below. The steam produced in the boiler proper descends through a helically coiled superheater tube placed in the middle space of the innermost cone. The issuing steam is dried and comes out at a high temperature, something that may be over 600 degrees Fahrenheit.

An interesting departure in steel works practice is about to be begun by the United States Steel Corporation in the establishment of a bureau for scientific research near Duquesne, Penn. A laboratory is to be created, the work starting in the spring, and experiments will be systematically carried on with the purpose of improving the processes and methods of steel manufacture for the benefit of the various constituent companies of the United States Steel Corporation.

Tests of Run-of-Mine Coal and Coal Briquets

A bulletin on the comparative tests of run-of-mine coal and coal briquets on locomotives and on a torpedo boat has just been issued by the technologic branch of the United States Geological Survey. The author of the bulletin, W. F. M. Goss, consulting engineer on briquet tests, gives the results of the tests in the following:

1. The briquets made on the Government's machines have well withstood exposure to the weather and have suffered but little deterioration from handling.

2. In all classes of service involved by the experiments, the use of briquets in the place of natural coal appears to have increased the evaporative efficiency of the boilers tested.

3. The smoke produced has in no case been more dense with the briquets than with coal; on the contrary, in most tests the smoke density is said to have been less when briquets were used.

4. The use of briquets increases the facility with which an even fire over the whole area of the grate may be maintained.

5. In locomotive service the substitution of briquets for coal has resulted in a marked increase in efficiency, in an increase of boiler capacity, and in a decrease in the production of smoke. It has been especially noted that careful firing of briquets at terminals is effective in diminishing the amount of smoke produced.

6. In torpedo-boat service the substitution of briquets for coal improves the evaporative efficiency of the boiler. It does not appear to have affected favorably or otherwise the amount of smoke produced. The briquets used in this series of tests were of a form requiring considerable bunker capacity for their storage, but as the form of the briquet is a detail entirely within control, this objection need not apply to the use of the briquets in actual service.

The tests of the coal and briquets on the locomotives were made under the direction of A. W. Gibbs, general superintendent of motive power of the Pennsylvania lines, by E. D. Nelson, engineer of tests, at Altoona, Penn., in coöperation with the technologic branch of the Geological Survey, which supplied the coal and manufactured the briquets.

Many low-volatile coals, such as those mined in the vicinity of [illegible], Penn., are semi-smokeless and therefore very desirable for use in locomotives at or near terminals; nevertheless, on account of their low evaporative efficiency, they have not been found altogether satisfactory when used as locomotive fuel. Their tendency to disintegrate rapidly on the grate during combustion causes large quantities of cinders and sparks of high calorific value to be discharged. These [illegible] accumulate in the smokebox or the front end, cinders obstruct the draft on the fires and reduce the capacity of the boiler. The investigation here reported, therefore, was undertaken to determine in what measure, if any, the briquet process will serve as a remedy for these defects and to discover the effect of the process on efficiency and economy.

The coal selected for the tests was taken from a mine working the "Lower" Kittanning seam, located near Lloydell, Penn., on the South Fork branch of the Pennsylvania Railroad; its characteristics as a locomotive fuel were therefore well known. The Lloydell coal is a very friable low-volatile bituminous coal, and the carloads selected for the tests consisted of run-of-mine. They were loaded and shipped under the direction of J. S. Burrows, of the Geological Survey. The coal was exposed to the weather for thirty days on the way to the St. Louis testing plant, before being made into briquets. It showed but little change due to this exposure except a decided increase in moisture, which, however, was eliminated in the briquetting process.

The binding material in all the briquets was water-gas pitch. This material was furnished to the briquet plant of the United States Geological Survey, at St. Louis, at $8 per ton, or .44 cent per pound. The least amount of binding material that would make perfect briquets was found to be 5 per cent. of the weight of the coal. The cost of the binder in one ton of the 5 per cent. briquets was, therefore, 45 cents.

The cost of the briquet process, including all charges, is estimated to be about $1 per ton of briquets; that is, the briquet process added approximately $1 per ton to the cost of the coal. The briquets were made, however, by an experimental plant, and the price is for this reason probably not so low as if they had been made on a much larger scale.

The briquets were made by the coal-testing plant of the United States Geological Survey at St. Louis. The coal was shipped from the mine at Lloydell under the supervision of an inspector of the Survey, who at the same time obtained mine samples. The samples were hermetically sealed and sent to the St. Louis laboratories for analysis. After the coal was made up into briquets it was returned to the locomotive-testing plant at Altoona for the tests.

To observe the effect on briquets of exposure to the weather, a number of the round and square briquets were placed on the roof of the testing plant. After four months of exposure for the round and three months for the square briquets, no serious change from their original condition was noticed. They seemed to be equally impervious to moisture and were still firm and hard.

The briquets were little affected by handling. They were loaded at St. Louis in open gondola cars, and shipped to

Altoona, where they were unloaded by hand and stacked. They were handled a third time in taking them to the firing platform of the test locomotive. After these three handlings they were still in good condition, very few were broken, and the amount of dust and small particles was practically negligible.

Conclusions Reached

The results of the tests justify the following conclusions:

(a) The evaporation per pound of fuel is greater for the Lloydell coal briquets than for the same coal in its natural state. This advantage is maintained at all rates of evaporation.

(b) The capacity of the boiler is considerably increased by the use of coal briquets.

(c) The briquet process appears to have little effect in reducing the quantity of cinders and sparks; the calorific value of these, however, is not so high in the briquets as in the natural fuel.

(d) The density of the smoke with the coal briquets is much less than with the natural coal.

(e) The percentage of binder in the briquet has little influence on smoke density.

(f) The percentage of binder for the range tested appears to have little or no influence on the evaporative efficiency.

(g) The expense of the briquet process under the conditions of the experiments adds about $1 per ton to the price of the fuel, an amount which does not seem to be warranted by the resulting increase in evaporative efficiency.

(h) With careful firing, the briquets can be used at terminals with a considerable decrease in smoke.

(i) The briquets appear to withstand well exposure to the weather, and suffer little deterioration from handling.

Western-coal Briquets

In coöperation with the Missouri Pacific, the Lake Shore & Michigan Southern, the Michigan Central, the Chicago, Rock Island & Pacific, the Chicago, Burlington & Quincy, and the Chicago & Eastern Illinois railroads, 100 locomotive tests have been made by the United States Geological Survey to determine the value, as a locomotive fuel, of briquets made from a large number of Western coals. All tests were made on locomotives in actual service on the road. In some tests there was small opportunity for procuring elaborate data, but in others, where dynamometer cars were employed, it was possible to obtain more detailed results. The purpose which these tests were intended to serve was not so much to determine the evaporative efficiency of briquets as to investigate their behavior in practical use.

Briquets made from Arkansas semi-anthracite, two qualities of Indian Territory slack, Indian Territory screenings, Missouri slack, Indiana Brazil block slack, coke breeze, and a mixture of coke breeze and washed Illinois coal were tested, and comparisons were drawn either with the same coal that was used in the briquet or with coal similar to it. In nearly every test the results reported show that the coal when burned in the form of briquets gives a higher evaporative efficiency than when burned in the natural state.

For example, Indian Territory screenings give a boiler efficiency of 59 per cent., whereas briquets made from the same coal give an efficiency of 65 to 67 per cent. Decrease in smoke density, the elimination of objectionable clinkers, and an apparent decrease in the quantity of cinders and sparks are named as the chief reasons for this increased efficiency.

An Obscure Armature Trouble

By H. F. Rudolph

The following case of motor trouble caused much worry to the electrical force in an industrial plant and was finally brought to the attention of the writer, who found the cause of trouble more through accident than anything else. A 6-horsepower series-wound direct-current crane motor had a winding of a peculiar character; the coils, instead of being form-wound, were hand-wound directly in the slots and the winding was so arranged that the finishing end of the wire in each coil was connected to the bottom of the cummutator bar, after which the beginning end of the coil was brought through the slot and connected to the top of the commutator bar. The armature winding was wave-connected, with two brushes; the machine was a four-pole motor, and the brush holders were so located that the top connection from each of the armature slots led to the commutator bar directly opposite (Fig. 1). This motor burned off two or three end connections per week at the point x in the sketch and no amount of investigation supplied any clue to the cause of the trouble. A new armature was finally procured from the makers, which developed the same trouble, burning off four end connections the first week. The motor was not overloaded, and the field-magnet coils were not partly burned out, so the motor was kept going for some time by repairing the spare armature and changing armatures every few days. Finally the coils were all disconnected from the commutator and individually tested for grounds, short-circuits or loose connections, and a bar-to-bar test of the commutator was made with a 10,000-ohm magneto. No trouble being found, the armature was reconnected and put back in service; it burned off four leads the first day.

We gave up in despair and appealed to the manufacturers, who suggested that expansion and contraction of the wire might be the cause and suggested the change indicated in Fig. 2. The wires were cut at S and new pieces of a larger size spliced on and loops for expansion left at the commutator end. A band of twine was wound on next to the commutator and the armature replaced in the motor, where it promptly burned out six coils completely. The design of the winding was such that replacing six coils involved the complete rewinding of the armature.

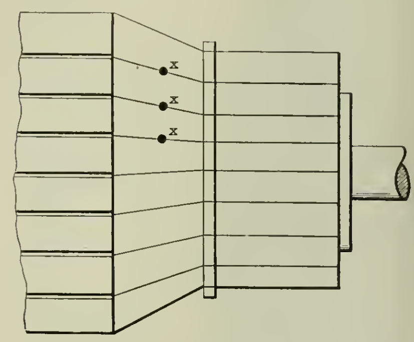


FIG. 1

This was done and before the commutator was replaced it was again tested for short-circuited bars, this time with 110 volts instead of the magneto. Upon the application of the current the mica at first smoked and finally became red hot, remaining so until the current was withdrawn. As all bars tested the same, new mica was placed in the commutator and the armature connected and put in service, where it remained for six months without a sign of trouble.

In the meantime the spare armature was tested and, the mica proving defective, new mica was inserted and the old armature coils reconnected. In order to satisfy ourselves that it was the new mica and not the new coils that cured the trouble, the armatures were again changed, but not a sign of trouble has been seen, although the old armature has been in service three months.

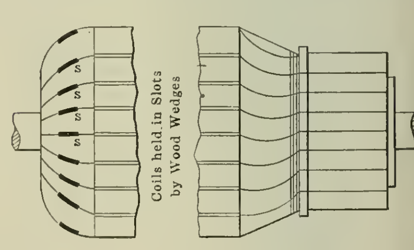


FIG. 2

The United States Civil Service Commission announces an examination on February 17 to secure eligibles for a vacancy in the position of engineer (competent to take care of a pumping plant, tank house, etc.) in the Indian service at Fort Berthold, North Dakota.

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Low Pressure Turbines and Steam Engines

The article in the January 5 issue, by J. R. Bibbins, states that "Professor Rateau's work in steel-mill and mine hoisting has also resulted in the practical application of low-pressure turbines in connection with the steam-regenerative principle, permitting the turbines to operate constantly, using the exhaust steam from engines intermittently operative. His work has been brought to our notice in this country by H. H. Wait in discussing regenerative application to steel mills. (American Institute of Electrical Engineers, December, 1907.)"

Mr. Bibbins' statement is undoubtedly correct as to his personal knowledge of the question, but I wish to say that I introduced Professor Rateau's steam-regenerative principle in America, and have been working to develop it since 1903.

In 1904, Professor Rateau himself presented to the American Society of Mechanical Engineers, at a meeting held in Chicago, a paper on "Different Applications of Steam Turbines." This paper fully described his regenerative system and gave illustrations of what had been done by him previous to his coming to America.

On September 21, 1904, I read a paper before the Western Society of Engineers, entitled, "Utilization of Exhaust Steam in Connection with Low-Pressure Steam Turbines," and in October, 1905, I also read a paper before the Lake Superior Mining Institute, entitled, "The Utilization of Exhaust Steam from Rolling Mill Engines, Hoisting Engines, etc., by Means of Steam Regenerators and Low Pressure Turbines on the Rateau System."

The International Harvester Company's plant described by Mr. Wait, in his paper before the American Institute of Electrical Engineers, was put up by the Rateau Steam Regenerator Company, which was the sole contractor for the entire equipment. This same company has also acted as sole contractor for the Vandergrift plant of the American Sheet and Tin Plate Company. These two plants are the only ones in America utilizing the steam-regenerative principle. They are also the only plants in this country where the exhaust of intermittent-running engines is compounded with low-pressure turbines.

Incidentally I should like to remark that two of the most complete and striking articles regarding the use of exhaust steam in low pressure turbines were published in POWER; one by F. G. Gasche, entitled, "First Rateau Regenerator Installed in America," and one by Professor Rateau in the issue of October, 1907, under the heading, "Compounding Piston Engines with Turbines."

I strongly agree with Mr. Bibbins when he mentions J. W. Kirkland in connection with low-pressure turbine work, as no one admires more than I do the splendid missionary work done by Mr. Kirkland on this subject.

L. BATTU.

President, Rateau Steam Regenerator Co.
New York City.

A Safety Stop

The stop shown in the accompanying illustration was made and put on by W. A. Bright, foreman of the Decatur Novelty Works, and is a neat little device. It is intended to take the place of the pin used on some Corliss-engine governors.

THE BRIGHT SAFETY STOP

The device is very simple and any engineer can make and attach one himself. The illustration shows three positions. The first is that in which the stop is placed just after closing the throttle and before the speed is much reduced. It will be noted that the lock is not directly under the end of the rod that comes down from the collar. As the rod drops the lock tumbles and allows the small lug to drop as shown in the second view. When the engine is again brought up to speed the rod rises, and the lock is pulled over to one side out of the way by the weighted end as shown in the third view. This leaves a clear path for the rod should anything happen to stop the governor.

[illegible]

Decatur, Ill.

Selection and Safety of Pipe Fittings

In the issue of December 15 there is an article on "Selection and Safety of Pipe Fittings," by A. J. Dixon, in which there appears to me to be a mistake. On page [illegible], in figuring the stress on the cap screws of the bonnet of the angle valve, he has added the stress due to tightening the cap screws to that of the steam pressure on the under side of the bonnet, which I do not think is correct.

Taking the figures given in his article, the total stress due to the steam pressure is [illegible] pounds, and that due to tightening cap screws [illegible] pounds, which he adds together to get the total stress.

The steam pressure can add no stress to the cap screws until it exceeds that due to the screwing down of the cap screws, as up to this point the two pressures are opposed and will be balanced when one is equal to the other. In this case the stress due to the steam pressure is greater than the initial stress on the cap screws, so that the stress added by the steam pressure would be only the difference between the two pressures, or a total of [illegible] due to the steam pressure only, or [illegible] pounds, a stress of [illegible] pounds for each screw instead of [illegible] pounds, as given in his article.

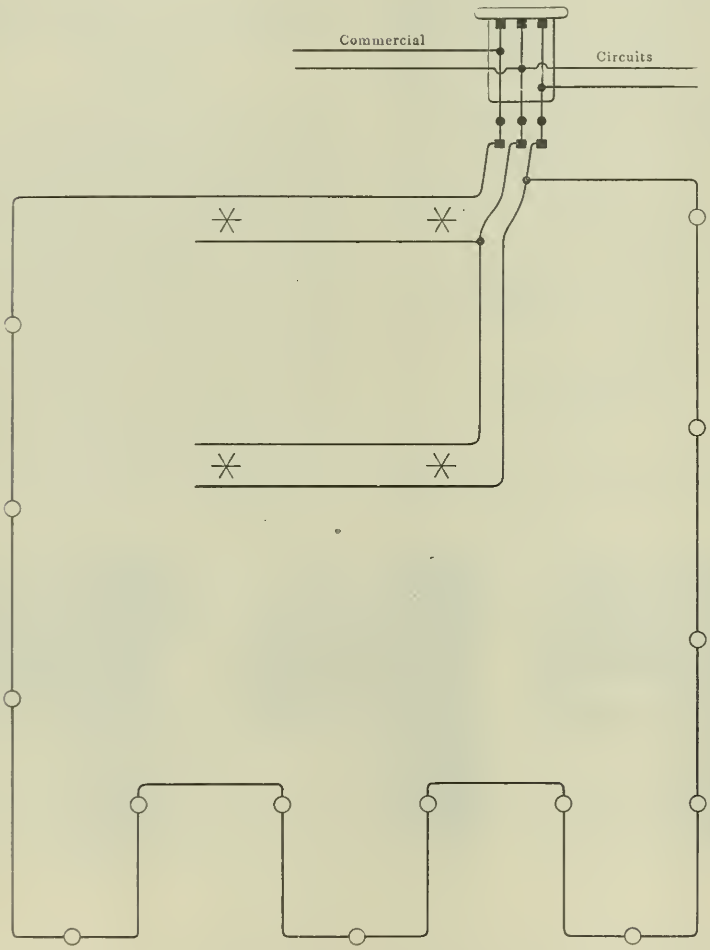
In a case where the initial stress due to screwing down the cap screws exceeded that due to the steam pressure there would be no additional stress on the screws upon admitting steam to the valve.

W. O. PERKINS.

Bristol, Conn.

A Lighting Problem

The accompanying sketch shows the proposed circuit-arrangement for a small country town which is going to be lighted from a larger town several miles away. The public square has a multiple-arc lamp at each corner, indicated by the crosses; the rest of the lamps, indicated by circles, are series tungsten incandescents, fourteen in number. The town being small, it is proposed to use a three-wire circuit and connect two of the arcs on each side of the neutral wire and the series lamps on a separate circuit. I suggested connecting them as shown in the diagram; as a time switch will be put in to handle the street lights, this will save a switch.



PROPOSED LIGHTING CIRCUIT

It is also proposed to run secondary circuits for commercial lighting, as in the diagram, instead of running three wires both ways.

I would be glad to have the opinion of some other readers as to how they would connect these circuits and run the commercial lines, and whether they think the diagram shows a feasible plan.

F. L. ROLPH.

Indianola, Ill.

Keeping Plant Records

Not very long ago the editors of POWER AND THE ENGINEER strongly urged the operating engineer to keep records from which to compute the cost of his plant output, but in the issue of December 8 they disparage the only means many of us have of keeping such records. While the criticisms in this latter editorial are doubtless well founded, it is nevertheless true that the periodical reading of switchboard instruments and the ordinary methods of measuring water and weighing coal can be made to give valuable results. Two years of experience with the methods under discussion have demonstrated to me that with careful readings and familiarity with the plant a reasonably close deduction can be made of the cost of output, even when elevator service, heating, etc., have to be taken into account. I have wished that some small-plant man would tell how he keeps his records, but perhaps they all think that without automatic recorders and special apparatus it would be useless to try to come anywhere near any useful figures.

We have no way of weighing the coal automatically; even the man who wanted to sell us a machine said it could not be installed owing to lack of head room. However, by many tests of the barrow capacity which are made at frequent intervals, I find that we get what we pay for in pounds, though not always in quality. As to the water, I have done nothing yet to verify the meter, but expect to do so before long. For obtaining an idea of the output, we have found reading the ammeter once an hour is often enough, as the load comes on gradually and remains at practically one point from 10:30 a.m. until 5 p.m., and then falls off gradually.

The voltage is kept constant and the load in amperes is put down each hour on a log sheet. The next morning I figure the total ampere-hours of the day's run. It is also noted on the sheet when engines are put on and taken off, so that the difference in their consumption of steam can be taken into account. The ampere-hours, the number of hours run, the kilowatt-hours and the percentage of the rated load made by the Corliss and the automatic engines are put down so as to be seen at a glance. The number of barrows of coal and ashes is also added and this completes the log sheet for one day. Saturday's sheet also shows all of the items for the week and the sheet for the last day of the month contains them for the whole month, as well as the coal delivered to the plant, the water (by ordinary meter) evaporated, and that used for blowing down and washing out the boilers and heater, the average tons of coal burned per day, the percentage of ashes to coal and the number of loads of ashes which we must pay to have removed.

From the records mentioned I figure how much of the coal, etc., must be charged to lights, and I do not think I am seriously out on the cost per kilowatt-hour.

Of course, by this system one cannot tell exactly the evaporation per pound of coal, but having the coal company's bill, the water bill, the supplies bill, the payroll and a good idea of the number of kilowatt-hours generated, I am able to tell very nearly what the costs are. Any engineer who has not tried it before will find keeping plant records more interesting than any other branch of his work.

A. N. BOGART.

New York City.

[We are glad to learn of Mr. Bogart's excellent work in the systematic keeping of plant records, and we admit, most cheerfully, that the methods under discussion *may* be made to yield fairly satisfactory results under the close supervision of a painstaking chief. Our experience, however, is that unless the supervision is exercised to a burdensome degree, records taken as described become slovenly and unreliable. However, our criticism was directed at the plant owners who fail to provide adequate facilities, not at the engineers, like Mr. Bogart, who do the best they can with what they have.—EDITORS.]

A Station Load Indicator

In an electric-light plant with which I am connected it is necessary for the engine-room force to know at all times the load on the station. For this purpose, there was formerly mounted on the switchboard-gallery railing a frame having card figures to indicate the load. As

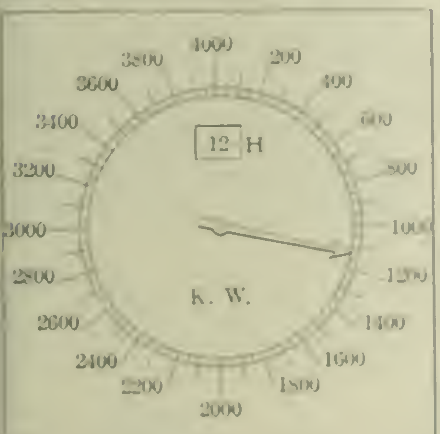


FIG. 1

FIG. 2

it was inconvenient for the switchboard operator to change the cards every half hour, I devised a dial indicator, as shown in the accompanying sketches. Fig. 1 is a face view and Fig. 2 a back view.

It consists of a piece of sheet iron 30 inches square, mounted on a light wooden frame. The dial scale and figures are painted white on a black background; the pointer is gilded. Across the back a strip *A* is fastened, leaving a space of about 2 inches between the strip and the sheet iron. Through the center of the strip *A* and the sheet iron is passed a short piece of 1/2-inch pipe just long enough to reach through with room for locknuts on each end to hold it in place. Through this pipe is passed a piece of 1/4-inch pipe, to one end of which is fastened the pointer. To the other end is fastened a short pointer *B* and handle *C*.

The short pointer works over a small dial similar to the large one on the front dial, and is used in setting the indicator; *D* is a tension washer to hold the pointer in place when set.

The hours from 1 to 12 are marked on a circular piece of sheet iron *E* which is fastened to a wooden hub and mounted on the pipe between the front sheet and the strip *A*. Through a hole *H*, in the front sheet, the hour figures can be seen, one at a time, the sheet being revolved to bring the various numbers into view.

The indicator is on the switchboard-gallery railing and is operated from the rear, as stated. It is quickly set and very easily seen from the engine-room floor below.

W. ROSSITER CARVER.

Indianapolis, Ind.

A New (?) Steam Gage

Under the heading announcing that subjects to be eligible for description in that department must be new or interesting, there appears in the department of POWER devoted to the description of power-plant machinery and appliances, in the issue of January 12, a description of an independent steam-gage movement. If there is anything new about this, the article fails entirely to bring it out. The movement mounted upon the base of the Bourdon spring and entirely disconnected with the casing has been a well known feature upon the market for a number of years and made by several makers. It is not at all evident why jar and vibration do not affect the accuracy or sensitiveness of such a gage as much as or more than that of the gage which is attached to the case. In fact, I think that experience with this class of gage has shown it to be more susceptible to jar, although it is, of course, free from distortion due to relative movements of the case and the spring.

T. B. AYRES.

Chicago, Ill.

Approximation of Terminal Pressure

The graphical method of working problems appeals to many engineers who have a very marked dislike for figures and formulas. The accompanying sketch shows a graphical method of getting a close approximation of the terminal pressure in an engine with any initial pressure and point of cutoff.

The rectangle *O P X L* is laid out to represent in length *O L* the stroke of the engine (plus the percentage of clearance, if more accurate results are desired). In hight *O P* represents the absolute initial pressure. The atmospheric line *E F* is drawn parallel to the vacuum line *O L* and at a distance above it equal to 14.7 or 15 pounds on the scale used, in this case a 40 scale.

Next, the diagonal *O X* is drawn, and from the line *P X* a vertical line is drawn from any point of the stroke at which it is desired to have cutoff take place. The distance between the diagonal and atmospheric lines measured with the given scale on the vertical lines will be found to be very close to the terminal pressure for that point of cutoff.

GRAPHICAL METHOD OF DETERMINING APPROXIMATION OF TERMINAL PRESSURE

In the sketch vertical lines are dropped at 1/4, 1/3, 1/2 and 3/4 stroke, and the distances between the arrow points indicate the respective terminal pressures for those points of cutoff.

In checking up the results mathematically consider the following example: Required terminal pressure in an engine with cutoff at 1/4 stroke, initial pressure 100 pounds gage and clearance 5 per cent of stroke size to keep the steam line well up. The absolute initial pressure will be 115 pounds, and as, theoretically, the pressure varies inversely as the volume, the terminal pressure will be in the neighborhood of $\frac{3}{8}$ of 115 or $43\frac{1}{8}$ pounds, or $28\frac{1}{8}$ pounds gage. The actual pressure in an engine at the end of the stroke will be less than the computed result, owing to the exhaust valve being open.

By plotting out the expansion curves for the different points of cutoff, it will be found that the power derived from an engine does not increase in proportion to the length of cutoff by any means, i.e., if cutoff takes place at $\frac{1}{4}$ stroke, and it is increased to $\frac{3}{4}$ stroke, the power derived will not be three times as much, although three times as much steam is being used than with the former cutoff.

This goes to show how important it is to steam users to secure engines that will carry the average load at an economical point of cutoff.

J. A. Carruthers.

Bankhead, Can.

Piston Repair

Not long ago one of the engines where I was employed gave signs of trouble inside the cylinder, and upon removing the head we found that a $\frac{1}{2}$-inch hexagon nut had got into the cylinder on the crank end, between the piston and the cylinder head, and the nut of the cast-steel piston

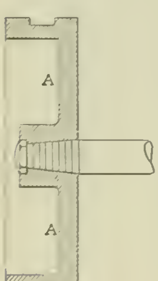


FIG. 1

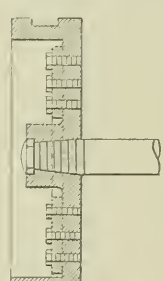


FIG. 2

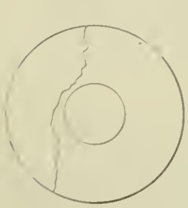


FIG. 3

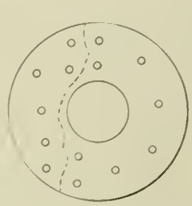


FIG. 4

of the type shown in Fig. 1 was cracked as shown in Fig. 2.

As we needed that particular engine the next morning, we at once got to work and procured a piece of $\frac{5}{8}$-inch steel plate which was cut and drilled in the shape shown in Fig. 3, fitted into the recess (*A*, Fig. 1) of the piston, and securely fastened in place with machine bolts, as shown in Fig. 4, the plate being drilled with a clearance drill and the threads cut in the piston.

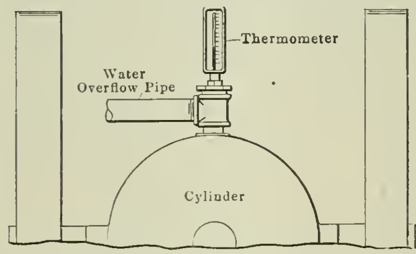
The engine was started the next morning and is running at the present time.

W. E. Chandler.

East Walpole, Mass.

Thermometer for Jacketing Water

One item gas engineers are prone to ignore is the amount of engine-jacketing water used. A scheme we adopted to decrease our water consumption was to



SHOWING LOCATION OF THERMOMETER

place thermometers on our outlet-water line just over the cylinders. Thus, we can watch the cylinder-water temperature and incidentally avoid turning too much water off.

We also placed a valve in the inlet pipe, having a pointer and index plate which, after experimenting, was marked at the proper point. We find that the engines work with the water temperature at about 140 degres Fahrenheit.

James Aylward.

Elyria, O.

Hydrostatics

On page 1051 of the December 22 issue, Mr. Livingston presents the results of some original investigations of the laws of hydrostatics. It is hardly necessary to state that there is a flaw somewhere in the experiment, for it would be contrary to all laws of hydraulics if the check valve were placed in equilibrium by equal unit pressures on unequal areas. Does Mr. Livingston know that the check valve was in equilibrium? Does he know that it moved off its seat? It would seem more probable that either there was a leak through the casting or that the water leaked through the valve seat.

If Mr. Livingston desires to be exact in figuring the pressures on the two sides of the valve, he should take the pressure on the top of the disk equal to the head shown, 5 feet 8 inches, less the hight of the disk, remembering that the pressure on the area taken by the stem is that of the head on the top of the stem, and not that on the valve seat, this also being true of the pressure on the stem on the under side of the disk.

W. L. Durand.

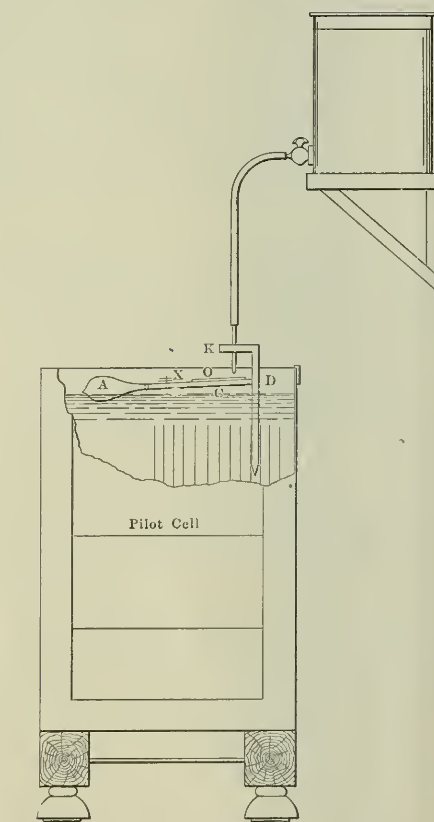
Brooklyn, N. Y.

Noncorrosive Float Valve

Difficulty has been experienced in attaining a standard hight of the electrolyte in pilot cells of storage-battery installations by corrosion of the movable joints of the float valve, causing sticking and failure to operate, the result being either a flooded cell, or no replacement for evaporation.

It is necessary with all pilot cells that the electrolyte be kept at a constant level so as not to deflect the specific gravity or the temperature readings. A sudden flooding of water would give a low reading by at least two points, for which no benefit of discharge or charge could be shown. By the condition of the pilot cell the standing of the entire battery is judged, both in charging and discharging. Therefore, the necessity of having a float valve which can be relied upon is readily seen.

The accompanying diagram gives an idea of how a noncorrosive float valve is constructed to meet all the requirements of a good cell filler. The materials used



CONSTRUCTION DETAILS OF FLOAT VALVE

are glass and hard and soft rubber. The glass float at *A* may be made out of an old 75-candlepower lamp, by first removing the metal base and sealing in the hard-rubber arm *C*. The counterbalance weights *X* are made of lead and placed as shown. The arm *C* moves on a hard-rubber pin inserted at *D*. The projection *K* is a hard-rubber holder for a glass tube, tapered at one end. A strip of soft rubber is fastened at *O* to close the opening in the glass tube when the water raises the float *A*. The storage tank for the water is placed about 2 feet above the cell. This style of float valve has been operating two years successfully.

MALCOLM C. SAEGER.

New York City.

Pressure Required to Lift a Check Valve

Mr. Helm, in his academic discussion of Mr. Pearce's valve-lifting problem, on page 201 of last week's issue, correctly says that his method of figuring by the difference in area between the top of the valve and of the seven holes in the seat "assumes that the valve cover makes perfect contact with its seat." In other words, he assumes that there is no pressure acting between the valve and the seat, in which case the pressure holding it to its seat should be reckoned from absolute zero, and not from atmospheric pressure.

The pressure on top of the valve, then, would be 115 pounds per square inch, approximately, and the pressure required to lift the valve by acting on the 5.5 square inches of the seven 1-inch holes,

$$\frac{115 \times 19.63 + 5}{5.5} = 410$$

pounds per square inch or 395 pounds, gage.

As a matter of fact, however, the valve does not make anything like a perfect contact with its seat. A pair of accurately ground surface plates, carefully manipulated, might approach that condition. The probability is that the pressure existing in the film of liquid under the valve is pretty nearly that of the fluid surrounding it, varying with the condition of the surfaces and the length of time they remain in contact.

J. H. McCARTHY.

Bethlehem, Penn.

I read R. S. Livingston's letter in the December 22 issue, entitled, "Pressure on Both Sides of a Valve Disk," in which he describes a simple experiment performed by himself several years ago, which seems to show that results obtained in practice do not agree with theories and figures, or that theories and figures have no place in design, as they give results which are not at all borne out in practice.

If, however, the problem is looked into more carefully it will be found that they do agree, and that when taken together, each one serves its purpose in making clear the truth which is oftentimes hidden, and requires the combination of theory and experiment in order to know the hidden law and, knowing it, one is able to use it in practical everyday life for the benefit of mankind.

The apparatus as shown in the form of a diagrammatic sketch on page 1051 consists essentially of a check valve having a rubber-disk clapper $2\frac{9}{16}$ inches in diameter which closes a passage having a diameter of $2\frac{1}{16}$ inches. The upper or back side of the valve is acted on by a column of water 5 feet 8 inches high which gives a pressure *P* of

$$5.66 \times 0.434 = 2.456$$

pounds per square inch above the valve which, acting on the area ($A = 5.157$ square inches) of the valve, gives a total force of

$$F = 2.456 \times 5.157 = 12.67$$

pounds tending to hold the valve on its seat.

This assumes that the valve disk or cover makes perfect contact with its seat, thus preventing the pressure of the fluid from acting on the under side of the clapper.

The area A_1 of the passage is 3.34 square inches, being 2.0625 inches in diameter, hence, the pressure p_1 per square inch on the front or under side of the valve necessary to cause equilibrium or to balance it will be

$$p_1 = 12.67 \div 3.34 = 3.8$$

pounds, which corresponds to a head of water of

$$3.8 \div 0.434 = 8.75$$

feet, or 105 inches above the valve seat which means that the water will rise, in the ½-inch pipe, to a hight of

$$105 - 68 = 37$$

inches, plus a small amount required to overcome the weight of the valve seat, before the valve will open and the water will begin to overflow from the large pipe.

The results of Mr. Livingston's experiment, which he chooses to call "practice," showed that the water actually rose to only ½ inch above the top of the large pipe when rubber and metal were in contact, and to only ¾ inch above, when the valve seat was coated with white lead and oil. In other words, the experiment showed that theory and figures gave a pressure approximately 33.5 per cent. (average of the two cases) higher than was actually required in the particular case under consideration. Mr. Livingston's diagram shows a rubber clapper without any metal backing, which allowed the pressure from above to force the central portion of the disk downward, thus making it concave toward the back and convex toward the front, which resulted in greatly reducing the area of the seat, which is clearly shown by the results of the test.

If Mr. Livingston or any other person desires to repeat the experiment and use every precaution to make very sure the valve seats properly, thus obtaining in practice the actual test [illegible] which is assumed to obtain, and upon which the theoretical figures are based, he will find that theory and practice are not at variance, but are true friends, each one acting as an aid to the other.

F. C. HELM.

Schenectady, N. Y.

Throwing Lamps in Series and in Parallel

On page 71 of the January 5 issue, E. J. Williams asks for a diagram showing connections to throw three lamps from

MR. [illegible]'S SKETCH

parallel to series and vice versa. The accompanying sketch shows a method using two single-pole, single-throw switches which, on closing, will put the lamps in parallel and on opening, puts them in series.

[illegible]

Brooklyn, N. Y.

The first of the two diagrams herewith submitted shows one method of meeting the requirements of Mr. Williams. With

FIG. 1

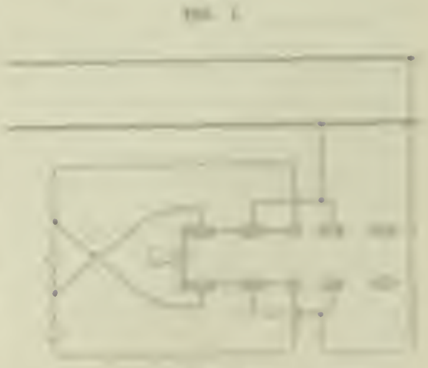


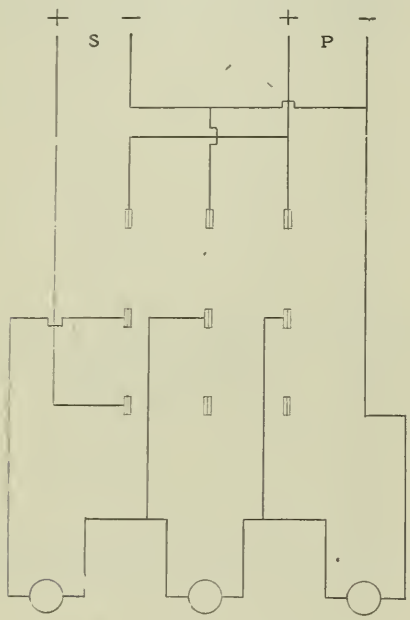
FIG. 2

the double-pole switch closed, as [illegible], the three lamps will be connected in parallel to the supply circuit. When the switch open they will be in series. This method, however, would make it necessary to use another switch to extinguish the lamps. On this account the arrangement indicated in Fig. 2 is preferable. A double-throw double-pole switch is used; closed to the left, as here represented, it will connect the lamps in parallel; closed to the right it will put them in circuit in series, and when open, the lamps will be entirely disconnected from the circuit.

George W. Malcolm.

Brooklyn, N. Y.

Connect a triple-pole double-throw switch as shown in the accompanying diagram, in which *S* is the series circuit and *P* the parallel circuit. With the switch



MR. ATWOOD'S SOLUTION

in the lower position the lamps are in series; with it in the upper position the lamps are in parallel.

E. M. Atwood.

Lawrence, Mass.

Interesting Diagrams from a Dry Vacuum Pump

The accompanying diagrams were taken from a dry-vacuum pump driven by a cross-compound Corliss engine. Each engine piston rod extends through the head-end cylinder cover, and connects to an air-pump piston. The steam cylinders are 18 and 30 by 30 inches; the air cylinders, 40x30 inches. Four barometric condensers, of a total capacity of 10,000 horse-power, are connected by suitable air pipes to this pump, which was installed to take the place of a number of smaller dry-air pumps.

At the time these diagrams were taken, the outfit had been running quite a while, but had never been indicated. The governor was not in operation, the speed being controlled by throttling, as will be seen by an inspection of the "before adjusting" diagram, Fig. 1.

Through carelessness on the part of the erector, one of the low-pressure exhaust valves had been put in upside down. The governor was connected, and a few changes in the valve gear resulted in the steam distribution shown "after adjusting," Fig. 2.

The valves of the air cylinders are of the Corliss type, positively driven, and as

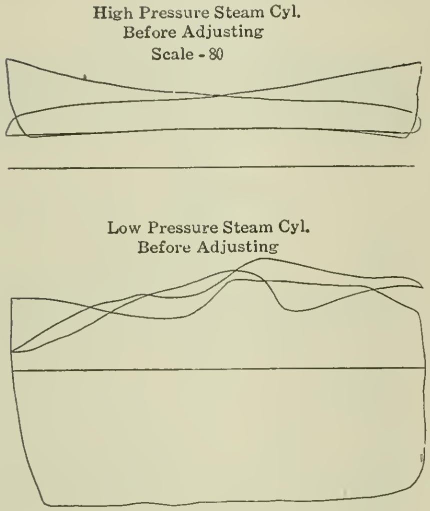


FIG. 1

set by the erecting engineer gave diagrams as shown by Fig. 3. By changing the eccentrics driving these valves and making some alterations in the lengths of the valve rods, the diagrams, "after adjusting," Fig. 4, were obtained.

This air pump is provided with a rotary valve which, at the end of each stroke, opens a passage between the two ends of the cylinder. The air in the clearance space, at a little more than atmospheric pressure, is then permitted to expand into

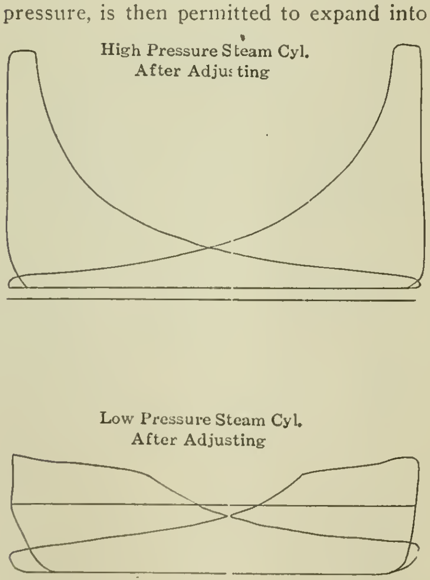


FIG. 2

the other end, where it may be forced out on the next stroke. The point in the stroke where this valve closes is clearly indicated at *A*, Fig. 4.

Although every precaution is taken to separate the air from the water before it leaves the condensers, a great deal of trouble is experienced with water entering the air-pump cylinders. The air coming from the condensers is passed through a baffle-plate separating arrangement and before entering the pump, it is passed through a large drum, which is intended to act as a separator for any water that

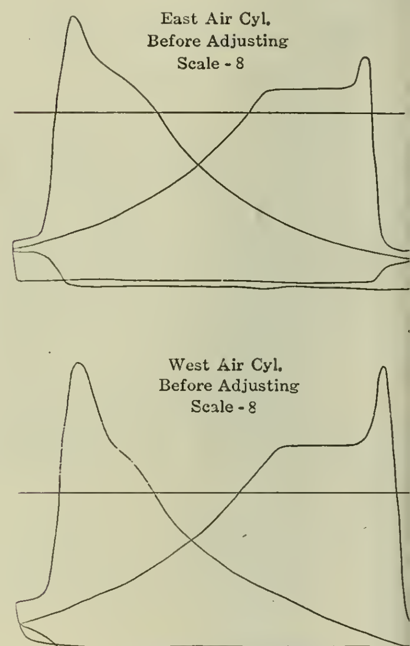


FIG. 3

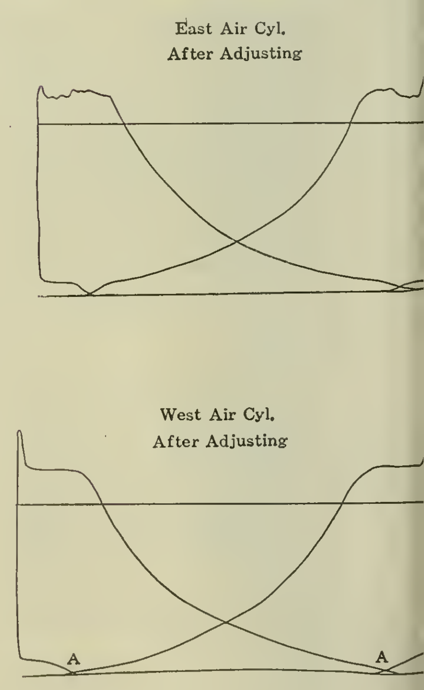


FIG. 4

may be carried over from the condensers. Yet water is being continually forced out of the relief valves, and it is necessary to run quite slowly to avoid danger of wrecking the pump.

A. L. Westcott.

Columbia, Mo.

Repairing a Valve Rod Stuffing Box

The accompanying illustrations show how a quick repair was made to the valve rod stuffing box on an indirect piston-valve engine. The exhaust pipe filled with condensation one night and the assistant started up the next morning without opening the drain on the pipe, which resulted in a broken gland at *A*, Fig. 1.

We removed the cap screws and replaced them with long studs, as shown in Fig. 2. The brass gland was held in place with a strip of wood, with nuts as washers instead of the screwed gland. There was only room enough for two turns of soft packing, yet it held so well that we replaced the wood strip with a cast-iron gland of the ordinary pattern, and drilled two extra holes in the head for gland studs.

George C. Jameson.

Buffalo, N. Y.

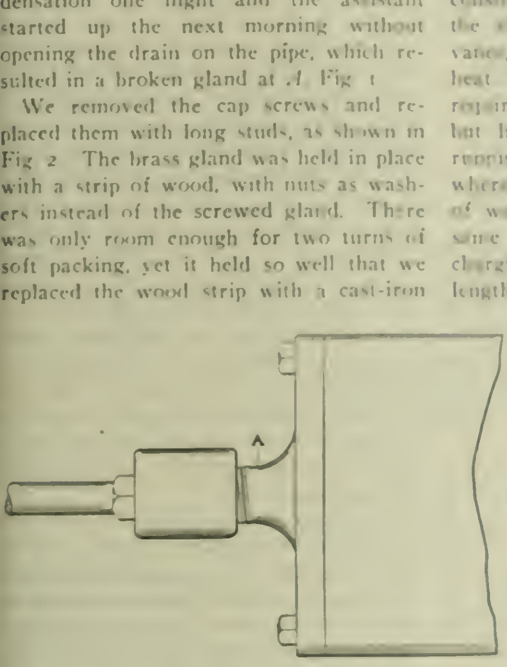


FIG. 1

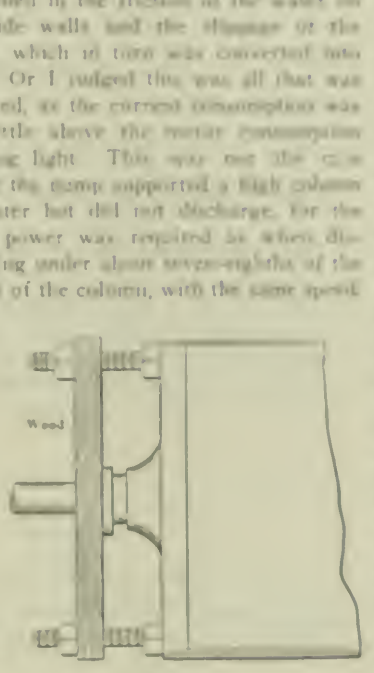


FIG. 2

Power Consumed in Centrifugal Pumps

I have noted frequent discussion in reference to the power consumed in centrifugal pumps when working under heads sufficient to prevent discharge, and under a closed discharge, and beg to offer some practical experience I have had.

Last year I had from one to twenty-five pumps, of all capacities, under my care, most of them working a 24-hour shift, and operated by an automatic device controlled by the rise and fall of the water in the building excavations, etc., which were being pumped.

Before the present automatic device was perfected various devices were used to control the discharge according to the supply, which varied greatly with tides, etc.

It may sound peculiar, but of the three methods where frequent stopping and starting were generally necessary, it was found most economical to allow the motor to run continually and close the discharge by a float, in preference to starting and stopping under the usual head or by use of a sliding resistance in series with the motor. The rank of the three methods in economy was as follows: Closing the discharge entirely; sliding resistance or variation of speed, and intermittent starting and stopping.

I noted that in pumps where either the suction or discharge was choked near the pump the only power required was that consumed in the friction of the water on the side walls and the slippage of the vanes, which in turn was converted into heat. Or I judged this was all that was required, as the current consumption was but little above the motor consumption running light. This was not the case where the pump supported a high column of water but did not discharge, for the same power was required as when discharging under about seven-eighths of the length of the column, with the same speed.

A specific case was that of a 2-inch pump working under an 85-foot head, with 7 feet for the suction. I had some difficulty in making it keep primed when running, for when at rest the weight of the column forced the packing out. In order to watch the action of the gland a vacuum gage was put on the suction, and a gate valve on the discharge pipe. When the gate valve was closed close to the pump, the current consumption of the motor was reduced and the vacuum dropped to from 8 to 10 inches or just sufficient to support the column of water in the suction pipe, and the pump soon became very hot. If the speed was insufficient to discharge in cases where the gate valve was open, the motor took about the same power as when discharging fully under seven-eighths of the head. I took many readings and obtained much data at the time, but unfortunately they were destroyed in a fire.

I came to the following conclusions: Pumps working under a closed discharge require only sufficient power to overcome the friction of water in the pump, support the column in the suction and overcome the loss in the bearings.

Pumps working against a column of water without discharge required the power necessary to overcome the friction of the water in the pump and bearings to support the column of water in the suction and discharge.

Pumps when working under full discharge followed very closely the law: Power required is proportional to the square of the speed and directly as the head. I also found that the [illegible] pumps [illegible] most economical when discharging at a velocity equal to eight times the square root of the head.

E. H. [illegible]

Berkeley, Cal.

Effect of Scale in Boilers

F. [illegible] McWilliams, in his letter in the December 8 issue, asks for information.

He says that many tell us that $\frac{1}{16}$ inch of scale will cause a loss of from 12 to 15 per cent. in fuel, depending on the character of the scale. While this is true to a certain extent, it is a difficult proposition to determine to just what extent the efficiency of a boiler is lowered by a deposit of scale on the plates and tubes.

There are a number of things to be taken into consideration in calculating the effect of scale in boilers, not only the character of the scale, but the thickness as well, and also the nonconductivity and the difference of temperature between the inside and outside surfaces of the boiler shell.

I have seen scale not over $\frac{1}{16}$ inch in thickness in boilers that, by actual test, showed a drop in efficiency of over 20 per cent. On the other hand, I have seen ½ inch of scale on the boiler shell and the ends of the tubes practically matted together, with the efficiency of the boiler impaired so little that it was hardly susceptible of calculation.

I have frequently seen carbonate of lime ½ inch in thickness, with very little injury done to the boiler and with very slight loss in efficiency. Alone it seldom produces a hard scale, but more often has a tendency to collect in large porous lumps or masses, in which case it is more liable to produce overheating and consequent burning of the sheets where so collected, than to lessen the efficiency of the boiler.

This scale can usually be washed out very thoroughly with a hose or by frequent blowing down of the boiler, unless there had been the presence of a lot of iron in the feed water, in which case the carbonate of lime will sometimes combine with it and produce a scale of varying degrees of hardness, depending on the amount of iron present. It is very seldom that carbonate of lime and oxides of iron are found in the same water in great quantities.

Entirely unlike carbonate of lime, the sulphate, or gypsum, has a hard, flint-like consistency, is moreover a nonconductor and one of the most detrimental of mineral substances. A very thin layer of this deposit is sure to bring about serious injury to the boiler unless treated very frequently with soda ash. Tannin is also very effective in precipitating sulphate of lime deposits, as is also caustic soda, but the simple soda ash is usually conceded to be about the best solvent for this form of scale.

Among the other common enemies of the boiler might be mentioned the carbonates and chlorides of magnesia, oxide of magnesia, silica and clay substances. Of these latter the chloride of magnesia is the most objectionable. At a temperature of 290 or 295 degrees Fahrenheit it will begin to give up free hydrochloric acid, due to decomposition, and as the temperature increases to near 298 degrees this liberated hydrochloric acid combines with the oxide of iron, continually forming on the surface of the boiler shell, with the result that the plates are corroded and pitted.

Deposits in boilers due to grease and oils in the feed water are also sources of great annoyance and danger, as a very thin film of this substance, while soft and apparently porous, forms a most perfect nonconductor, prevents the water from coming in contact with the plates, and is almost certain to bring about overheated sheets and tubes, with the attendant disastrous consequences.

Mr. Williams further asks: "If the loss with $\frac{1}{16}$ inch of scale is so great, it would be interesting to know where this heat goes to. Does the boiler setting absorb more heat than it would otherwise, or is the loss entirely accounted for by a rise in the temperature of the escaping gases?" To the first I would reply, not at all; to the latter, not entirely, but possibly to some extent.

We all know that the degree of heat transmitted from the furnace to the water in the boiler depends upon the conductivity of the intervening metal, and it is also known that the water cannot be heated to a higher temperature than is equal to a corresponding pressure of the steam.

Let us consider steam at 100 pounds, absolute pressure, the corresponding temperature of which is 327.9 degrees. It is impossible to increase the temperature of the water above this without increasing the steam pressure.

With a boiler plate free of scale, with the water in perfect contact with it, it is impossible to heat the plates much higher than the temperature of the water, or 327.9 degrees at 100 pounds pressure, a temperature which any plate will stand without any injury whatever.

Suppose the plates are coated with a thick deposit of nonconducting material, thoroughly insulating the water from them, then it is evident that the temperature on the different sides of the plates cannot equalize as formerly, one counteracting the other, thus permitting the plate to reach a higher temperature than the water in the boiler and the consequent overheating of the plate until it may reach a cherry red, depending upon the thickness, quality and nonconducting properties of the scale. This, then, explains where the heat goes, not in the brick setting of the boiler, nor all in the escaping gases, but the greater part is absorbed by the plates, which accounts for their rise in temperature. If the plates did not take up or absorb what the water loses, there would never be any danger of overheating due to the presence of scale in the boiler.

J. L. Bradshaw.

Memphis, Tenn.

Low Compression Saves Coal

I used to be ashamed to send my indicator diagrams for engineers to criticize, but when I saw a set of diagrams from a cross-compound engine which M. E. Copley praises as evidence of the only way to set valves to save coal, I thought they resembled a pair of Chinaman's shoes

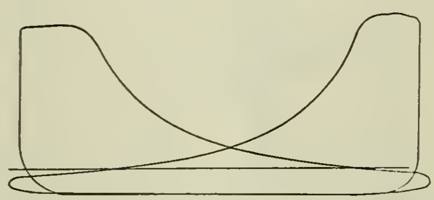


FIG. 1

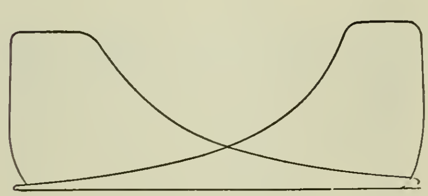


FIG. 2

after having been worn over the Texas border on the way to Uncle Sam.

Mr. Copley says that slight compression saves coal. Perhaps it does, but the valve setting on his compound engines does not seem to me to be the best for the coal pile. Readers who know about indicator diagrams can see that the exhaust valves do not get open until the piston has traveled over half stroke. Steam on the one side of the piston is pushing the piston ahead and the piston is pushing the steam out through the exhaust port.

What good is a condenser to an engine with such valve setting? If an engineer wants to get the benefit of the condenser he should set the valves so the exhaust will open before the piston reaches the end of the stroke and close as late as possible.

I inclose a set of diagrams from an old Corliss engine in service since 1872. In summer I run condensing, as the diagram, Fig. 1, shows. With this valve setting the engine runs on $2\frac{6}{10}$ pounds of coal per horsepower-hour. The diagram, Fig. 2, shows the valve setting for winter, as we use the exhaust steam for heating with the Paul system.

M. E. Cunningham.

Waterbury, Conn.

Grease Lubrication of Governor Pins

I use grease successfully in the lubrication of the governor pins of four Westinghouse compound noncondensing engines under my charge. This I consider a difficult lubricating proposition, as the weight on the bearing and journal is heavy and the motion, instead of being one of continuous rotation, is an oscillation through a short arc, only. The engines are direct-connected to 114-volt direct-current generators, delivering current for forming and charging storage batteries in the process of manufacture, and for laboratory purposes. For this work the requirements as to constancy of voltage are very exacting, and the matter of close speed regulation is therefore of unusual importance.

The plant consists of two 18 and 30 by 16-inch 350-horsepower engines, each direct-connected to a 2000-ampere eight-pole generator, and three 12 and 20 by 12-inch 150-horsepower engines, each direct-connected to an 800-ampere six-pole generator. These engines run at 150 pounds steam pressure and are operated for thirteen consecutive shifts through the week—two shifts each 24 hours for six days in the week, Tuesday to Sunday, inclusive, and one shift on Monday.

The governor pin of one of the larger units is lubricated by oil, from a regular Westinghouse center oiler, which consumes 2½ to 3 gallons of oil per week of thirteen shifts. The governor pins of the other 350 horsepower engine and the three 150-horsepower engines are lubricated with an A No. 1 grease, and consume 4 to 6 ounces of lubricant per week of thirteen shifts.

The lubrication by grease is accomplished as follows: The governor mechanism is of the Westinghouse high-speed engine type. The governor pin, which is 3½ inches in diameter and 12 inches long on the larger engines and 2x12 on the smaller, runs in a brass bushing which is carried on a radial extension of the flywheel hub. Fixed to one end of this pin is the lever carrying at its ends the two governor weights, aggregating 1000 pounds. In the operation of the governor, the pin oscillates through a maximum arc of about ¾ inch, between light load and full load on the engine. The movement of the pin in the bushing is therefore relatively small. At the same time the importance of safe and effective lubrication is very great. Any least liability of "sticking" would condemn the lubricant causing it, for it would result in impairment of the governor action, which would not be tolerated in these engines, operating under the stated exacting conditions, to say nothing of the risk of racing, with its attendant danger of bursting flywheels.

The grease is applied by means of two ordinary hand-feed spring-tension cups, set in ½-inch tapped holes in the bushing. These holes meet a half-round groove of ⅛-inch radius scored on the inside or bearing surface of the bushing, and running to within ⅛ inch of the ends. This (top) groove is thus fed direct by the two grease cups; and two similar horizontal grooves, spaced at 60 degrees from the top groove, are fed from the latter by several diagonal grooves, which serve also further to distribute the lubricant over the journal.

This arrangement answers well and for nine years has proved the effectiveness of grease for governor-pin lubrication. The cups are filled once a week, and the lubricant is not fed into the bearing by screwing down the plungers of the cup, but is allowed to flow naturally. The cups, once filled, require no further attention during the thirteen consecutive shifts and there is neither waste nor lack of lubricant.

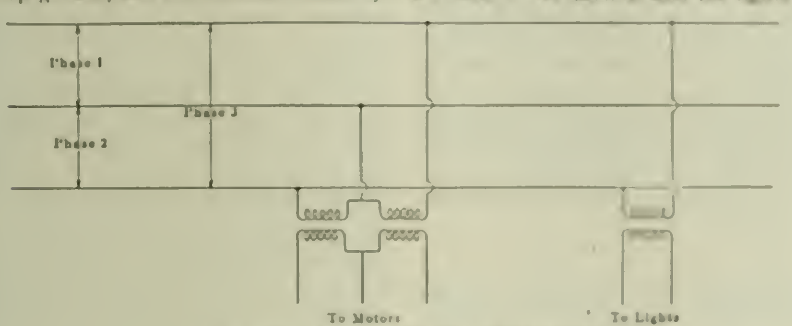
Although this and other experience going to show the success of grease lubrication and its economy, as compared with oil, make me an advocate of grease as a lubricant, I am ready to concede that there are places where oil must be used. Thus, in these same Westinghouse engines the lubrication of the main eccentric rod and its appurtenances is effected by oil fed at the top of the rod and shaken down by the oscillation to the bearing surfaces below. Here, of course, grease would not serve. But aside from such special cases, in the writer's opinion, since the lubrication of any moving part of a machine is really a greasing, it is better to use good grease to begin with. The value of oil as a lubricant resides in its permanent greasiness, while its other qualities tend to waste and to mess.

In conclusion, I wish to state that the engine room in which grease is used for this work, as described, is an unusually hot one, the temperature registering [illegible] degrees Fahrenheit for seven months in the year.

Frank Mellon,
Chief Engineer, Electric Storage Battery Company.
Philadelphia, Penn.

Transformer Connections

I submit the accompanying diagram and the following for criticism. Two transformers are connected in open delta on a three-phase line supplying current to three-phase induction motors, and a single-phase transformer is connected to one leg for lighting. If the power transformers are connected to phases 1 and 2 should not the lighting transformer be connected to phase 3? How will this affect the regulation of the system? The motors are used in the daytime and the lights are then turned off; at night the lights are on and the motors are out of service.



MR. CARROLL'S TRANSFORMER CONNECTIONS

R. S. Carroll.
Portland, Ore.

Reversed Polarity

The trouble caused by the reversing of the polarity of one of the generators operating a three-wire system, which Mr. Young gave an interesting account of in the number of December 22, could be caused in a number of different ways. In this case, however, it was probably due to weak residual magnetism, allowing the machine to build up in the reverse direction. This is often noticeable on generators having a magnetic circuit of very soft iron. I have also known of the polarity being reversed by a sharp heavy shock on or near the machine when repairs are going on. A momentary current from some outside source flowing through the field coils in the wrong direction while the machine is at rest often causes the same result.

The reason that the outside 220-volt wires gave no indication of voltage was because they were of the same polarity, the central or neutral wire then carrying the current formerly carried by the two outside wires, instead of the small balancing current which it is supposed to carry. If a load had been put on with this arrangement it would have been practically impossible to keep the voltage normal, owing to the excessive drop in the neutral wire.

When Mr. Young reversed the series field connections he made a bad matter worse, owing to the fact that as the machine began to generate it would cause the residual magnetism to become still weaker. After the brush connections had been reversed the current flowing in the series fields with a load would naturally tend to lower the magnetic flux through the armature, instead of increasing it, thereby causing the drop in potential as the load came on. If the brush connections had been changed in the first place no other alteration would have been needed.

It very often happens that connections cannot be easily changed, or if changed, would materially injure the appearance of the apparatus. In such cases, and in fact nearly every case where direct current can be obtained at the proper voltage, the writer favors magnetizing the fields from this outside source, so as to cause the polarity to stand as it should for proper operation. It is a good idea to have a pilot light connected across the two outside 220-volt wires and located either on the switchboard or, better still, near the generator set, where the operator can see it and when starting whether or not the polarity is reversed. He could then immediately remedy the trouble and not keep customers waiting for light or motive power.

Frank X. Bliss.
Bennington, N. H.

Card Indexing

Having preserved my copies of Power, as well as those of several other technical magazines, I began some time ago to look for some method of indexing the matter contained in them.

The separate issues were punched with five holes, about ½ inch from the back, and dividing the year's issues into two volumes, a dark paper cover was made for each, after which a shoe lace was run through the holes, binding all tightly together.

For the indexing, a form of card index is prepared. Matter is divided into main heads, such as Steam, Electricity, Hydraulics, Gas, etc. Under these heads come subdivisions, as Types (under which are listed the articles describing particular installations in different parts of the country), Operating, Repairing, etc.

These cards and combinations may be arranged in any way the user thinks best, but I have found the foregoing very convenient. One need not have a separate card for every article, for any number of articles bearing on one particular subject may be noted on one card, together with notes giving a short outline of the article in question. This last feature is where the card index surpasses the regular index furnished, as it is sometimes difficult to tell from the title of an article just what may be published in it, but a few notes on the card will show the gist at a glance.

William H. [illegible]
Berkeley, Cal.

Water Evaporated per Pound of Coal

Under the above caption appears a very interesting letter by E. E. Edwards, on page 1052 of the December 22 number. If Mr. Edwards will make a test of his coal he will very likely find that it is much higher in heating value than his boiler trial indicated, and that the trouble is more apt to be in the boiler and furnace, in the form of air leaks, poor circulation and faulty boiler setting.

If he would take a sample of his flue gases and have them analyzed he would doubtless be surprised at the results.

C. T. McKnight.

San Antonio, Tex.

Cement Roofing

In many cases cheap roof construction is used, which in the end proves very expensive. I caused to be placed on a roof about 30 squares of corrugated iron that did not last quite a year. Before it had become entirely unserviceable, I repaired it with a permanent, and what I consider the best, roofing that can be used. I stretched over the entire roof a 2-inch mesh poultry wire, and with a trowel spread cement about ¾ inch thick; by troweling the cement when in a plastic condition it entirely enveloped the wire.

No crack nor check appears in the roof, which has 4x12-foot spans, although the iron has nearly disappeared. In testing this roof, several men at a time have walked over it, and it showed no weakness. It is fireproof, and will practically last for all time. But the most interesting fact about this cement roof is the cost, about $2 per square, buying the wire and cement at retail. I used three parts sand and two parts cement.

Arthur Seymour.

Linton, Ind.

Steam Gages and Indicator Springs

One night while indicating our engines we noticed an unusual drop in pressure between the boilers and engines. The gage at the boilers showed 100 pounds pressure, while the indicator on No. 1 engine showed an initial pressure of 74 pounds, a difference of 26 pounds. No. 2 indicator on No. 2 engine showed a drop of 20 pounds, although 20 feet farther from the boilers than engine No. 1. There is no apparent reason for such a drop, as the pipes are short and of ample size and have straightway valves.

To locate the trouble we put No. 1 indicator on one of the gage connections to the boilers. With the same spring, and the same gage pressure, 100 pounds, the indicator showed 82 pounds, a difference of 18 pounds. We then tried No. 2 indicator in the same way. This gave us 90 pounds. A 50 spring was used in both cases. We next tried No. 1 indicator with a No. 60 spring and got a reading of 90 pounds, the gage still showing 100 pounds pressure. The last two readings being alike, the No. 50 spring in No. 1 indicator must be 8 pounds heavy, and the steam gage 10 pounds light, if the two springs are correct.

The steam gage was tested six months ago. The indicator springs are also practically new, and of a well-known make. The difference in this case is in favor of the boilers, but in many others it may be otherwise.

The question is, how long may we expect springs to retain their accuracy and steam gages to remain correct?

W. J. Wilkinson.

North Bay, Ont.

Development of the High Speed Engine

I think Frank H. Ball, in his lecture before the Modern Science Club, as quoted in the January 19 number, is "off" in some of his historical statements. He credits Mr. Porter as having shown a high-speed engine at the Paris exposition in 1875. There was no 1875 Paris exposition. Mr. Porter exhibited a high-speed engine in the London exhibition in 1862, which, though not as high-speed as his later ones, was fast enough to astound the English builders, and at the Paris exhibition he exhibited three, one, I think, about 12x24-inch, which ran at 200 or 250 revolutions per minute, and a 6x12-inch engine which he thought to run at 1000 revolutions per minute, if I remember correctly, and which he did run, I believe, at 600 or 700 revolutions per minute. The third engine was a complete 6x12-inch engine with one-quarter of the cylinder cut out to show the construction and action of the valves and valve motion.

As to the Armington & Sims people building the first single-valve shaft governor, I do not think they started in business until the early eighties; while the first Straight-line engine was built in 1871, and the second built at Cornell in 1875, and exhibited at the Centennial in 1876.

J. C. Hoadley had built shaft-governor single-valve portable engines before, but they were not, as far as I know, introduced in regular horizontal engines before Mr. Hoadley went out of business.

Though Mr. Sims was a Hoadley man, when the Armstrong & Sims engine came out it could not be said to be a continuation of the Hoadley design, being different in all essential features.

John E. Sweet.

Syracuse, N. Y.

Culm and Coal Dust for Fuel

In Mr. Jeter's article on "Culm and Coal Dust for Fuel," published recently, there are several statements that are not borne out by the experience of some us who have experimented with briquets. He states that a ton of briquets made from anthracite dust equals three tons of best anthracite, as proved by a number of tests.

The best anthracite to my knowledge comes from Colorado. According to Kent, the approximate analysis of the best quality of Gunnison county coal is as follows: Moisture, 2 per cent.; volatile matter, 2.5 per cent.; fixed carbon, 91.9 per cent., and ash, 3.6 per cent. This would give a heating value of 14,100 B.t.u. per pound of coal. According to Mr. Jeter's figures, a ton of briquets would develop 42,300 B.t.u., to attain which would require the consumption of one-half hydrogen by weight, or by volumes 12 parts hydrogen to one of carbon.

The first briquets of my acquaintance were made from Carterville (Ill.) washed slack. There was little difference in the burning qualities between them and the egg coal from the same district. The smoke was no greater and the ash slightly less. In my young days I believed the nearer the boiler was to the fire, the better it would steam. This is undoubtedly true with anthracite or wood, but it is a great mistake with soft coal, and the lower the ratio between the volatile matter and fixed carbon, the farther the grate should be from the shell of the boiler. My last venture was to set the grates 48 inches from the boiler (for Belleville, Ill., screenings), and my next one will be 54 or 60 inches. In the last case the ratio of volatile matter to fixed carbon was about 1 : 1 and the amount of soot generated was quite small.

I believe that anthracite culm washed and briqueted can be made the ideal fuel. The ash-forming ingredients and sulphur, if present, can be removed in great part by washing and a pitch binder will furnish enough hydrocarbons that the resulting briquets will approach the semi-bituminous coals of Maryland, West Virginia and Arkansas in composition and heating qualities. As anthracite does not usually exceed 10 per cent. in ash, and pitch has none, the briquets should be an improvement on the general run of commercial coal in that respect. They will need ample room for combustion of the volatile matter and must be fired as bituminous coal is fired, and when properly handled, produce no more soot or smoke than George's creek or Pocahontas coals.

LeRoy Baker.

St. Louis, Mo.

A uniform boiler-construction law for the Dominion of Canada is being agitated, with a bright prospect of its adoption.

Some Useful Lessons of Limewater

Various Practical Experiments for the Boiler Room, Which Will Add to the Furnaceman's Knowledge and Increase His Efficiency

BY CHARLES S. PALMER

Mr. Furnaceman, this is for you. You are sitting on that barrel of lime that has been rolled into your boiler room, waiting for the masons to put on that addition to the mill. But you are not thinking of the mill; what is bothering you is the trouble with the water, and that scale that will get onto the boiler tubes. The water looks all right, and there is the heater in the corner which does take out some of the stuff that makes the scale; while up on your shelf are those samples of boiler compounds that the salesmen left for you to try; and sometimes they work, and just as often they don't, and you are at your wit's end. Now, you may not believe it, but you can do a bit of study and thinking right down here in this dusty place—thinking and doing, too—that will help you to get onto your job a little better. Try it; it will not do any harm, and it may put you on your feet as you have never stood before. It may help you to understand your work better, and no man is doing right by himself or his business unless he knows how to do the thinking that goes along with his special work. Some of the best and most skilled workmen wear plain clothes, and the hints that will be contained in these articles may put a dollar or two in your pocket.

Do you know that you are *sitting* on your opportunity? Do you realize that that barrel of lime has some secrets that it will pay you to know about? There is a whole college course of practical chemistry right under you, waiting only for you to take hold of it and use it in your daily work and thinking. It isn't merely a matter of muscle that makes the difference between a low-paid and a high-paid man. There isn't anyone who is holding you back, except one man, and he certainly has got it in for you. That man is the chap that walks under your hat. Did you ever think of that? Then take a brace—a good hard brace—and let us help you to do some commonsense study right down here in the boiler room. It can't hurt, and ten to one it will show you something that you can use to help the man who pays your wages, and to help you to command more pay. So, take right hold, here and now, and tell us if we talk over your head, for we want you to learn something to your advantage. Once you get started, you'll find it easy.

You may get the apparatus and chemicals which you will want in these help lessons from your druggist; and for every dollar you put out now on this furnace-room laboratory, to use right down by your boiler, you will get a return some time that will pay you back ten to one; not only in the mental satisfaction of knowing your work better, not only for your being able to hold your head higher from knowing what others know and are learning with you, but certainly, for the better position and pay that you

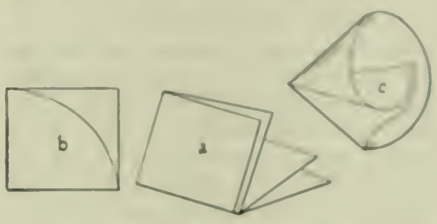


FIG. 1

can command in the long run, and perhaps in the short run. If it should happen that your druggist cannot supply you, the materials may be obtained from Eimer & Amend, 205 Third avenue, New York City, or E. H. Sargent & Co., 143 and 145 Lake street, Chicago, Ill. The former will charge $2 for them all packed ready to ship, and the latter will deliver them to the nearest railroad station for $3.00.

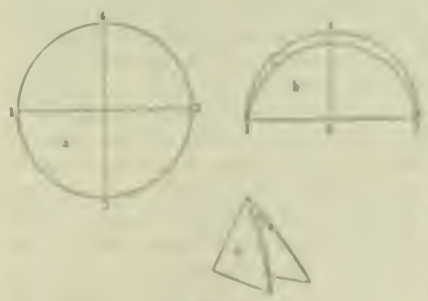


FIG. 2

Following is the list of materials required:

- 1 plain-glass pinch funnel, with long stem.
- 1 corrugated or grooved-glass 2-inch funnel.
- 50 sheets of filter paper, [illegible] inches, or several [illegible] sheets, as preferred.
- 4 straight glass tubes, 1 foot long each, [illegible] ¼ inch in diameter.
- 2 glass tubes bent at right angles, same size as the straight tubes, one with the arms of equal length, one with one arm 3 inches long and one with one arm 5 inches long.
- 2 glass stirring rods, 3/16 or ¼ inch in diameter.
- 1 foot of rubber tubing to fit the glass tubes.
- 2 four-ounce glass flasks, with glass corks.
- 1 four-ounce glass beaker.
- 1 six-ounce glass beaker.
- 1 round 3/16-inch file, to smooth the holes in the corks.
- 12 thin-glass test tubes.
- 2 sheets of litmus paper, one red and one blue.
- 1 four-ounce bottle of hydrochloric acid.
- 1 four-ounce bottle of nitric acid.
- 1 four-ounce bottle of sulphuric acid.
- 1 four-ounce bottle of ammonia.
- 1 four-ounce bottle of sodium hydroxide.
- 1 four-ounce bottle of sodium carbonate.
- ½ pound of potassium chlorate.
- ½ pound of black oxide of manganese.
- 1 two-ounce bottle of solution of barium nitrate.

A box of gummed labels is useful, but homemade labels will answer.

The First Lesson

Take a piece of lime about the size of an English walnut and break it into any clean bottle holding about one-half pint. Nearly fill the bottle with water as pure as can be got. Of course, distilled water is best, but rain water, boiled water, condensed water from waste steam, etc., will do very well. Close the bottle with a clean, common cork, shake well and let it stand a few minutes. Next prepare a clean funnel. One with channels and grooves down the inside of the conical part, and called a "corrugated funnel," will filter faster than a plain one. The funnel should be of glass, about 3 or 4 inches across the mouth, and if the stem is 3 or 4 inches long the suction of filtered liquid in the stem will actually help to pull the liquid through faster than it will in a funnel with a short stem.

As for the filter paper, common "qualitative" paper will do. It should be white and smooth, not like the close grained [illegible] that some druggists try to palm off on the beginner. You can buy it cut in round shapes, and of various sizes, so as to [illegible] to fit the funnel. A piece 4 or 4½ inches in diameter will fold down to [illegible] the funnel, being about [illegible] inches across the top. [illegible] in sheets, fold, crease and cut it as shown in Fig. 1. Take a piece about 7½ inches square, fold it twice, as shown at *a*, lay it down and trace a curve *from the closed corner* of the paper, as at *b*, and cut this folded paper along the curve; when you open it, it will look something like *c*. Or, if you get the filter paper in packages of "cut" paper, you will fold it as shown in

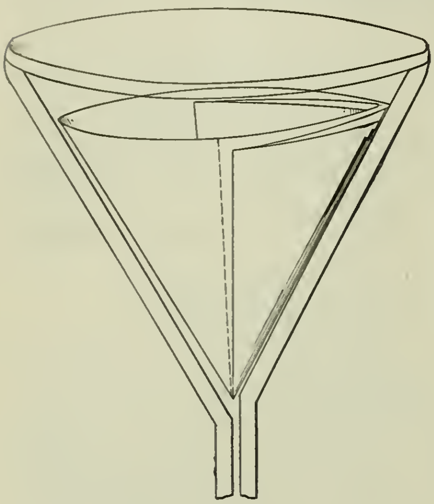


FIG. 3

Fig. 2. Referring to *a*, first fold it across the line *1-2*, to halve it, and then, to quarter it, fold along the line *3-4*, folding the point *1* over and down on point *2*; then when you open it, it will look much like *c*, Figs. 1 and 2.

Next, fit this piece of quarter-folded filter paper down into a funnel about 4 inches across, so the point or apex of the cone of the paper fits nicely down into the opening of the stem of the funnel. You will notice, when you have done this, that on one side there is only one thickness of paper, while on the other side there are three thicknesses. That is all right; it will do its work. You will also note that when the paper is in the funnel, closely fitting it, it will look like Fig. 3. You will further note that to have the conical cup of filter paper closed on the under side, where it fits the funnel, the paper has to turn back on itself twice. All this may seem simple to the man who knows all about it, but you will have to use your wits to get some of these simple things right. You can do it, however. A sketch of the corrugated funnel, with its stem in a bottle, is shown in Fig. 4.

When the filter paper has been fitted into the funnel, which has been set with its stem in the neck of a clean bottle, as stated, dampen the paper with a few drops of water, to "break its back;" otherwise, it will spring back and crawl out of the funnel, even if the funnel is standing upright.

The next step is to open the bottle of limewater, which may be quite milky. Don't lay the cork down anywhere, but hold it between the third and fourth fingers of the right hand, with the palm upward. In fact, that will be found to be the best way to take the cork out of the bottle. The cork will not get soiled, then, and is ready to go back in place instantly. Or, you may hold the cork in your left hand and use it to direct the stream of liquid as it is poured into the filter paper in the funnel. If the cork is held close to the mouth of the bottle, as it is tipped with care to pour, the stream will follow down the side of the cork.

We are to filter the milky limewater through the funnel into a second clean bottle, say half a pint, or even a pint or more; for you will use this limewater on a number of different occasions. If the stem of the funnel fits too tightly into the mouth of the second bottle, slip a bent match or wooden toothpick between the funnel stem and the mouth of the second bottle, to leave a crack for the air to escape through as the filtered limewater runs in (as shown in Fig. 4).

How to Clean a Bottle

To digress for a moment, you may as well learn a trick for cleaning bottles. Tear up a small piece of common paper (any kind, newspaper will do), say a piece 5 inches square, into little bits the size of a dime or smaller. Put these paper bits, with a little soapy water, in the bottle and shake well, and with a motion to make the wash water swing around the inside of the bottle. The edges of the paper cut off the dirt from the smooth surface of the glass, and when the bottle is rinsed several times it is clean, cleaner than washing with shot will make it, as a rule.

To go back: Don't fill the filter paper in the funnel higher than to within about ½ inch from the top, then there will be no danger of the milky water creeping up above the paper, running down the side between the paper and glass and thus get through without going *through* the paper. All this and a dozen other points you will learn by trying; it is really very simple, and anyone can do this in a kitchen or boiler room. Filter enough into the second bottle of water so that it will be full, for it will be found that the air will act on this filtered limewater, and if the bottle is full to start with less air can get in below the cork.

It takes a few minutes to get this bottle of filtered limewater ready for use. When it is ready you will label it with one of the adhesive labels which came with your outfit; or, if you haven't that, get your wife to make you some flour paste by cooking a teaspoonful of common wheat flour in hot water. You should write "Limewater" on the label. If you know how to do all this, why, just skip the reading up to this point; but you will have this first reagent on hand; and you had better fill the bottle of lime again with water, shake and cork it, laying it aside ready to filter more limewater as needed.

This bottle of filtered limewater is the *door* leading to a whole lot of useful facts and self-instruction; indeed, it is a laboratory by itself. Look at it. It is as clear as water, and you may doubt whether it is anything more than common water. But just *taste* it; that is test No. 1. It is perfectly safe to taste it, for you may have given some of it to your baby at home, with its milk. Before you get through with this, you will see why you gave it to the baby. The limewater tastes slightly bitter-sweet, and it has also what is called an "alkaline" taste, a taste that you will want to learn.

Pour some of the limewater into a clean tumbler or one of the little thin-glass cups, "beakers" they are called. Breathe down into this limewater strongly; or, better still, blow through the limewater your good, sound breath, through a clean pipe stem, a straw, or one of the pieces of glass tubing which came with your outfit.

How to Prepare Glass Tubing

When you use glass tubing, it is a good thing to soften the edges at the ends by holding the tube in a hot flame for a few moments so as almost to melt the glass, if the ends are not already rounded; the ends of the tube may also be rounded with a file; but be sure to smooth the edges, or you will cut your tongue, your

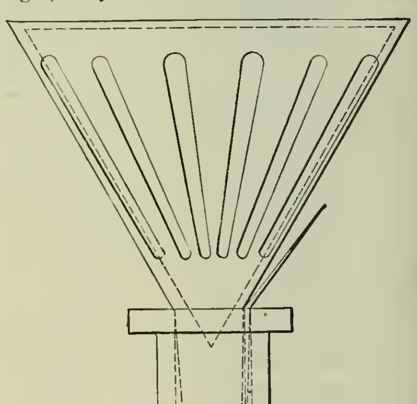


FIG. 4

corks, or your rubber tubing, and it is simply a matter of doing things shipshape *to round the edges* of glass tubing.

As you blow your breath into the limewater, and as you shake the liquid around, so that the gases of the breath can mix well with the liquid, you will notice that a whiteness comes in the limewater. It gets milky, and if left standing a white sediment soon appears. This white sediment is lime (or calcium) carbonate. It is a union of the carbonic-acid gas from the breath with the "base," lime, and the two together have made the "salt," carbonate of lime (or calcium, calcium being the hidden metal that is at the bottom of the lime, just as iron is the metal at the bottom of common iron rust). The carbonic acid gas in your breath came from the burning of the food in your body, by the millions of tiny furnaces in the muscles and red blood corpuscles; and the lungs make the chimney from which the invisible smoke of the breath gave off the carbonic-acid gas, just as truly as though the carbon of the food had been burned in your grate under your boilers. This shows again that the limewater is an active chemical. This is test No. 2.

You well know that all of your food contains carbon, the same element which makes up the bulk of coal. You know this from the fact that if the bread toast gets too much fire, it shows real coke or charcoal on the edges; and if your roast beef gets burned, there is the same coke or charcoal on the surface. You also know that bread and meat will burn in the fire as though they were of close kin to wood and coal; the same thing is true of sugar, starch and, especially, butter and fats. Now this turns your own attention to that fire right at hand. Why not test that with this limewater? You will do it in the following manner:

How to Apply the Test to the Furnace Fire

You will need a common wide-mouthed bottle, say, a horseradish bottle (see Fig. 5). Fit this with a good cork, which has two holes just wide enough to take in tightly the two pieces of bent-glass tubing *A* and *B*. Make the holes in the cork with the small blade of your knife, or with the cork cutter that comes with your outfit, then round the edges of the holes in the cork with a rat-tail file. The bent-glass tubes come with the outfit. You will note that one of these pieces of glass tubing goes just through the cork and the other piece reaches down below the surface of limewater which has been poured into the bottle. The tubing *A* is joined, by the bit of rubber tubing *C*, to the stump of a common clay pipe. You will want to try this piece of apparatus by sucking with your mouth at the end of tube *B*. Naturally, bubbles will come through the limewater, as indicated by the arrows. Don't blow in this, unless you want to force the limewater out of the pipe. Your common sense will show you why. Now that you know that your cork and tubes fit fairly tightly, place some small, live and glowing coals from your boiler fire in the pipe bowl. There you have the real Turkish pipe, with well-cooled smoke; but what you are after is the action of the gas from the glowing coals on the limewater. It will not hurt you to suck some of this any more than it does to smoke your old pipe with tobacco in it.

As you draw the burnt gas from the glowing coals through the limewater, you will notice the same milkiness forming, and the same white sediment will gather as when you blew into the limewater with your breath, and for the same good reasons. The coal is mostly made up of carbon, and if you don't pack the coal too tightly in the pipe, you will not get much through that you need to note now except this carbonic-acid gas. This acid

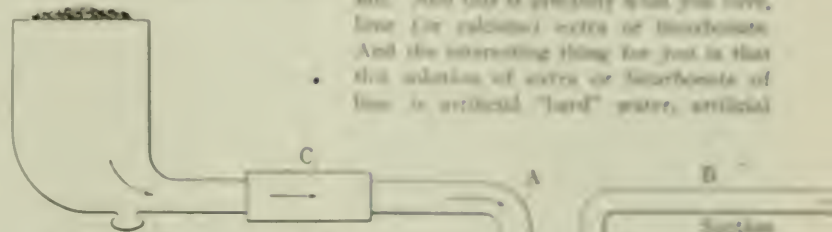


FIG. 5

gas will unite with the lime, which is a base, and together the two will make the same white insoluble salt, carbonate of lime (or of calcium). Note that the lime, as such, is soluble to a considerable extent in water, while the carbonate of lime is *not* soluble, or, as they say, when a thing is *not soluble*, it is insoluble. As a matter of measure, it takes about seven or eight hundred parts of water to dissolve one part of lime (not very much but enough to show well), and it takes some sixteen thousand parts of water (cold water) to dissolve one part of carbonate of lime; not very soluble, so it is called insoluble.

The Basis of Boiler Scale

Now this white sediment of insoluble carbonate of lime (or calcium) is a large part of the scale that forms in or on your boiler tubes when you use what is called temporary-hardness water (permanent-hardness water is another thing, which you will study later). But this form of carbonate of lime is the same thing as common white limestone or marble, and it is the same as much of your scale. But what you want to know is this: If this white sediment is so insoluble in water, how does it get into the boiler, when your water supply is quite clear and shows no such thing at least to the eye? You will see how to explain that if you go on to the next step with the limewater.

Go back to the beaker of limewater in which you blew your breath to bring down the white sediment of carbonate of lime. Take this and keep on blowing for some minutes, five or ten, shaking it about so that the bubbles of breath will mix thoroughly with the milky water. Pretty soon this will begin to clear up, and presently a change will come in it. The sediment will partly dissolve, and it will look as though you could almost see through it. Now filter this off, through a clean piece of filter paper and with a clean funnel, into another bottle. Now you have a new kind of limelike water; it is not the original limewater, for it has gone through the throwing down as carbonate; neither is it the plain carbonate, for that is insoluble in water, while this is soluble enough to dissolve somewhat in water.

You can begin to guess for yourself what has happened. If you got the "salt" carbonate of lime, by adding the carbonic "acid" of the breath to the "base," lime, why here you must have a "salt" which has still more of the carbonic acid; in fact, an extra or bicarbonic-acid salt. And this is precisely what you have, lime (or calcium) extra or bicarbonate. And the interesting thing for you is that this solution of extra or bicarbonate of lime is artificial "hard" water, artificial temporary-hardness water. You can do something with this artificial temporary-hardness water that is exactly like what you do with it if you put it wholesale into your boiler. Just warm it, and the extra carbonic acid will go off, and down will come the white, insoluble plain carbonate, not very much, but enough to see and quite enough to make trouble when on a large scale. It was the extra carbonic acid which changed the plain insoluble carbonate into the somewhat soluble extra, or double, or bicarbonate, "hard" water in fact. The plain carbonate is hardly soluble. From this you throw down plain carbonate of lime by the breath and by the gas from the glowing coal, by means of carbonic-acid gas in the breath and in the "breath" of the glowing coal. This plain carbonate of lime is *insoluble* in water. From this plain and *insoluble* carbonate you made some extra, or double, or bicarbonate (by adding extra carbonic acid): and this extra or double, or bicarbonate of lime is somewhat *soluble* in water. This is "hard" water, and it can be broken up and the limelike part thrown down again, as the *insoluble* plain carbonate; just as happens in making soft scale on your boiler tubes from your temporary-hardness water.

This temporary-hardness water can also be made, of course, not only by *blowing* the *breath* through limewater until the first plain *insoluble* carbonate has partly redissolved as extra or bicarbonate, which is fairly *soluble*, but also by *sucking* the gas from the glowing coals (as in Fig. 5) through the limewater in the horseradish bottle until it begins to clear again, say five minutes' suction with good glowing coals in the pipe bowl. After it begins to clear up, open the bottle, filter the water clear, pour it into a *clean* tumbler or beaker, and warm it. Enough plain insoluble carbonate will come down so that you will notice it if you look for it, and yet so little that one can easily overlook it if he doesn't look for it.

This is only the beginning of what that barrel of lime will teach you; but with all the bother of this fussy filtering, you may have done another piece of filtering which is worth your while, Mr. Furnaceman. That is, filtering out some clear ideas from the milky water of careless ignorance and prejudice. In the next article we will begin to discuss this filtering of new ideas, carefully and one at a time.

Electricity in Great Britain Mines

The appointment of an electrical inspector of mines in Great Britain is in itself an indication of the great strides being made in the application of electricity to mines. It is estimated that 50 per cent. of the new plant being put down in British mines is designed for production and distribution of electrical energy. The electrical industry is devoting a more intelligent study to the special conditions encountered below ground, on the one hand, to increase the safety and efficiency of the machine, and on the other to cheapen the cost. Mining engineers are now rapidly discovering advantages, from a purely mining point of view, in the use of electricity.—*The Mining World.*

At Charlottenburg 146 horsepower are transmitted by means of a belt, 10 millimeters = 0.39 inch in width and 5 millimeters = 0.185 inch thick, running at a speed of 61.5 meters a second, equal to 12,103 feet per minute, with a tension of 200 kilograms = 440 pounds. On the same shaft in another place is a 100-millimeter = 3.94-inch steel belt replacing a 600-millimeter = 23.6-inch leather one, both carrying 250 horsepower.

Calorimeter Tests of Steam

By W. H. Booth

Papers on power plants are often read, particularly in Europe, in which great weight is accorded to the calorimeter tests of the steam produced by a boiler. It is more or less amusing to note the assumption with which the reader of the paper sets forth his figures of 99.01 per cent. of dryness and the solemnity with which his listeners sit and receive such figures, and the natural sequel to such figures in the shape of some grotesque efficiency of the boiler which never could have given such an efficiency of dry steam. It is no part of this article to throw doubts on the accuracy of calorimeter instruments. Doubtless they give accurate results for the steam passed through them, but the crux of steam-dryness testing rests entirely with the sample of steam tested. The calorimeter tells what water there is in the small sample passed through it, but it does not, nor can it ever tell how much water is passing through the main steam pipe from which the sample is taken.

An old steam engineer was recently passing by a boiler which was being tested for the purpose of glorifying the particular mechanical stoker with which the boiler was fitted. The calorimeter test was in progress. "Why," asked the old man of the young experimenter, "do you take your sample of steam from that particular place? Why do you not use this cock which is specially provided and from which these samples of steam are to be drawn?" The reply of the young experimenter was as instructive as it was ingenious. "Because," said he, "the steam came so very wet at that tap and here I get it dry." And does not that reply give away the whole case for the calorimeter test?

From two points on one valve box or casing there was to be drawn steam wet or dry. Both the samples could not represent the truth of the matter. The test was made of dry steam. Yet the pipe was carrying a lot of water and this water was going to be counted unto the mechanical stoker for evaporation. Granted that the steam was not so wet as the one point showed it to be, it could not have been so dry as the other tap appeared to indicate.

All manner of devices and arrangements are put up with the object, or pretense, of drawing a correct sample. A pipe is turned toward the current of steam. It is fitted with a cross piece extending right across the pipe and perforated. An attempt is even made to draw steam through the sampling tube at the same velocity with which it is flowing in the main pipe, so that the correct proportion of water particles may be taken along. If such precautionary guess work is admitted desirable, is it not convincing proof that such sampling must be quite unreliable? No man can possibly say, with the most elaborate means of take off, that the calorimeter is being fed with steam of the quality the boiler is producing. Why, therefore, should the mockery of the test be continued? It was "sprung" on the electrical steam user as a piece of refinement which was demanded by modern conditions, and it has clung on as the obsolete and dangerous vermiform appendix has clung to mankind for long ages after he has ceased to hibernate and require such an addition. Indeed man today often dies of inflammation caused by the very nuts he once stored in the appendix that was made for such food.

But how can the quality of steam be really known which a boiler is giving forth? Plainly and bluntly it cannot possibly be known by any method short of testing the whole output in a suitable calorimeter. This plain statement refers solely to saturated steam. All saturated steam at a given pressure has a given temperature, no matter how wet or how dry it may be. The thermometer does not help us, for steam and water which come out of a boiler together have no temperature difference. But this very fact is a hint toward a certain elucidation of the problem.

Given a thermometer in the boiler steam space and another one of equal readings in the steam pipe, and a superheater in between, and the two thermometers will give, not the percentage of wetness, but that of dryness, and this dryness will always be over 100 per cent., or at least not less than that, if any reliance is to be placed on the figures of the test. One thermometer must read a trifle above the other, and when it does this it is proof the steam is dry. Some sort of a small superheater is therefore necessary if boiler tests are to be made for figures on which the slightest dependence is to be placed. Not one in all the many published boiler-test records is likely to be correct unless some slight superheat at least has been given to the steam.

The proceedings of the technical societies teem with boiler-test figures, books have elaborate tables of test figures, and conclusions are drawn from such figures and theories advanced on no better foundation than the baseless fabric of a vision. Boiler-test figures may be found showing very nearly 90 per cent. efficiency for the boiler alone, apart from the help of the feed heater. As the conjurer says after each of his juggling displays, "Isn't it marvelous?" It is. Any engineer who wishes credence to be lodged in his test figures should endeavor to have his test include for the superheater also, and in view of the present uncertainty as to the true specific heat of steam he should aim only to get a superheat of a few degrees, just sufficient to render it certain that there is superheat. Otherwise, no one who knows will place any value on the figures of his test.

Horatio Allen and the Novelty Works

Sketch of the Career of the Man Who Brought the First Locomotive to America and Became the Head of an Immense Engine Industry

BY EDWARD P. BUFFET

It was Horatio Allen who brought the first locomotive to America, who acted as running-engineer on the first trip, and who later grew to be of the first magnitude as a builder of marine engines.

To understand how he came to import that locomotive we must look back to the time when the Delaware & Hudson Canal Company was pioneering what has since become a tremendous factor of industry, the transportation of anthracite to tidewater. At this time Horatio Allen was a young civil engineer just beginning to make his mark in life.

From Law to Locomotives

He was born May 10, 1802, in Schenectady, N. Y. His father, Dr. Benjamin Allen, a school principal, gave him a good start on the road of learning and at eighteen the boy graduated from Columbia College with high rank in mathematics. Those were days when none of the doors of a college opened directly upon technological walks of life, so that a young fellow who had been mingling on common footing with the rest of the scholastic herd would have been no more likely to have his attention called to engineering as a vocation than today he would be likely to select the profession of a sandwich man as a logical sequence to taking his degree.

It is therefore not to be wondered at that Horatio Allen at first set about reading law, as his later engine-building contemporary, Charles T. Porter, and many others have done, from lack of reason to the contrary if from no more rational motive. But it took him less time than it did Mr. Porter to discover his real adaptedness and switch off upon the right track. So at about the time he cast his first vote he entered the employment of the Delaware & Hudson company. Afterward he spent a year or two upon the Chesapeake & Delaware canal, but near the close of 1825 he was appointed resident engineer of the summit level of the Delaware & Hudson canal under the eminent John B. Jervis. That brings us to the point where we started, when the company was hauling out its coal by canal and when locomotives did not yet exist on this side of the Atlantic.

In Quest of Knowledge and Engines

The performances of the steam locomotive on the Stockton & Darlington road in England were arousing the interest of American engineers, and in particular of Horatio Allen. Though at an age—twenty-five—when most men rightly feel that they must establish their reputation by steady service with going concerns before cutting loose and offering themselves to the world as technical leaders, Allen threw up his job in order to go to England and acquaint himself with what he was convinced would prove the carrying power of the future. But perhaps he already had the situation better in hand than appears, for previous to sailing he received a commission to act as agent for the Delaware & Hudson company, empowering him to procure railroad plates and one or more locomotives for a 16-mile railroad which it was building to connect its mines in Pennsylvania with the canal. One locomotive the company desired as a pattern for manufacture of additional engines in the United States; as an alternative to which plan it might wish to have them all made in England. The ultimate decision was to procure three more. The company agreed to pay Mr. Allen's passage and expenses, permitting him to remain abroad about three months, the whole not to exceed $600.

Railroad plates of the kind mentioned were primitive rails ½ inch thick by 2¼ inches wide at the bottom and 2 inches at the top and 12 to 15 feet long, to be laid on wooden string pieces. It was desired to have the plates rounded if this would not entail too much additional expense. Further, Mr. Allen was asked to report on improvements in coal "wagons," especially as to the size of wheels and manner of connection to the body. Mr. Jervis wrote him a long letter filled with specifications for his guidance.

Visit to Stephenson

Leaving New York in January, 1828, Mr. Allen arrived at Liverpool, where he was cordially received by George Stephenson. The famous trial of the "Rocket" on the Liverpool & Manchester railroad was not destined to take place until October 14, 1829, in the course of which were the discussions still continued between locomotives and fixed engines for the road. The fixed engines would probably have been used on inclined planes in connection with greater or smaller grades, which arrangement seems to have been a favorite one in the early days of railroading and which still was [illegible] to be seen in operation in this [illegible] vogue in Pennsylvania. Locomotives had, however, been in successful service at Killingworth, Eng., as early as 1814, and there were in use on the Stockton & Darlington railroad locomotives of a common type which the instructions from Mr. Jervis favored. In compliance with the instructions of his chief Mr. Allen ordered one of this model from Foster, Rastrick & Co., of Stourbridge. It had four coupled wheels, all drivers, two vertical cylinders of 36-inch stroke, placed at the rear of the boiler, "grasshopper" beams, wooden-spoked wheels and tubular boiler with several large flues. The blankness of the circular space on the front of the boiler was embellished with a lion's head, whence this engine was dubbed the "Stourbridge Lion."

The "Rocket" and Its Predecessors

While Mr. Allen deferred to the [illegible] ideas in ordering one locomotive of that type, he [illegible] by Stephenson's [illegible] to contract with that [illegible] firm at Newcastle, for [illegible] other engines essentially of what later became celebrated as the "Rocket" type. These, when brought to New York, were placed [illegible] in the city, where exhibitions were given with wheels running free of the ground. [illegible] it is the "Stourbridge Lion" which is known as the first locomotive on an American railroad. If the "Rocket" type engines had been put into service at once [illegible] America would have anticipated the proving of that type in England.

First Locomotive Run in America

The "Stourbridge Lion" was held up during the winter of 1828-29 at the [illegible] of the Delaware & Hudson canal [illegible], Honesdale, Penn., [illegible] and in the [illegible] of August, 1829, made its [illegible] trip on the road from the canal into the Pennsylvania woods [illegible]. The [illegible] crossed the Lackawaxen river [illegible] [illegible] of such an engine in service was only 4 to 6 miles an hour, and had it jumped the track at that velocity he might have stepped off upon the ties without losing his cigar. However, he was at the time running without load and may have speeded up the machine enough to startle the beholders.

More than half a century elapsed before Horatio Allen again visited the scene of his exploit, which occasion was marked with lively emotions at the memories it awakened.

Railroading in South Carolina

The month after his epoch-making run, Mr. Allen became chief engineer of the South Carolina railroad. It was then in question whether to employ horse or locomotive traction there, and his counsel in favor of the latter was unanimously accepted by the directors. As he has stated in his pamphlet, "The Locomotive Era," there was no reason to expect any material improvement in the breed of horses, but in his judgment the man was not living who knew what breed of locomotives the future was to place at command.

By his recommendation the gage of the road was made 5 feet, but a similar suggestion that he later made to the Erie road was rejected, to the great disadvantage of modern heavy railroading. A railroad gage is one of the standards which it seems impossible to change and which is snatched at by the anti-metric cranks as an argument against changing any.

Invention of the Swiveling Truck

To Horatio Allen is due a large share, if not the whole credit, of originating the swiveling truck. The light plates on 6x12-inch stringers which then served for rails were incapable of sustaining a heavy weight, the safe load on the Liverpool & Manchester railway being three tons, or even less, per pair of wheels. Hence the limitation of locomotive wheels to four necessitated the use of light engines and entailed correspondingly heavy operating expense in transporting a given quantity of freight. In 1831, Mr. Allen called the attention of the South Carolina railroad directors to this difficulty and recommended the employment of more than four wheels, with swiveling trucks to enable the passage of curves. Consequently he was empowered to place contracts with the West Point Foundry for locomotives built on that principle. The first of these was the "South Carolina," and put in operation early in 1832. A couple of years later a patent was granted to Ross Winans, of Baltimore, for eight-wheeled cars with two trucks. Some such were built or used by the Newcastle & Frenchtown Turnpike and Railroad Company in defiance of Ross' patent claim. This led to twenty years' expensive litigation, virtually involving the interests of all the railroads, and it was not until 1858 that Winans' patent was finally declared invalid. During the dispute recourse was had to evidence that the double-truck principle had been employed before the patent date by Horatio Allen.

The South Carolina railroad locomotives of this type were double-enders, consisting of two engines facing apart and joined by a firebox in the middle. Each boiler was double-barreled and rested on a four-wheeled, jointed, swiveling truck, there being one cylinder to each truck.

John B. Jervis himself was another pioneer in using the truck form of construction and seems to have been at least a close second. The truck idea had, indeed, been foreshadowed as long ago as 1812 in an English patent to William and Edward W. Chapman.

After completion of the South Carolina railroad, Mr. Allen was variously occupied. He married, traveled abroad for two or three years and served as principal assistant engineer of the Croton aqueduct under his old chief, John B. Jervis.

The Novelty Works and the "Novelty"

Horatio Allen's *Lehrjaehre* and *Wanderjaehre* came to a close in 1844, or thereabouts, when he entered, as one of the proprietors, that famous engineering works in New York City with which his subsequent career is identified. He became a member of the firm of Stillman, Stratton & Allen, owners of the "Novelty Works."

About the early part of the thirties, Rev. Dr. Eliphalet Nott, president of Union College, Schenectady, N. Y., who had been active in introducing anthracite for house stoves, invented a steam boiler to run on that fuel and decided to build a steamboat in which to make a test. Besides burning this novel fuel, he proposed to install a novel mechanical equipment throughout, wherefore the boat was called the "Novelty." This name attached itself to a shop which he established to do repair work, etc., on the vessel. It consisted of a wharf and some buildings situated in New York City, on Burnt Mill point, so-called, at the foot of Twelfth street, East river. The "Novelty" herself ran from New York to Harlem. The Novelty Works gradually extended its attention to outside business, and from an equipment of a few tools in a little shed, grew to be the biggest marine-engine building establishment in the country.

Development of the Works

In the early days the business was conducted by Nott & Co., under superintendence of N. Bliss, formerly of the West, the foreman being Ezra K. Dodd, who afterward was made chief engineer of the "Novelty." Later Thomas B. Stillman took charge of the plant and, in 1838, it passed into the hands of a firm including himself, John D. Ward, Robert M. Stratton and C. St. John Seymour. Messrs. Ward and Stillman were the mechanical men of the firm. Among the work turned out were two ocean steamers, the "Lion" and "Eagle," for the Spanish government. Mr. Ward retired from the firm in 1841 and Mr. Seymour not long afterward, Mr. Allen being admitted about 1844. Eventually he secured practical control of the enterprise with the financial aid of Brown Brothers, bankers, Mr. Stillman retiring.

In 1855 the concern was chartered as a corporation with $300,000 cash capital, the corporate title, "Novelty Iron Works, of New York," expressing what had from the beginning been its popular designation. Horatio Allen became its president and dominating spirit.

A Great Old-time Engine Shop

It may be of interest to summarize an account of the Novelty Works given about the time of the war, in order to estimate how progress in similar plants has been made between that period and the era of West Allis and East Pittsburg.

Near the entrance gate, with its porter's lodge and offices, was a large crane for handling shafts, cylinders, boilers, vacuum pans and other ponderous pieces of machinery. To the left was the iron foundry, 206x80 feet, with a wing. It contained four cupola furnaces capable of melting at one heat 65 tons of iron, which could be cast into one mold. There was also another furnace. The foundry blast was led through an underground pipe of 5 square feet sectional area. Some of the foundry cranes were as strong as 20 tons load. Here were made the bedplates for the steamship "Atlantic," weighing 37 tons, and for the "Arctic," 60 tons. In the summer of 1854 there was cast the cylinder of the steamer "Metropolis," of the Fall River line, having a diameter of 105 inches and a length of 14 feet, with 12 feet stroke of piston. Twenty-two people sat down to lunch in the cylinder, with room to spare, and a horse and chaise were driven through it.

The smiths' shop was equipped with thirty forges, hammers and some cranes of large capacity, evidently of gib type. In one case a piece of iron weighing 14,366 pounds had been forged and handled. There were also machine and finishing shops, two boiler shops, etc., each with its appropriate machinery.

The whole establishment was divided into twenty departments, each having its foreman, viz.:

Iron founders, brass founders, machinists, boilermakers, carpenters, coppersmiths, blacksmiths, metallic lifeboat builders, instrument makers, hose and belt makers, painters, masons, riggers, laborers, cartmen, watchmen, storekeepers, patternmakers, draftsmen and clerks. All told, an average number of more than 1000 men were employed, and the work turned out amounted to some $1,330,000 a year. At one time over 1500 men were employed and owing to the scarcity of labor Mr. Allen went to Europe to obtain hands. The works occupied nearly two blocks and included two slips sufficient in size for the largest steam vessels. Machinery for many of the old Collins line and Pacific Mail steamships were built there. In addition to marine work the company turned out a varied line of mechanical products, such as stationary engines, pumps, sugar machinery, steam fire engines, and hydraulic presses.

Allen's Engineering Faith and Practice

Horatio Allen was a firm believer in oscillating-cylinder engines as compared with beam engines for sidewheelers. He wrote a pamphlet, 1867, claiming for these superiority in compactness, lightness, simplicity and application of power. An "objective point" (to borrow a term from a certain Mrs. Malaprop of our acquaintance) seems to have resided in the valve mechanism. An experimental valve gear which Mr. Allen applied to the engines of the "Adriatic" caused so much trouble that it had to be taken out. It employed large conical plug valves with a device for lifting them to be turned, so as to prevent their jamming. It would probably be indulging in unwarrantable panegyric to describe Mr. Allen as a great inventor. But he believed in himself and he disbelieved in Sickels, of whom he considered himself a standing rival, and whose cutoff, C. T. Porter says, he would never allow to be applied at the Novelty Iron Works. The same authority tells us, however, that Mr. Allen, in his later years, when judging at the Centennial, united in an award to Sickels with an expression of cordial admiration.

At the time of the war the Novelty works built engines for several vessels of the Federal navy, including the double-turreted monitor "Miantonomah."

From this period dated a long controversy in the navy upon the economy in using steam expansively. Chief B. F. Isherwood, of the Bureau of Steam Engineering, and others, advocated moderate pressures with moderate ratios of expansion, while their opponents, including E. N. Dickerson, advised high pressures and high expansive ratios. The dispute became so animated that a commission was formed under Government auspices to make tests and, if possible, answer the question. These experiments were carried on at the Novelty works, largely under direction of Mr. Allen, who was of the high-expansion party, but who suspended judgment during the trials.

These investigations lasted so many years that the world grew weary of waiting for the results and the Government tired of paying for them. It seems that the points at issue were not all clearly settled and the results did not go to vindicate the extreme claims of either party. The data collected tend to show that with increased pressure the economical point of cutoff shortens, but that with any pressure the most economical degree of expansion is soon reached and further expansion rapidly grows wasteful.

Subsequently Commodore Isherwood and Mr. Dickerson arranged a series of comparative tests of the "Winooski," with Stevens cutoff and double poppet valve, to moderate pressure and cutting off at six-tenths of stroke, against the "Algonquin," with Sickels cutoff and single poppet valves, to [illegible] pressure and cutting off at one-tenth stroke. The "Algonquin" failed.

The Closing Years

Engineering work flourished during the war and the Novelty works were kept very busy. But their profits were not correspondingly large. The cost of labor and materials was constantly advancing, and since the machinery built was of a sort that often required a considerable time to complete, the tendency was for expenses to exceed the estimates underlying contracts. In later years business slackened. Meanwhile the equipment was growing old and the real estate occupied by the plant had become very valuable. All things considered, it seemed wise to wind up the business, and about 1870 this historic establishment passed out of existence.

Mr. Allen survived the works a score of years. His death occurred within a few hours of the close of the ninth decade of the century, at his home near South Orange, N. J.

Horatio Allen made a variety of inventions, from 1841 to 1875, those among them relating to steam cutoffs and valve gears standing out conspicuously. Toward the close of his life he interested himself in methods of teaching astronomy and constructed a number of instruments for the purpose. He was the author of an elementary book on arithmetic.

During his connection with the Novelty works his eminence in his profession was recognized by a number of outside appointments. Thus, he was consulting engineer for the Erie railroad, the Panama railroad and of the Brooklyn bridge. He also served a term as president of the Erie.

Horatio Allen has been marked by his contemporaries both with criticism and with praise. A tendency to dissent from some of his opinions is manifest in the "Engineering Reminiscences" of Charles T. Porter, who, among other depreciating remarks, animadverts upon Mr. Allen's [illegible] as president of a group of judges at the Centennial.

On the other hand he is spoken of with high commendation by his old friend, M. N. Forney, who upon his death published in the Railroad and Engineering Journal, which Mr. Forney was then editing, and afterward in pamphlet form, a biographic[illegible] with some interesting old documents relating to the early locomotive experiments. Mr. Forney describes him as a man of [illegible]

New Turbine Plant for the Atlantic Mills

Plans for a steam turbine power plant of [illegible] kilowatts capacity have been completed by the management of the Atlantic Mills, one of the largest textile concerns in Rhode Island, and a contract was awarded for a [illegible]-kilowatt Westinghouse-Parsons steam turbine to be delivered about April 1, when it is expected the new station will be ready for the installation of the first unit.

On the extensive property of the Atlantic Mills are several reciprocating engines ranging from 500 to 1500 horsepower. These will be superseded by the steam turbines and electric drive will be substituted for belt drive.

To steam engineers the novel feature of the new power house of the Atlantic Mills is in the selection of a turbine of the noncondensing type designed to give maximum economy when operating against a [illegible] back pressure. All of the exhaust steam, amounting to approximately [illegible] pounds per hour, will be utilized in the various manufacturing processes in which live steam now is used, these processes being for the most part in the dyehouse. This use of exhaust steam is not in itself wholly new, but it is unusual to find a dyehouse large enough to require the exhaust from so large a turbine as one of [illegible] kilowatts. The Atlantic Mills dyehouse, it may be added, is one of the largest in the country.

The noncondensing operation of steam units has been restricted very largely to reciprocating engines, and the operation of a turbine noncondensing is considered exceptional. The Atlantic Mills is one of the first to adopt this method, and it is expected that the saving over the present arrangement of using live steam will be [illegible]

One advantage is claimed for the turbine exhaust [illegible] which is necessary in the processes in which the steam comes in contact with textile goods.

The Alinement of New and Realinement of Old Shafting

By James Lomas

While discussing this subject with a friend of exceptional experience, he ventured the astounding remark that it would be impossible to find a line of shafting in any mill or works in approximately true alinement. There is undoubtedly much truth in his statement.

The importance of shafting being correct in its position, that is, level in its bearings and in a perfectly straight line sidewise the whole length, cannot be overestimated. Those persons of experience who have had to deal with the faults and follies of incorrect and badly executed work, know well the extra cost of maintenance requisite to keep a mill or works in constant operation; overtime for the engineer-in-charge; occasional stoppage of the machinery through needless friction in the bearings; wheels, pulleys and couplings loosening daily, and breaking; extra cost of fuel and labor in the fire room; extra wear and tear of the engines, etc. These are only some of the troubles attributable to shafting not being in alinement.

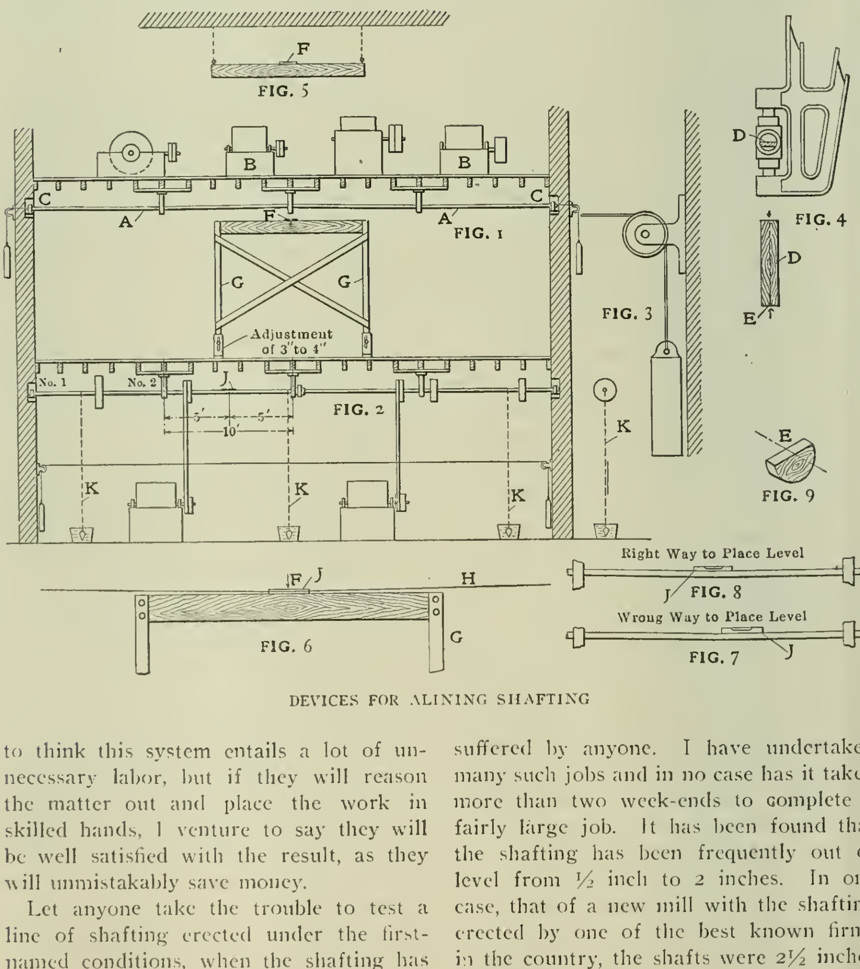
The causes of all these troubles are manifold. On new work the system of erecting generally carried out is unquestionably faulty; and such faults may arise from many sources, such as the settling of the foundations of the building, the warping or twisting of the floors where wood beams have been used, the distortion in structural steel and iron work; and where fireproof floors are constructed either of brick, concrete or similar material and the shafting is erected before the floors are thoroughly set and dry (and this usually takes considerable time), the result of the millwright's labor will be unsatisfactory. As soon as a mill or workshop building is sufficiently advanced in construction to enable the millwright to fix the hangers or brackets he is generally told to do so. Often this occurs before the windows are in their places. The reason for doing this is because there is much to be saved in cost of erection. The room is clear of obstructions and this simplifies the work very much; scaffolding is often at hand and there are many other conveniences which help the work forward. This method, of course, suits the workman, the contractor and the owner, and on first sight appears strictly economical, as it gives a quickly executed and cheap job. But after giving the matter fair consideration it will readily be found to be false economy and an increasing extra expenditure will be requisite until the work is remedied. To illustrate this refer to Fig. 1, where *A A* shows a line of shafting attached underneath a floor, above which a quantity of heavy machinery is being installed. The weight of the machinery has distorted the floor; the shafting, of course, is out of alinement, no matter how carefully the work was done before the heavy machinery was placed in position.

The same thing occurs if a line of shafting is carried on a ground floor through floor stands or pillow blocks, as the floor or foundation is almost sure to settle. Luckily, the remedy is simple if those who are responsible can be led to see it. The logical system to adopt is to allow the mill to be finished and the shafting erected before the machinery is fixed. Then a short time before the machinery is put in operation realine the shafting and make all the bolts, etc., secure; the shafting is much more likely to run under better conditions and for a longer period without attention except the usual oiling and cleaning, etc.

Of course, many people will be tempted to think this system entails a lot of unnecessary labor, but if they will reason the matter out and place the work in skilled hands, I venture to say they will be well satisfied with the result, as they will unmistakably save money.

Let anyone take the trouble to test a line of shafting erected under the first-named conditions, when the shafting has been at work three months, and he will require no further confirmation that the system is entirely wrong. However, under any circumstances it is necessary to have a second alinement to obtain the best results, and if strict economy is to be considered a periodical alinement should be made, say, every twelve months. Of course, the bearings should be under constant examination.

If the reader will study the method of the realinement of old shafting shown in Fig. 2-*J* its simplicity will be apparent, and the cost of putting mill shafting in order will be a mere fraction compared to the advantage gained. Let mill owners think for one moment of the continual loss occurring through the defective condition of their mill shafting, that has probably been working for years without any attention further than the usual oiling. As long as the motive power is sufficient to move the shafting around it is not considered necessary to do anything more until suddenly there is a smash and everything is stopped, sometimes for days. Yet to remedy all this is such an extremely simple matter to the practical man, as will be seen by again referring to Fig. 2-*J*, and the benefits to be derived therefrom need not be further commented on. The work of realining may be done when the mill is stopped for a holiday or at a week-end, and little or no inconvenience need be suffered by anyone. I have undertaken many such jobs and in no case has it taken more than two week-ends to complete a fairly large job. It has been found that the shafting has been frequently out of level from ½ inch to 2 inches. In one case, that of a new mill with the shafting erected by one of the best known firms in the country, the shafts were 2½ inches diameter and the distortion was owing to the steel beams that the hangers were attached to and which were imbedded in a fireproof ceiling; the floor above was covered with heavy machinery. The irregular torsional strain on the shafting was the cause of about a dozen ends of shafts twisting off and the split muff couplings were constantly coming loose. This went on until the whole of the shafting had been realined, although the mill had not been at work more than twelve months.



DEVICES FOR ALINING SHAFTING

Where the shafting is carried in adjustable bearings the leveling is a simple matter, but where nonadjustable fittings are in use the work is much more difficult, still not so much so but that intelligent workmen can deal with it. The best line to use for the purpose is piano wire which, when used as shown in Fig. 3, gives very little deflection or sag. The next best is the strongest line procurable, but fairly fine.

How to Erect and Aline Shafting

Having determined the position and type of hanger, wall bracket, pillar bracket or pillow block to be used, fit the two end bearings in position. Next secure the line as short a distance as possible beyond the end of each bearing. The usual method of so doing is by driving a spike into the wall or other convenient place. The line is carried through the end bearings, pulled taut and made secure. This method is very unsatisfactory, inasmuch as from various reasons considerable deflection or sag occurs; consequently, the line requires to be repeatedly tightened. A much better method is shown in Fig. 3, a bracket with pulley is fixed at each end of the shaft line and the line placed through the end bearings. A weight is fastened to each end of the line (see Figs. 1 and 2). Thus the line is kept taut without further trouble.

At this stage it will be necessary to get the line level from end to end, having placed in each end bearing a strip or float, made as per Fig. 4, and secured the bearings so as to hold the strip firm with the central line marked H on the strip parallel to the line (cord or wire) that the rest of the bearings are to be lined by. Then proceed to fix the straight-edge, the center of which must be exactly at half distance between the end bearings. This point is very important, for if placed at an unequal distance between the end bearings, the deflection of the cord will mislead the erector. The straight-edge may be carried by a cord attached to each end and hung from the ceiling, see Fig. 5-F or a temporary frame made as per Fig. 6-F, whichever is the most convenient under the circumstances. Having carefully leveled the straight-edge, adjust the two fixed hangers so that the cord will be parallel to the straight-edge. Then, having made that secure, notice the deflection in the cord H, Fig. 6, and a simple calculation will show the relative position of the central hanger.

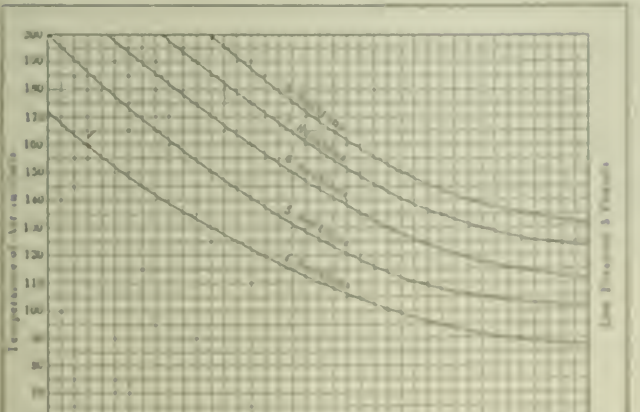
Next, fix the central hanger, making allowance for the deflection of the cord line; having made this secure, place a wood center as per Fig. 9-E in the middle of this center bearing to support the cord line. There will then be very little deflection on the cord line in the intermediate distance between the central and end hangers. The rest of the hangers may then be fixed in position and made secure. Having fixed such hangers in position the shafting may then be placed in the bearings, the couplings fixed in their position and made good, having made everything all right by fixing the caps on the bearings, etc. The shaft may be revolved to insure it being properly placed in the bearings before the leveling is done. The spirit level I should be a reliable make, 18 inches to 2 feet long, and adjustable. When using it on the shaft it should be exactly central between the bearings, as there will be some deflection in the shaft, and if tested on one side of the center between the bearings, the center will be misled. See Figs. 7 and 8.

If the work has been carefully carried out up to this stage, it will be found that very little adjustment will be necessary. The next thing to do is to take a wooden rod having marked on it the plumb line on the shaft level, take it at a convenient distance from the floor, say 3 or 4 feet. On each, drop a cord line from each end of the shaft with a heavy plumb bob or weight attached and let the latter rest in a pail of water. See Fig. 4-E. This insures steadiness of the plumb line. Then carry the strait line, Fig. 3, the whole length of the shaft and adjust it so as to be about 1/32 inch clear of the dropped line at each end. Then by dropping a plumb line from each bearing as shown in Fig. 2-E, begin at No. 1 and lay out all a line with the same plumb line until the whole have been erected.

In practice it is found where the space is filled with machinery it is necessary only to carry out the aforementioned instructions, excepting that a scaffold or other contrivance may be required above the machinery. In erecting nonadjustable hangers on brackets, the adjustment is obtained by using wood or other packing pieces between the faces of the bracket and the beam, making the work much more difficult. Yet the instructions given herewith generally are applicable, except that each bracket or hanger should be leveled by resting the straight-edge on its underside and spanning the next, beginning at No. 1 and proceeding to the end. The straight-edge should not be less than 10 feet long, 10 to 12 inches wide and 1½ or 1¾ inches thick and the two edges will be exactly parallel.

Heating Power of Steam Coils

The amount of heat transmitted per square foot of heating surface from steam coils naturally depends upon the difference in temperature between the steam on the inside and the air upon the outside. But the air temperature close to the pipes is largely influenced by the rate of flow across the surface. When the air remains practically stagnant the condensation will be but a fraction of a pound per hour per square foot, but as the velocity increases so also does the condensation, which is a direct measure of the heat which is transmitted, until the condensation will rise to two pounds per hour for the same surface.



CURVES SHOWING EFFECT OF STEAM COILS IN HEATING AIR area. Manifestly the higher the velocity the more rapid will be the rate of transmission; hence the primary advantage of the blower system of heating under which the air is compelled to pass rapidly across the surface of exposed steam pipes.

The ultimate temperature given to the air passing across a stack of steam coils must depend not only on the steam pressure, but on the initial temperature of the air and above all on the arrangement of the pipes. The less the depth of the heater or the distance across which the air passes the greater will be the condensation per unit of surface, but the less will the temperature of the air be increased. Intensity of temperature with a given steam pressure can only be obtained by depth of heater.

These relations are not generally known with exactness except by those directly interested in the manufacture and installation of such apparatus. Special interest, therefore, attaches to the accompanying curves from the catalog of the Massachusetts Fan Company, Watertown, Mass. Without going into details of construction or conditions these suffice to show that minimum velocity and maximum depth of heater are essential to intensity of temperature. Between these extremes lies average practice with heater depths ranging from four to six sections (16 to 24 pipes) and velocity from 1200 to 1800 feet per minute.

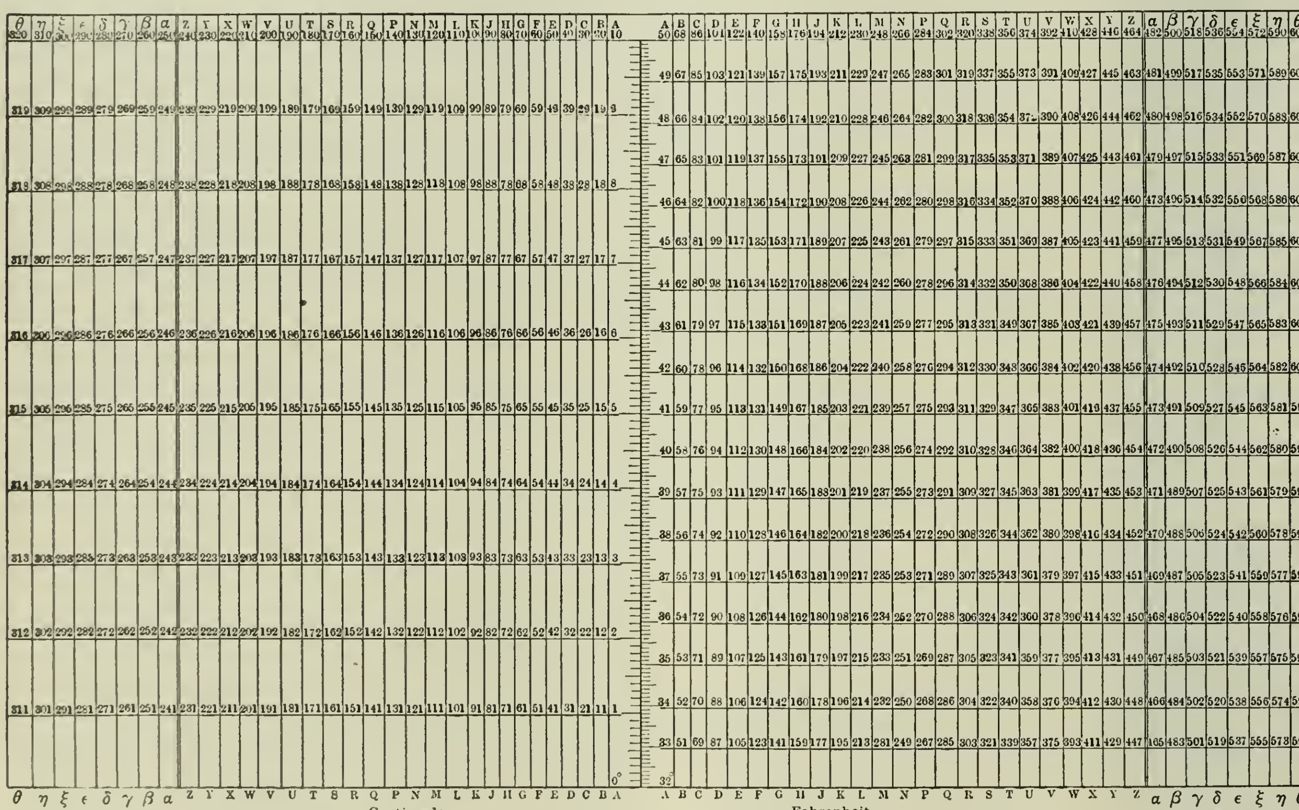
Scale and Table, Giving Epuivalent Graduations of the Fahrenheit and Centigrade Thermometers*

By M. T. Hand

The accompanying scales and chart are intended to give at a glance, without any calculation, the equivalents between any degree or tenths of a degree of the Centigrade and Fahrenheit thermometers. In the center of the chart is shown a double scale divided into degrees and tenths of a degree. The scale on the right is the Fahrenheit thermometer scale and that on the left is the Centigrade thermometer scale. It will be noted that from the graduations of the Fahrenheit and Centigrade scales each portion of the Fahrenheit scale, advancing by 9 degrees from the freezing point, has a coincident portion of the Centigrade scale advancing by 5 degrees. The chart is based on this duplication of scale. It is necessary, therefore, only to lay out to any scale nine equal divisions, subdivided into tenths if desired, using this as the Fahrenheit scale, and then dividing the space on the other side of the vertical into five equal divisions, subdivided into tenths, to have the corresponding equivalents of the Centigrade scale.

In order to make the chart symmetrical and easy to read a scale of 4½ inches for 9 degrees Fahrenheit was used and then doubled. The reproduction is on a reduced scale, of course. Instead of extending this scale in a vertical line, the recurring points on each scale have been placed on a horizontal line, i.e., the point showing 9 degrees above freezing on the Fahrenheit scale or 41 degrees Fahrenheit actual reading, has on the scale as laid out the same relative position as 59 degrees Fahrenheit, 77 degrees Fahrenheit, 95 degrees Fahrenheit, etc. Also 5 degrees Centigrade has the same relative position as 15 degrees Centigrade, 25 degrees Centigrade, 35 degrees Centigrade.

To use this chart the whole degrees of either the Fahrenheit or Centigrade thermometers are found opposite each other in corresponding columns on either side of the scales. For example, 185 degrees Fahrenheit, which is found in column *J* of the right-hand side, has its equivalent in column *J* of the left-hand side directly opposite, namely, 85 degrees Centigrade. For tenths of a degree of either thermometer the corresponding tenths of the other thermometer are read directly from the scale, i.e., if the example had been to find the Centigrade equivalent to 185.5 degrees Fahrenheit, the whole degrees would have been read as stated from the chart,



SCALE AND TABLE GIVING EQUIVALENT GRADUATIONS OF THE FAHRENHEIT AND CENTIGRADE THERMOMETERS

*Copyright, 1908, by M. T. Hand.

while the graduation of the right or Fahrenheit side of the scale, five divisions above the horizontal line marked 185 degrees Fahrenheit, is at once seen to be opposite the graduation equivalent to 0.28 degree on the Centigrade scale. Therefore, 185.5 degrees Fahrenheit equals 85.28 degrees Centigrade. To familiarize the reader with this process several examples and answers are given below.

Examples

Change 296.8 degrees Fahrenheit to Centigrade: 296 degrees Fahrenheit is found in the right-hand chart column *Q*. In the left-hand chart column *Q*, and nearest the horizontal line opposite, is found 147 degrees Centigrade, while on the scale on the left-hand side and across from the graduation corresponding to 0.8 degree Fahrenheit above the horizontal line marked 296 degrees Fahrenheit is found the graduation to give 0.11 degree Centigrade. The total result is, therefore, 296.8 degrees Fahrenheit equals 147.11 degrees Centigrade.

Change 200.3 degrees Centigrade to its equivalent Fahrenheit reading: 200 degrees Centigrade is found in the left hand chart column *V*. In the right-hand chart column *V*, on the horizontal line opposite, is found 392 degrees Fahrenheit. As the top of the scale has been reached, return to the bottom for the fraction of a degree above 200 degrees Centigrade, and accordingly across from the graduation corresponding to 0.3 degree Centigrade at the extreme bottom of the scale is found the Fahrenheit scale graduation 0.54 degree Fahrenheit. Therefore, 200.3 degrees Centigrade is equal to 392.54 degrees Fahrenheit.**

Change 411.5 degrees Fahrenheit to Centigrade: 411 degrees Fahrenheit is found in column *X* on the right-hand chart. In the left-hand chart column *X* is found 211 degrees Centigrade on the horizontal line nearest opposite the horizontal line indicating 411 degrees Fahrenheit, but this line is above the Fahrenheit reading it is desired to transpose. It is, therefore, evident that the whole degree Centigrade corresponding to 411 degrees Fahrenheit is not 211 degrees Centigrade, but 210 degrees Centigrade. Then read the fractional part of the Fahrenheit temperature directly across from the 0.5 degree Fahrenheit scale as 0.81 degree Centigrade. Therefore, 411.5 degrees Fahrenheit is equal to 210.81 degrees Centigrade.†

A little practice will enable one to immediately make these transpositions from one thermometer reading to the other.

A "Valveless" Engine

By W. H. Booth

A novelty in engine work appeared at the Olympia exhibition of motor cars in London recently. It was described as a valveless engine and was of French origin. Actually, however, it was not a valveless engine, but was a curious adaptation of the slide valve with movable seat, of which one may read in Rankine. This particular adaptation is only rendered practicable by reason of the petrol engine being single-acting with an open-ended cylinder. Conceive of a cylinder with a bore about ½ inch larger than the piston, leaving an annular space between the cylinder and piston of ¼ or 5/16 of an inch. Into the closed end of the cylinder projects the cover, the projecting boss being of the same diameter as the piston, so that there is a deep annular space around the projecting boss.

In the cylinder, fitting closely one inside the other an easy working fit, are a pair of ground cylindrical shells longer than the cylinder and of such a thickness that while the smaller one fits nicely within the larger, the former acts as the cylinder for the piston and the larger one slides nicely inside the actual cylinder. The smaller shell projects farthest outside the open end of the cylinder and has upon it a pin attachment for a pivoted valve rod. The larger shell is a little short and has a similar attachment. The two are caused to work up and down by eccentrics on a shaft driven from the crank shaft of a 1:2 chain gear, so as to suit the Otto cycle of a petrol engine. Both shells project into the space about the cover projection.

The cylinder has an inlet port nearly halfway around it, a little below the cover projection, and an exhaust port at the same level nearly half around the opposite side of the cylinder. The inner shell has similar ports, also at the same level, and the outer shell has similar ports, but the exhaust port is larger than the inlet port. Both shells project up into the cover annular space, and the combination forms an annular slide valve with movable seat, thus securing with a short travel the operations of fuel inlet, compression, explosion and expulsion in the four-stroke cycle. Great saving is made over the ordinary [illegible] of valves.

To the ordinary motor car man [illegible] a mechanical [illegible] and that he [illegible] is a bad thing. It is curious that this should be so, for the gas engine was always held to have taken a new lease of life when the valves became [illegible] and the old slide valve dropped out. And the steam engine for highly superheated steam is not considered to be of any use unless it is fitted with valves of the [illegible] order. And here is the last word in petrol engines with two shells and the long rubbing surfaces and it is [illegible] because it is to cut out the [illegible].

So far [illegible] are saying everywhere that practically there were but two innovations in all that great space, since last year. One was that shell valve system and the other was [illegible] the adaptation of the Joy valve motion to the steam engine of the White steam car. The engine, which is compound, has the cylinders brought very close together so that there is a stiff, short crank shaft by reason of the [illegible] of the [illegible], rendered possible by the Joy gear. There was one other steam car in that big show besides the White (American) and the Turner (English) steam cars. This is the Rutherford. It does not seem a great number as a start for the eventual supremacy of the steam car which some, not without good reason, believe will occur. But it will need to move quickly, for motoring is not, I believe, so firmly established in certain directions as some people think. It is largely a flashy business, the sport of the wealthy, and very little more progress in the direction of the art of flying, as shown possible by the Wright brothers, may turn the craze for the last new thing in the direction of flying. Flying is an accomplished fact, and nothing is likely to prevent a very considerable advance during the next two years. Flying machines will become safer and anyone with room to house one and money to work it will be able to fly, with probably but little more risk, if so much, as when riding in a high speed motor car.

In certain quarters the flying machine is regarded as all important for war purposes. It may be of some service—I would prefer the word observation—in such a connection, but it will not be much good as a serious weight carrier and the day has gone by when a quick passenger would be valuable, for there is too much [illegible] about for that. Flying will be the hobby of the rich, and people who live by the roadside will welcome the change. There will be accidents at first, but chiefly to the riders themselves. But we are sorry to see so able a [illegible] and engineer as one of the Wrights coming to harm, for their achievement is very great. Not only have they solved the flying problem, they have shown that the machines can come to earth gently. This has [illegible] the doubts of many who, while believing flight to be possible, had fears that the alighting problem was not [illegible].

[illegible], the cylinder head of one of the engines in the [illegible] building, Boston, Mass., blew out and the flying pieces struck the other engine and "[illegible] it out of commission."

**Use especial care in reading from the bottom of the chart to add the total number of tenths corresponding to the Centigrade graduation, i.e., 0.9 degree Centigrade is equivalent to 16 tenths plus on the Fahrenheit thermometer scale, so that 200.9 degrees Centigrade is equivalent to 392 degrees Fahrenheit plus 1.62 degrees Fahrenheit or 393.62 degrees Fahrenheit.

††Use care when reading from the bottom of the Centigrade chart not to read 1 degree too high. The degree readings corresponding to the horizontal line at the extreme bottom of the chart have been omitted to avoid confusion by finding the same reading in two different columns.

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Contents PAGE

More Frequent Internal Inspection

Because a steam boiler is covered by an insurance policy is no ground to believe that it is safe to operate for twelve months without an internal inspection. Nevertheless, this is a view held by some engineers and more steam-plant owners.

An insurance policy covering a boiler risk is a mighty good document for two reasons: it demands the payment of damage losses, and practically insures a safely operated boiler because of the inspection feature which accompanies it.

There is no need of going into the question as to what the inspection of boilers amounts to; it is already known. However, the importance of frequent inspection is, in most cases, greatly underrated, not only by the engineer, but also by the insurance companies, although one company at least is sitting up and taking notice of its desirability. The practice has been to make three inspections each year, two external and one internal. While the external inspections are efficient as far as they go, they do not reach the vital parts of the boiler.

There are hundreds of engineers who never know whether the safety valve and the steam gage operate together until the inspector makes his quarterly visit. This is because the engineer has no means of checking up his steam gage for accuracy. The fact that the lever of a ball-and-lever safety valve is marked 100 at a certain point is no assurance that the valve will blow off at 100 pounds gage pressure. The external inspection takes in these matters and is, therefore, of value, especially in the smaller plants; but the internal inspection is the kind that counts most for safety and economy.

One inspection company which formerly made a practice of making two external and one internal inspections yearly, now not only makes the same number of external inspections, but has adopted semi-yearly internal inspection instead of annual. Surprising as it may seem, the cost of repairing defective boilers under the old method of inspection exceeded the losses due to violent explosion, and these losses are confined to ruptures and not mere bagging which results from scale, oil, etc. The twice-a-year internal inspection has so reduced these lesser losses that the company has found that although it costs more to operate the inspection department, due to the increased duties of the inspectors, the saving made in avoiding expensive repairs amply compensates for the extra work and expense involved. The insurance company is not the only party benefited, as the steam-plant owner is, under this new system, doubly sure that his boilers are kept in good condition, regardless of the qualifications of his engineer.

What is sauce for the goose is sauce for the gander. If the making of two internal inspections is a paying proposition to the insurance company it is a good thing for the engineer. True, most engineers do not yearn for the task of inspecting boilers, but it is a duty that must be performed, and if properly carried out is a remunerative investment, not only in dollars and cents but in ease of mind.

A perusal of the reports of boiler-insurance companies for a year will present a startling array of facts, and the most significant of all is the faulty condition of boilers, due to scale, etc., which good management and frequent inspections would have prevented.

There will doubtless be some opposition on the part of the steam-plant owner against the so-called hardship of cutting out a boiler twice a year for internal inspection and while, to some, it may be time and money ill spent, to the great majority it means the saving of time and money spent in repairs, when of a nature not covered by the risk.

In the steam plant not covered by an insurance policy, nor under the jurisdiction of a State inspector, it is the duty of the engineer-in-charge to keep his boiler in a safe condition. He has to say whether the boiler shall be internally inspected twice a year or not. The responsibility is his.

Turbine Condensers

We present in this number, among our leading articles, an abstract of a paper on "Surface Condensation for Steam Turbines," by Professor Josse, director of the engineering department at the Technical High School at Charlottenburg. This paper has already been commented on in our correspondence columns and has excited considerable interest. The curve sheets and table have been converted into English measures and are of more than passing interest.

To manufacturers and users of condensers this paper is of especial value, giving as it does additional data regarding the transfer of heat through tubes from steam to water, supplementing the excellent work of Weighton, Stanton and Morison in England, Ser and Joule in France and Hepburn in America.

The investigation of the heat transference between air and water is put out in excellent shape for use, as is also the problem of taking care of the air leakage into the condenser. The details of the wet-vacuum pump, as illustrated, show a development of the suction-valveless air pump somewhat different from similar pumps in the United States, and the manner of introducing the noncondensable vapors to the barrel of the pump is new. The piston speed of this pump, 260 feet per minute, would be considered quite too high for good results in this country, necessitating very light valves and valve springs.

Professor Josse's condensers are small

compared with surface condensers for turbine work as we know them, and Weighton's experimental condensers were even smaller. It is unfortunate that none of the larger condensers, say from 5000 to 10,000, or even 15,000 square feet of surface, has been tested to the point where the vacuum fell off from lack of ability to condense the steam, as otherwise an opinion might be formed as to the value of the coefficient of heat transference U under the condition obtaining in surface condensers of commercial size for turbine work.

Professor Josse's statement that the surface-condenser outfit for turbine work may cost thirty to sixty per cent. of the cost of the whole turbine plant, which presumably applies to marine work in Germany, is more than surprising.

Loss in Alternating Current Wires

When electric current passes "through" a wire the passage involves two losses, one of pressure or voltage and the other of energy, the latter being the consequence of the former. If the current is of the "direct" class and reasonably steady in value, the proportion of the applied pressure used up in forcing the current through is exactly the same as the proportion of the applied energy wasted by the resistance of the wire. That is to say, if the "drop" in the circuit is ten per cent. of the applied voltage, ten per cent. of the applied energy will be lost in forcing the remaining ninety per cent. through the circuit; if the "drop" is two per cent., then two per cent. of the applied energy will be used up in overcoming the resistance of the circuit, and so on.

When the current is either an alternating or a rapidly pulsating direct current such as some of the early arc-lighting dynamos yielded, the percentage of energy loss rarely equals the percentage of pressure "drop" in the circuit. The lower the power factor of the complete circuit and load, the greater will be the difference between the percentage of energy loss and that of pressure "drop," because a low power factor is due to a counter-electromotive force generated in the windings of the load apparatus and self-induced by the current in the circuit wires. The farther apart are the wires of a circuit, the greater will be its self-induction and the lower its power factor.

The practical moral of the foregoing explanation is that alternating-current circuit wires should be located as close together as the pressure and insulation will permit, and that the percentage of energy loss in a motor circuit, which is easily figured, is no criterion of the voltage drop, which is not easily figured and has an important influence on the torque of an induction motor. The motor torque varies as the square of the voltage at the terminals of the machine; consequently, an excessive drop in voltage in the circuit wires may reduce the torque of a motor seriously.

Natural Resources

On Friday, January 22, the Government closed the presentation of its case against the anthracite railroads. The hearing will be resumed on February 16, in New York, when the defendants will open their side of the case.

The Government has offered in evidence a table of statistics showing that of the 70,000,000 tons of coal produced, only about twenty-one per cent. was produced by independent operators, and about two-thirds of this is in the hands of the railroads by contract.

Have we learned the lesson of the coal fields?

Who could have foreseen, when Col. George Shoemaker brought a load of the black-rock fuel into Philadelphia and nearly got into jail for trying to sell it, that in about one hundred years the transportation and industries of the country and the comfort and well-being of the people would come to depend upon it more than upon any other one factor? Who could have foreseen the enormous possibilities of a perpetual corner in anthracite coal, and with what derision would a forecast of the present situation and an appeal to forestall it have been met.

And yet we are passing through another period of absorption of public resources by private interests. The possibility of electrical transmission has endowed water powers hitherto of little or no value with great earning capacities. While there might have been some difficulty in establishing a governmental or communal ownership of the coal fields, the constitutions of most of the States and of the United States itself establish the right of the people to the use of natural streams. The people should be very guarded in surrendering that right, and we notice with pleasure that the President has vetoed several bills transferring the public holdings in such properties to private interests. This policy should not be continued to a point which will discourage needed development, but such grants when made should be so guarded and restricted as to secure the immediate development of the site as opposed to speculative holding, and the supply of power therefrom to the public at prices which will pay a fair profit upon the actual investment.

A few years will see a large proportion of the industrial power of this country generated by falling water. [illegible] per cent. [illegible] Without such measures and restrictions the country [illegible]

[illegible] as it is now in [illegible]

Power from Niagara Limited

Although the ordinary discharge of the Niagara river is about 222,000 cubic feet per second, and it is commonly held that by utilizing the total fall between the lakes 7,400,000 horsepower are available, or 4,000,000 at the falls, it has recently been decided by this country and Canada to limit the total amount of water used for power purposes. A treaty has been drafted to this effect and doubtless will soon be ratified. Agitation on this subject has been rife for some time and arguments for the side of the power companies, appeals from the lovers of natural splendor, views of the hotel men and transportation companies and, finally, the economic aspect of the navigation on Lake Erie, have all been given due consideration and the result has been to limit the total amount of water used by the power companies in Canada to 36,000 cubic feet per second and those on the American side to 20,000 cubic feet, it being the opinion of the engineers of the International Waterways Commission that this amount would not be detrimental to the scenic effect.

In the foregoing perhaps the navigation should have been given first place, for it is reported that every 10,000 cubic feet per second of water [illegible] by the power companies lowers the level of Lake Erie by one inch. With large amounts engaged in the carrying trade [illegible] of draft represent a [illegible] of tons in freight capacity, and for this reason probably more than any other the amount of water for power purposes was restricted to [illegible] cubic feet per second. The treaty expressly provides that the level of Lake Erie shall be maintained, allowing, of course, for the natural fluctuations of the level.

During 1907 the mean discharge was [illegible] cubic feet per second, where the average for fifteen years previous to January, 1903, and to April 30, 1908, the discharge was [illegible] cubic feet per second.

From the scenic side of the question it would seem a hardship to limit the available supply of water to so small a percentage of the total, and at first sight it would appear to be sentimental extravagance on the part of Government [illegible] [illegible]

Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

Receiver Pressure Regulation for Compound Engines

In plants where low-pressure steam is used for heating or industrial purposes and where the amount of steam so used is less than the exhaust from the engines, it is often economy to use a compound engine, taking the low-pressure steam from the receiver. In such cases it is difficult by hand regulation of cutoff in the low-pressure cylinder to hold the receiver pressure constant, as the demand for steam or the load on the engine varies.

To secure this result, Charles T. Main, engineer, of 45 Milk street, Boston, Mass., has devised two forms of pressure regulator which have been installed in many plants on cross- and tandem-compound engines. The two types are used as best meets conditions. The advantages claimed to be secured are more uniform pressure in the receiver than is possible by any other means, thus giving a uniform steam supply, and saving of fuel by avoiding the blowing off of steam through relief valves or the supply of high-pressure steam to the receiver through reducing valves.

In Type A regulator, Fig. 1, there is a small cylinder *C* in which is a piston *P*, with the receiver pressure admitted to the cylinder below the piston. Above the piston the cylinder is open to the atmosphere. The piston rods *R* and *R'* connect with the arm *A*, and through this move the trip rods of the valve gear *T* and *T'*. To the rod *R* is connected the arm *B* and on this arm are hung two weights *W* and *W'*.

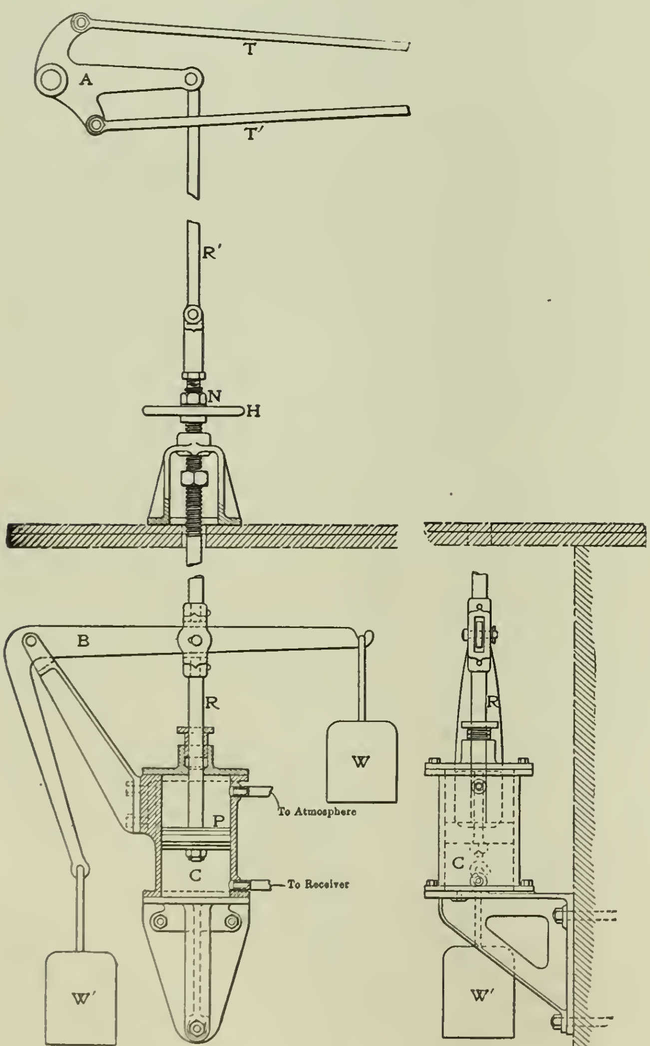


FIG. 1. TYPE "A" RECEIVER PRESSURE REGULATOR

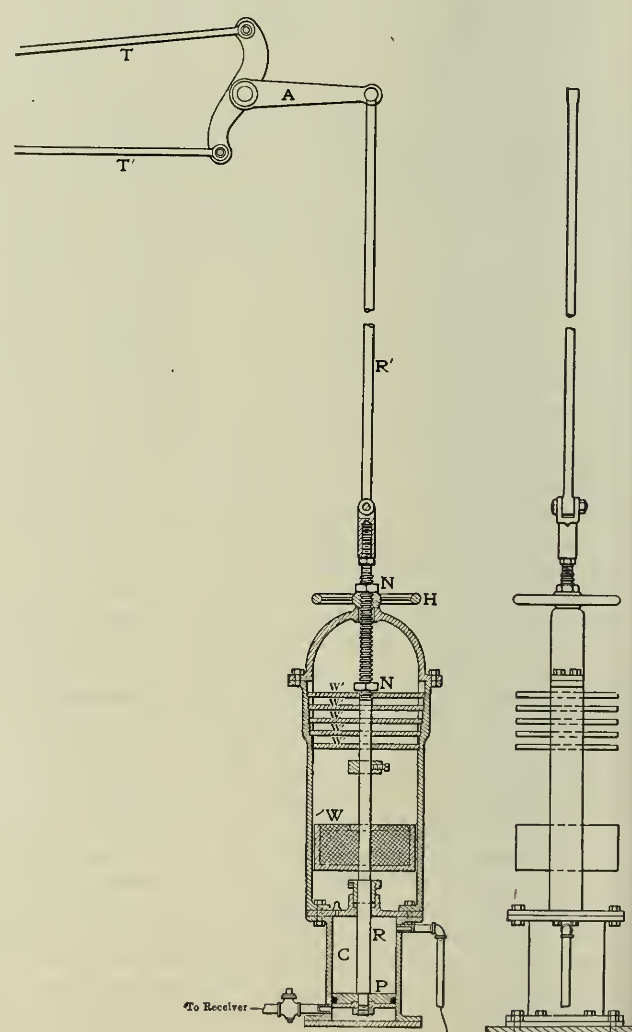


FIG. 2. TYPE "B" RECEIVER PRESSURE REGULATOR

When the pressure in the receiver increases, it raises the piston and increases the cutoff in the low-pressure cylinder; when the pressure falls, the weights bring down the piston, thus decreasing the cutoff in the low-pressure cylinder.

The weight *W* determines the lowest pressure to be carried in the receiver and the weight W'', as it swings from the vertical under pivot, balances the variable pressure from the shortest possible cut-off to full stroke on the low-pressure cylinder.

The hand-wheel H is used to get a long cutoff when starting up the engine, also to fix the minimum cutoff, or if desired to run with fixed cutoff. The nuts N and N' can be set to limit the range of cutoff.

Type B regulator works on the same principle, but has a series of weights W'', which are lifted in turn as the rod R rises. The weight W' determines the lowest receiver pressure and weights W'' balance the variable pressure through the extreme range of cutoff.

A Novel Design of Indicator

We illustrate herewith a novel design of steam-engine indicator, the joint invention of George A. Mower, of 147 Queen Victoria street, London, and James F. Gill. In this device perforated diagrams are obtained, the perforations being produced by the passage through the paper of an electrical current.

The apparatus comprises a cylinder A, piston B and calibrated springs C, as in the ordinary type, but as it is only necessary that the piston shall move to a very small extent, the cylinder A is made correspondingly short. Fixed rigidly to the piston B is a light metallic rod or

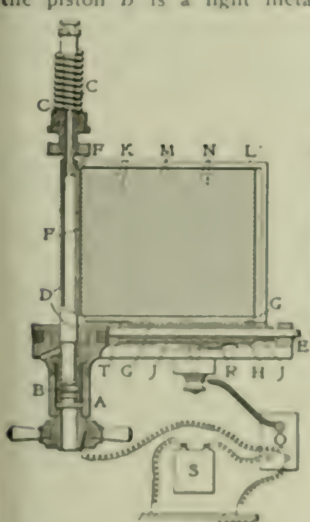


FIG. 1

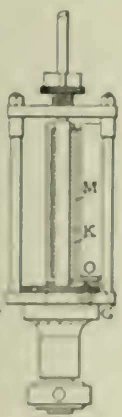


FIG. 2

FIG. 3

tube D with a series of short teeth F forming electrical contact points at equal intervals along its length. The teeth F are formed integrally with the piston rod D.

The laminated plate K is mounted on the frame of the indicator in an electrically insulated case L and is composed of a series of alternate strips of metal foil M and insulating material N. This laminated plate K is so disposed that the contact points F on the piston rod D just barely touch the edge of the laminated plate K. The series of metal-foil strips M is approximately the same in number as the contact points F on the piston rod D, but they are slightly differently pitched so that (as in a vernier scale) a limited movement of the piston will cause the

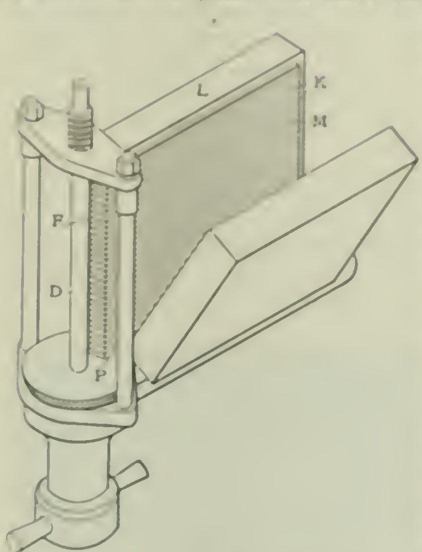


FIG. 4

metal strips M to be electrified in succession, one of the series of contact points F making electrical contact with one of the series of metal-foil strips M; thus as the piston moves up through its limited amount of travel the point of electrical contact will move through a large range on the plate K.

A similar laminated plate O of approximately the same size as the plate K is secured thereto by means of a hinge P and spring, so that it lies on the plate K with its conductors all at right angles to those on the plate K. A second metallic rod E arranged at right angles to, and with contact points G similar to those on the piston rod D, but insulated from the frame T of the apparatus, is arranged to move through a limited distance and to make electrical contact with the metal-foil strips on the second plate. The contact points G are on a tube H insulated from the rod E by the ebonite or other nonconducting sleeve J. This second rod E is connected through suitable reducing gear to the piston of the engine to be indicated. An electric-sparking coil Q with a safety spark gap is connected so that the current therefrom passes through the spring R [illegible] to the tube H and contact points G on the second rod E, thence to one of the metal-foil strips in the second laminated plate O, according to the position of the engine piston, thence to a metal-foil strip M in the first laminated plate K and out through the contact F on the piston rod D and casing of the indicator, thence to earth and back to the coil through the battery S.

To take a diagram: Open the apparatus as shown in Fig. 4, place a flat piece of any suitable paper between the two laminated plates K and O, secure them by the spring clip, attach the reducing gear to the piston of the engine and turn on the indicator cock, switch on the electricity and the current will flow, and its disruptive sparking action will pierce holes in the paper which is the only impediment in the path of the current. The position of these small holes will correspond to the intersection of the two conductors at right angles which are electrified at the same instant, thus producing a diagram from which may be obtained a true record of the variations of pressure in the engine cylinder. If this perforated diagram is placed on a page of a book and an inked roller passed over it, the diagram will appear, its boundaries being defined by small dots.—*Mechanical Engineer.*

Wagner Induction Motor Starter

The accompanying engraving illustrates the type of starting apparatus built by the Wagner Electric Manufacturing Company, St. Louis, Mo., for use with squirrel-cage polyphase induction motors of more than 5 horsepower. The starter is of the autotransformer class, with the transformer inclosed in one iron case and the switch inclosed in another which is oil-filled. The transformer is provided with a number of sub-voltage taps giving different percentages of full voltage, and from which any desired tap may be se-

[illegible]

lected, the permanent wiring to the switch after one or two trials under actual running conditions.

The switch, as will be noted from an inspection of the illustration, is of the drum type, [illegible] mechanism is equipped with a quick-action make-and-break [illegible] to the minimum the possibility of arcing between the [illegible] starting the motor the handle is moved always in the one direction. It may be turned back to the "off" position only from the first starting position; after once passing the first starting position it cannot be carried to the "off" position except by moving it through all of the succeeding positions.

In the "off" position the transformer and motor are both dead. Upon turning the operating handle into the first starting position the motor is connected to the sub-voltage tap of the transformer, with the fuses short-circuited; the connections thus established cause the compensator to deliver sufficient pressure to start the motor with minimum line disturbance. Turning the handle to the second position connects the motor to the full voltage and disconnects the autotransformer, the fuses being still short-circuited. Finally, in the third or full running position the fuses are cut into the circuit. This starter may be used in connection with any standard make of squirrel-cage motor. It is built for two- and three-phase work at any of the standard voltages.

Dinner to N. A. S. E. Officers

Friday evening, January 22, the Chicago Association of the N. A. S. E. gave a dinner to the officers of the national body at the Boston oyster house. The dinner was entirely informal, as it was arranged simply because of the officers' presence in Chicago on business connected with the association.

John F. McGrath, of No. 28, was master of ceremonies, and all the distinguished visitors were asked to say a few words to the assembled members and friends. The speakers were introduced in the following order: Fred J. Fisher, of Los Angeles, Cal., national president; Joseph F. Carney, of New York, past national president; William J. Reynolds, of Hoboken, N. J., national vice-president; Royal D. Tomlinson, of Milwaukee, past national president; John W. Lane, of Chicago, editor of *National Engineer*; John A. Kerby of Cincinnati, E. J. Lee of Albany, N. Y., J. H. Van Arsdale of St. Louis, W. W. McLane of Boston and Alfred Johnson of Chicago, trustees; F. W. Raven, of Chicago, national secretary. Nearly two hundred members participated in the enjoyment.

Hoboken Association No. 5, National Association of Stationary Engineers, will hold its annual entertainment and ball at Odd Fellows' hall, on February 9. The committee has prepared a first-class entertainment, and it is expected that the event will be up to the usual high standard.

Silk City Council No. 18 (Paterson, N. J.), Universal Craftsmen, Council of Engineers, will hold its annual entertainment and reception on February 12. A good time is assured.

Technical Education

By H. Addison Johnston

The trouble with the ordinary technical graduate is that when he gets his diploma, and can play three scales and "Home, Sweet Home" on the engineering piano with one finger, he thinks he is second only to Paderewski. He forgets, or rather he has never realized, that long experience in actual construction is necessary before he can safely and surely apply his mathematical theories to everyday work.

The engineering school does teach a man a whole lot about *how* to build engines, that it is very essential that he should know, but the only way to learn *to build* engines is to build engines. In this connection, hear the sad story of Jones:

Jones was a young, quite recent, technical graduate, and what he did not know about engineering was not worth knowing. Jones had not specialized particularly on thermodynamics, but he thought he knew something about it, and there is no doubt that he passed his examinations. Jones was great on accurate calculations; nothing worried him so much as leaving off the decimals; why, he could figure out the proper diameter of a staybolt to nine places of decimals and tell the probable error and all that. Jones was a very decent fellow, but one thing he hated, and that was to notice those awful, inaccurate, rule-of-thumb methods which prevailed in some shops. Why, in one shop Jones had visited, instead of having the last batch of bolt iron properly tested as to its elastic limit, ultimate tensile strength and resistance to shear, and calculating the allowable stresses and figuring a factor of safety, the superintendent had just casually remarked that he "guessed six five-eighth bolts would do for that there flange," and that was all there was about it. It was simply shocking that such practices were allowed in this scientific age.

Well, one day, at the club, Jones was comfortably explaining to the company the beautiful accuracy of scientific mathematical calculation as compared with the unreliable guesswork of cut-and-try schemes, when an acquaintance, Brown, by name, who was in the gas-engine business, asked him if he could give any simple, accurate method of calculating the compression pressure in a gasolene-engine cylinder when the percentage of clearance was known.

"Why, certainly," said Jones, swallowing the bait whole, quite pleased at the opportunity to be of assistance. "The pressure of a gas varies inversely as the volume, 'Mariotte's law,' you know. Pressure multiplied by volume before compression equals pressure by volume after compression, like this," and he stepped to a small blackboard and wrote:

$$P_1 V_1 = P_2 V_2.$$

"Oh! I see," said Brown, who knew something of mathematics himself, even though he was a practical man. "Well, just for an example, what would a pressure gage show the compression to be on an engine with, say, 20 per cent. of the total cylinder volume as clearance?"

"That's easy," replied Jones. "The normal air pressure is 14.7 pounds, and we call the total volume 100; then the clearance will be 20." Then he laid out the following:

$$P_1 = 14.7. \quad V_1 = 100. \quad V_2 = 20.$$

$$P_1 V_1 = P_2 V_2. \quad P_2 = 73.5.$$

"There, that's it: 73.5 pounds compression."

"Must be something wrong," said Brown. "I saw an engine with 20 per cent. clearance tested and it had 110 pounds."

Jones checked over his figures. "Can't find anything wrong with the figures; must be the equation that's wrong. Um—um. Say! that equation is wrong. I have got the isothermal instead of the adiabatic equation. You see the air gets hot when it is compressed and that runs the pressure up. I should have written the equation this way:"

$$P_1 V_1^{1.41} = P_2 V_2^{1.41}.$$

"I guess this will bring it out about right."

Jones always carries a little table of logarithms in his pocket and pretty soon he said, rather dubiously: "That works out to 142 pounds compression; seems about as far out too high as the first one was too low."

"Well, put it on the board beside the other, anyway," said Brown. "After awhile we'll average them up. Looks to me, though, that you forgot to subtract 14.7 from your figure to get the gage pressure. You've got the absolute."

"Why, so I have," replied Jones. "Never thought of that; but, say, that first figure was too high by the same amount. It should have been only 58.8 pounds. The last one looks a little better now, though; 142 — 14.7 = 127 pounds compression gage. That engine you saw must have had leaks in it."

"No it didn't," said Brown. "But it strikes me the Prof. John Perry says that 1.41 is too high for air; 1.37 is the proper figure."

"Well, perhaps it is," said Jones, looking slightly worried. "I'll work it out."

Jones works out again:

$$P_1 V_1^{1.37} = P_2 V_2^{1.37}.$$

$$P_2 = 119$$

pounds gage.

"Getting closer," said Brown. "But that's too high yet; now I come to think of it, some other fellow says that 1.33 is the proper figure to use instead of 1.37."

Jones works out once more:

$$P_1 V_1^{1.33} = P_2 V_2^{1.33}.$$

$$P_2 = 111$$

pounds gage.

"There, that's right," he exclaimed. "Your pressure gage must have read a pound too low."

"Perhaps it did," replied Brown. "But it seems to me that you have missed something. You see there is always a slight vacuum in a gas-engine cylinder at the end of the suction stroke. The piston moves out so fast that the air cannot get through the valve quick enough to keep up the pressure. I don't suppose the pressure would be over 14 pounds in some engines when the piston started on the compression stroke."

Jones said nothing, but worked it out with the new value for p_1:

$$P_1 V_1^{1.3} = P_2 V_2^{1.3}.$$

$$P_1 = 14 \text{ pounds}; \frac{V_1}{V_2} = \frac{100}{20} \quad P_2 = 106$$

pounds gage.

"This is rotten," said Jones. "It's getting worse."

"We've only a few more left," said Brown. "Have you ever noticed that these mechanically operated inlet valves do not close until the piston has moved back about 5 per cent. of the compression stroke? You did not take that into account."

"Oh, well, I'll work it out a few times more," said Jones, crossly. "That 5 per cent. loss will just about have the effect of increasing the clearance to 21 per cent. instead of 20 per cent.

$$P_1 V_1^{1.3} = P_2 V_2^{1.3}.$$

$$P_1 = 14. \quad \frac{V_1}{V_2} = \frac{100}{21}.$$

$$P_2 = 97$$

pounds gage.

"Jones, there's another thing we did not take into account," said Brown. "There's a whole lot of hot exhaust gas in the cylinder that's going to warm up the charge and send the pressure up a little."

"Yes," snapped Jones, "and now you mention heat, I suppose the cold fresh charge will be warmed by contact with the warm cylinder walls, to begin with, and the hot compressed charge will be cooled by contact with the warm cylinder walls, to finish with, and little drops of gasolene will make some vapor and raise the pressure, and little leaks around the piston will lower the pressure, and if you know any more little variable constants or constantly varying variables, why spring them now."

"Cheer up," said Brown. "Don't get worried. Just add up all the half dozen results you've got and strike an average."

Jones worked out

$$\frac{127 + 119 + 111 + 106 + 97}{5} = 112$$

pounds gage.

"Just about right, eh?"

"Well, almost for the engine I saw," said Brown, getting up to go.

"Hold on!" cried Jones. "how the deuce do you figure your compression space to get the right pressure?"

"Well, I'll tell you," replied Brown, "though it's a secret and I wouldn't have it leak out for anything. When we get out a new type of engine we open our mouth and shut our eyes and make a real good guess; then, if the pressure doesn't suit, we juggle the length of the connecting rod or the depth of the cylinder head until it does."

Alfred R. Wolff

We present herewith a likeness of the late Alfred R. Wolff, whose death, on January 7, was announced in the January 19 number. As previously stated, Mr. Wolff was one of the foremost heating

THE LATE ALFRED R. WOLFF

and ventilating engineers in the United States. He was a charter member of the American Society of Mechanical Engineers. In 1880 he started a general engineering practice at 88 Park Row, New York, removing in [illegible] to the [illegible] He took up the designs of power, heating and ventilating plants and established a practice which extended over a period of twenty-eight years. He was a member of the Engineers' Club. Mr. Wolff's practice of consulting engineer for power-plant, heating and ventilating installations has been taken over by Messrs. Nygren, [illegible] Tenney and Arthur K. Ohmes, under the firm name of Nygren, Tenney & Ohmes, with offices in [illegible] building, corner of Fulton and Nassau streets, New York City.

Marine Engineers' Convention

The thirty-fourth annual convention of the National Marine Engineers' Beneficial Association was held in Washington, D. C., during the week beginning January 18, with headquarters at the Ebbitt house. There were about one hundred delegates in attendance. The reports showed the organization to be in a prosperous condition. The National Marine Engineers' Supplymen's Association, also in session at the Ebbitt house, entertained the delegates and guests during the week with trolley rides, theater parties, etc.

The leading social feature was a smoker held in the ballroom of the New Willard hotel, at which there was an attendance of about four hundred, including many Government officials. The entertainment was first-class in every particular, the entire company going from New York City especially for this occasion. On Wednesday afternoon the visitors were received by President Roosevelt, who was present at the meeting and congratulated the members of the association upon their high standing in the engineering world. The President shook hands with each visitor.

On Thursday the following national officers were elected: W. F. Yates, president; [illegible], first vice-president; W. P. [illegible], second vice-president; C. N. [illegible], third vice-president; George A. [illegible], secretary; [illegible] Jones, national treasurer; W. D. [illegible], [illegible], E. J. Houghton, advisory board; [illegible] Smith, trustee. The election of officers of the supplymen's association resulted as follows: Herbert [illegible], president; John W. [illegible], vice-president; [illegible], secretary-treasurer.

Combined Associations, N. A. S. E.

The seventh annual entertainment and ball of the Combined Associations of the National Association of Stationary Engineers of Manhattan and the Bronx, New York, was held at the Grand Central Palace Saturday evening, January 23. The attendance was larger than ever before. The hall was beautifully decorated with streamers, floral and flag effects. An [illegible] vaudeville performance was given, after which the hall was cleared for dancing. [illegible] Dancing and [illegible] many [illegible] being [illegible] of the [illegible] Besides [illegible] were [illegible] prominent engineers and [illegible]. There were [illegible] of the leading engineering [illegible] on the list of patrons.

The officers of the Combined Associations are: Fred [illegible], chairman; J. R. [illegible], vice-chairman; [illegible], treasurer; J. [illegible], secretary. The grand success of the [illegible] was due to the [illegible] combined, earnest efforts of the officers and the several committees, who deserved the hearty praise bestowed upon them.

Eccentric Firemen's Ball

The fourteenth annual entertainment and ball of the Eccentric Association of Firemen, Local No. 56, I. B. of S. F., of New York, was held at Grand Central Palace on Saturday evening, January 23. The large and prettily decorated hall was filled to its capacity. A vaudeville performance preceded a long dancing program, and goodby's were said after a most enjoyable night. This event always attracts many people prominent in the engineering world, and besides these there were present a number of distinguished guests, including J. Pierpont Morgan and daughters, William K. Vanderbilt, Postmaster E. M. Morgan and wife and Lewis Nixon.

Business Items

Schuchardt & Schutte have removed their New York offices and warerooms from 136 Liberty street to the West Street building, 90 West street.

Arthur Hoyt Bogue has resigned as general manager of the Atlas Preservative Company of America and has opened an office as manufacturers' direct representative at 142 Pearl street, New York.

Jersey City Association No. 1, N. A. S. E., wishes to get manufacturers' catalogs, samples, etc., for its meeting room. Such catalogs should be sent to John T. McEntee, secretary, 295 Third street, Jersey City, N. J.

John P. Cosgro, who during the past few years has spent considerable time in the southwestern part of this country and the northern States of Mexico, has been appointed district manager of the Allis-Chalmers Company, with offices in the El Paso & Southwestern building, El Paso, Tex.

Henry I. Lea, who has been associated with the Emerson McMillin and the Dawes syndicates, the Western Gas Construction Company and the Westinghouse Machine Company, has opened an office in Room 616, The Rookery, Chicago, Ill., as gas engineer. He will design, construct or manage gas works and make examinations and reports.

Cyrl J. Atkinson, designer of the Atkinson gas producer, which has been manufactured by the Industrial Gas Power Company, lately severed his connection with that company, and is now located with the Dornfeld-Kunert Company, of Watertown, Wis., which is building under his management and supervision improved forms of his gas producer, both of the suction and pressure types.

The copartnership heretofore existing between Frank B. Williams and George H. Williams, doing business under the firm name of I. B. Williams & Sons, Dover, N. H., has been dissolved by mutual consent, George H. Williams retiring. The business, that of making leather belting, will be carried on in future under the same firm name by Frank B. Williams, who assumes all outstanding obligations.

The Minneapolis Steel and Machinery Company has been given the contract for furnishing the new engine for elevator "D" of the Consolidated Elevator Company, Duluth, Minn. They will install a 26- and 52- by 48-inch vertical tandem compound Twin City Corliss engine, with flywheel 16 feet in diameter grooved for twenty two 2-inch ropes. The entire engine will be completed by April.

The National Tube Company has just issued a handsome pamphlet under the title of "Shelby Steel Tubes and Their Making." After a brief review of the history of the art, the seamless process is described step by step, illustrated by numerous half-tone reproductions of photographs of the processes and the product in the various stages. It is beautifully printed upon heavy plate paper and will make an attractive and interesting addition to the library of an engineer.

Edward C. Brown, manager of the Hawaiian office of the Dearborn Drug and Chemical Works, at 42 Queen street, Honolulu, is making an extensive oriental trip of three or four months, during which he will visit Japan, the important seacoast cities of China, Australia, the Philippines, Java and other important islands in the Pacific ocean. Mr. Brown has most successfully handled the Dearborn company's business in the Hawaiian islands since that department was opened some ten years ago.

The Lagonda Manufacturing Company is distributing an interesting booklet of twenty-four pages on "The Scale Question." The booklet gives numerous facts about steam-power plant economy and protection and will interest all who own or have charge of boilers, economizers, condensers, etc. Among the new Lagonda products described therein is the Weinland air-driven wing-head cleaner. This machine is a miniature rotary engine which goes into the tube and rotates the cleaning head in much the same manner as a turbine does, but is claimed to be more powerful. The booklet will be sent to all who write to the Lagonda Manufacturing Company, Springfield, O.

New Equipment

It is said the McCook (Neb.) Electric Light Company is planning to rebuild its plant.

The Mammoth Spring (Ark.) Electric Light Company will rebuild its burned plant.

E. C. Bowman, Birmingham, Ala., contemplates the construction of a cold-storage plant.

The Houston (Tex.) Electric Company is planning the installation of additional equipment.

The Carthage (N. Y.) Electric Light and Power Company is planning to install another generator.

The citizens of Glasgow, Mont., voted to issue $50,000 bonds for water works. J. J. Mullins, town clerk.

The Ocala (Fla.) Ice and Packing Company will increase the capacity of its ice and cold-storage plant.

G. W. Cavanah, town clerk, Sebree, Ky., will receive bids until Feb. 15 for constructing water-works system.

J. Fletcher, owner of the electric-light plant at Wolsey, S. D., contemplates installing a new engine and generator.

The Ennis (Tex.) Ice, Light and Power Company contemplates installing a 200-horsepower boiler and engine.

The Valley Electric Company, New Brighton, Penn., is planning the installation of a 500-kilowatt turbine unit.

A new electric-light plant is to be built at the De Pauw University, Greencastle, Ind. R. L. O'Hara is president of board of trustees.

The City Council, Barberton, Ohio, is said to be considering the purchase of a new air compressor for the water-works plant, to cost about $8000.

The Lincoln (Ill.) Railway and Light Company has under consideration the question of installing a steam-heating plant using exhaust steam.

It is reported that a new dynamo and engine will be installed in the Municipal electric-light plant at Quincy, Fla. B. A. Puckett is manager.

The Skagit River Power Company, Denver, Colo., has completed plans for the construction of a 100,000-horsepower plant. E. M. Riggs is president.

A Low-Head Hydroelectric Development

An Interesting Plant at Milford, Maine, to Develop 12,000 Horsepower under a Head of 20 Feet, and Generate Three-phase 2200-volt Current

BY S. RICE

Low-head water-power developments are, as a class, of much greater importance to the country than those of any other type, both because of their numerical superiority and from the fact that the conditions which render them possible are more frequently met with near large manufacturing centers, where the current generated may be used, than are conditions necessary to high or medium heads, which require the vicinity of mountains, hills or unusual geological formations such as exist at Niagara.

At Milford, Me., there has been placed in successful operation one of the most interesting of the low-head power developments to be met with anywhere in the United States. The source of power is the Penobscot river, which flows in a group of lakes in Piscataquis county, not far from the Canadian border, and flows in a general southeasterly direction to

FIG. 1. THE DAM AND POWER HOUSE AT MILFORD

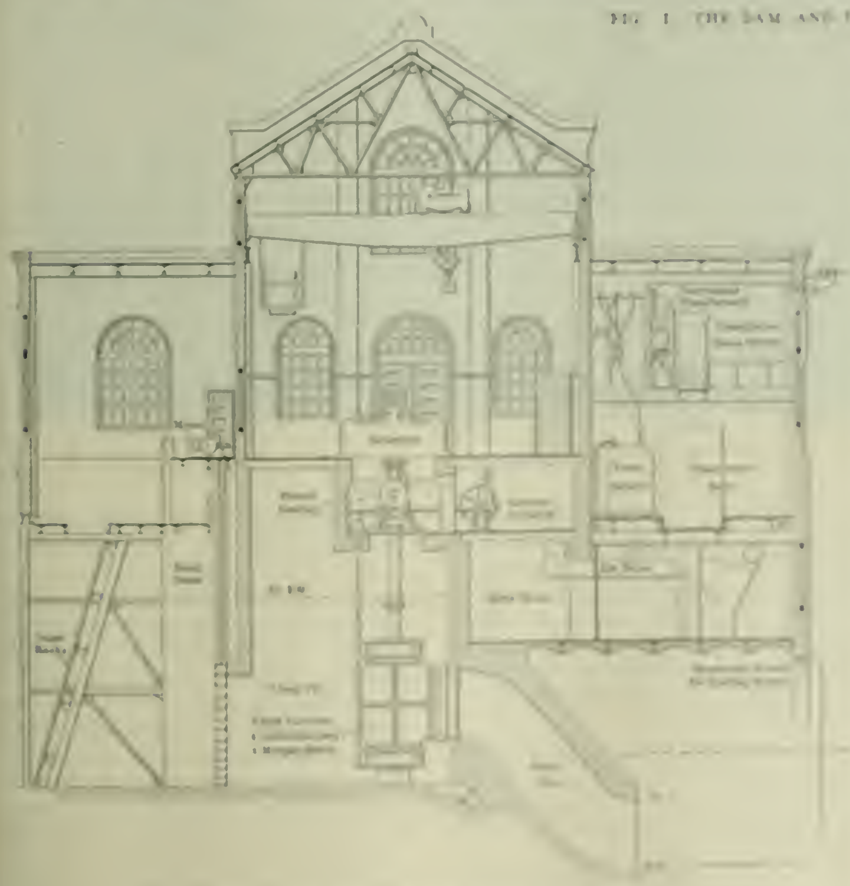


FIG. 2. SECTION OF POWER HOUSE THROUGH [illegible]

Penobscot bay, draining in the upper reaches a territory of about [illegible] square miles.

Near Millinocket, about [illegible] miles up the river from Milford, the Great Northern Paper Company has constructed a dam, where about [illegible] horsepower is developed under a [illegible]-foot head and used to operate electric generators to supply current for motor drive throughout the company's mills. The [illegible] made by damming the Penobscot river at this point create storage for about [illegible] cubic feet of water, and the Great Northern Paper Company is under contract with the governmental authorities to let down a minimum of [illegible] cubic feet of water per second.

South of Millinocket the highest head of water is found at Milford, where the total fall of the river from the source, as shown by the U. S. Geological Survey, is approximately [illegible] feet, and there the Bodwell Water Power Company has built a plant to develop [illegible] horsepower under the normal working head of 20 feet. The immediate cause of erecting a central power station at this point was the opportunity to contract to [illegible] to be furnished the [illegible] Manufacturing Company located at [illegible], about [illegible] miles distant, but there are quite a number of paper mills and other industrial establishments in the vicinity of Milford, and the manufacturing city of Bangor is situated on the river 10 miles below; so that there was every prospect of being able to dispose continuously of the full available quantity of current, and this expectation has been realized.

Across the river from Milford, in the vicinity of Old Town, are two woolen mills and a pulp mill, water for which is taken from the river through a canal discharging below the new dam; but the amount of power diverted by this means is not enough seriously to affect the Bodwell company's project.

Concrete Dam

The dam built by that company extends 1000 feet from the new power house to the abutments of the canal above mentioned on the western side of the river. This is of solid concrete construction, 12 feet wide on the crest and varying from 14 to 32 feet at the base. This latter difference is accounted for by the irregularity of the bed of the stream, necessitating stronger and wider foundations in its deeper parts. The spillway extends the entire length of the dam, and there are no openings with the exception of a 25-foot log sluice next to the power house and adjoining the dam on the eastern side and a fishway 30 feet at the bottom and 10 feet at the top, which extends between the log sluice and the power house. These are controlled by steel gates, motor-operated.

Power House

The power house is located at the easterly end of the dam on the Milford side, being constructed of concrete as far as the generator floor and having brick walls above that level. It has a length of 225 feet 10 inches and a width of 84 feet 8 inches and is divided into three main parts. The central part, with pitch roof, contains the hydraulic turbines and governors and the electric generators; the up-stream aisle contains the rack and flume gates and the down-stream aisle houses the auxiliary electrical machinery and other apparatus.

Up to elevation 115, which is 15 feet above the crest of the dam, or datum, the foundations and walls are of concrete. All walls above this elevation are of brick surrounding a steel frame. There are two sets of racks, outer and inner, the former being placed a short distance up stream from the power house. These are built of structural-steel frames, securely braced, and extend 6 to 7 feet above the crest of the dam. The general construction is clearly shown in the side elevations of the power house. The steel gates are motor-operated. All of the rigging is so arranged that there are no gears or other appliances liable to be clogged or have their operation interfered with by ice or other débris that may be carried through the racks. Water enters to each turbine through a separate flume, the walls of which are of concrete reinforced with steel. Discharge is directly into the river below the dam.

FIG. 3. THE GENERATORS AND EXCITER UNIT

The Turbines

The hydraulic turbines are built for operating at their best efficiency under a head of 20 feet and a speed of 150 revolutions per minute. Under these conditions the flow of water through each is at the rate of 483 cubic feet per second, with delivery of 875 horsepower. Each turbine has two 45-inch runners of the Francis type, mounted on a heavy vertical shaft and with central discharge casing connected to a draft tube built of reinforced concrete. Every portion is easy of access for inspection and repairs. The water flow is regulated by movable vanes, operated by vertical shafts and levers from the piston of an oil-pressure governor.

The head under which these turbines run will be increased, perhaps as much as 5 feet, by the raising of the head water, and it is also expected farther to increase the head by improvements in the river below the power plant, bringing the tail

FIG. 4. ONE OF THE ALLIS-CHALMERS TWIN TURBINES

water down nearly or quite to the top of the outlet of the draft tubes and making the ordinary working head from 25 to 27 feet. The dam was built heavy enough to have the required hight added, and grooves were left in the top of the structure for bonding. The wheels are built for operating at their best efficiency under a head of 20 feet at the speed above noted; but with a head of 25 feet the percentage of efficiency will not be materially reduced. Under a 14 foot head normal speed is also maintained and the output is relatively high. All parts are so proportioned that, when running under the full contemplated head of 27 feet, the machine will stand the operating stresses within a liberal factor of safety.

As a water power is of highest economy when the energy developed from the natural resources available is the largest under all operating conditions, a lowering of 6 inches, or 30 per cent., of the available head will cause serious reduction of the capacity of the plant, if the turbines are not designed with careful consideration of such conditions. The speed of the 875-horsepower units being specified as 150 revolutions per minute, this must also be maintained at the low head of 14 feet caused by backwater in the river at time of flood, and it is here that the turbines should develop as much power as possible.

While it is not difficult to design a turbine to meet the requirements of speed and power at 20 feet and at the same time show a good efficiency, it calls for more than ordinary engineering skill also to obtain satisfactory results under the reduced head of 14 feet. It must be borne in mind that when tests are conducted in the flume at Holyoke to prove the efficiency of the turbine, such tests have to be made at a head which does not vary much. It is, therefore, an easy task to design a runner which shows up nicely at Holyoke, while it is questionable whether such a runner will give in operation a result which is the most satisfactory commercially. Many engineers believe that they secure a high grade wheel when they note on the test sheet that the efficiency exceeds 80 per cent., and quite often this very turbine will not be as good an earner of money in the plant as another one which probably showed less efficiency at Holyoke, but was designed to be better adapted for the commercial-operating conditions. From this point of view the special turbines at Milford were designed, and it is not surprising that their performance has given satisfaction and an unusually high efficiency obtained.

Between each turbine and generator, in the basement above the wheel, is a thrust bearing carried by a cast-iron base ring grouted into the concrete arch over the turbine pit at elevation 107. Each of the bearings originally used with the first of the units to be installed consisted of two cast iron disks with an annular groove to which oil was supplied at 225 pounds pressure. This made an excellent bearing but was expensive to maintain and entailed too great risk in operation, as an accident or wrong manipulation by an operator, resulting in derangement of the mechanism, might not only cause the pressure to drop or be lost entirely, but would cause every unit running at the time to be put out of commission, entirely ruining the disks the moment they came in contact and tying up the plant most effectually until each unit had been dismantled and the defect repaired.

After a brief operating experience, during which disaster was several times avoided by a close margin, it was decided to equip all of the units in the station with oil-bath bearings, which, being self-contained and floating in oil, not only require very little attention and no auxiliary apparatus and consequently reduce the number of operatives necessary, but also eliminate any danger from a sudden shut-down and effect a saving of over [illegible] per cent. in oil. The starting up of the first unit with which the new oil-bath bearing was equipped, full load was put on the machine within a few minutes' time and the unit has been in continuous operation ever since, at decreased temperature, with no change of oil.

For each of the turbines in this station there has been provided a vertical oil-pressure governor, so arranged as to be visible either from the switchboard or any portion of the main floor. These governors can be controlled by electric switchboard connection, automatic regulation by flyballs or hand regulation. They are driven from the wheel shafts through bevel gears, shafting and link belting. Each governor is cylindrical in form and made up of two chambers, the upper being an oil and the lower a pressure chamber; the latter has an oil gage and a pressure gage, so that the volume of air and oil and existing pressure are always in plain view, and it is provided with an adjustable safety valve. Between the two chambers lies a horizontal differential cylinder, the piston of which is directly connected to the regulating shaft.

The oil pump is of the rotary type and placed in the oil reservoir. It is self-lubricating and is connected by a shaft projecting through the casing, directly with the turbine. The chain which forms a part of the connecting mechanism is easily detached. The flyballs, which are designed as a sensitive but absolutely static apparatus, are tested and carefully adjusted to the required percentage in change in speed. They are driven by

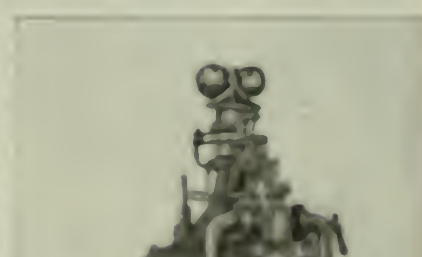


FIG. 5. ALLIS-CHALMERS GOVERNOR

means of a bevel gear located in the oil reservoir and can be started or stopped by means of a friction-clutch coupling, without stopping the pump. The regulating valve is not rigidly connected to the floating lever of the flyballs, but is balanced.

Generator Equipment

The generator room contains [illegible]

of the power plant and is 36 feet wide. Room is provided for 12 alternating-current generator units of 750 kilowatts capacity each and one 300-kilowatt exciter unit, the distance between units being 16 feet. Another exciter of 200 kilowatts capacity is driven by a three-phase, 2200-volt induction motor and placed below the switchboard gallery in the same bay.

The generators are of the revolving-field type, three-phase, 25 cycles, delivering current at a terminal pressure of 2200 volts. Excitation is 120-180 amperes at 125 volts. The switchboard is of blue Vermont marble and located in a gallery 15 feet above the floor. It consists of the usual complement of generator, feeder and exciter panels and special regulator and auxiliary-circuit panels. For all 2200-volt connections oil switches are used. They are located in concrete cells on the thrust-bearing floor directly underneath the switchboard. The power transformers, designed to step up from 2200 to 22,000 volts, are placed in the basement of the south bay, and in the room above are two banks of instrument transformers. The station is served by a 25-ton Niles crane, electrically operated, and is heated by the blower system, a motor-driven Sturtevant blower being placed in a subbasement under the transformers.

FIG. 6. SWITCHBOARD GALLERY

Miscellaneous Improvements

By W. H. Wakeman

Fig. 1 illustrates the governor of a Putnam engine, with its substitute for a dashpot, which is designed as follows: The column of this governor is hollow and contains a rod which connects the inner ends of the fly-ball arm to the hollow casting *A* that is pivoted to the lever *B* and is carried by a shaft, one end of which rests in the bearing *C*. The cap on this bearing is lined with leather instead of babbitt metal, and it is held in place and clamped on the shaft by one cap screw. When the governor balls rise, *A* falls, and *vice versa*, thus causing the shaft to turn slightly in the bearing *C*. As it does not move freely it offers resistance to rapid changes in the position of the governor balls; therefore, it is a very good substitute for a dashpot.

The leather lining is durable but, of course, it wears slowly, and when it becomes too loose the engine races. To remedy this defect it is only necessary to tighten the cap screw. One day this engine raced when starting up, which was very unusual, and applying the natural remedy made no improvement because the cap was what would be called "brass bound," if it were on the crank pin of an engine; therefore, it could not be tightened until repaired. To turn out the cap screw, remove the cap and take out the leather lining was a short job, and as it would take several minutes to fit a new leather lining into place, a piece of writing paper was fitted into the cap and the leather put back. This was sufficient to give the cap a hold on the shaft, and provided enough friction to control the governor perfectly. The advantages of this method are that it required less than five minutes to do the job, and the perfect fit of the leather on the shaft was not disturbed. From present indications it will probably last a year.

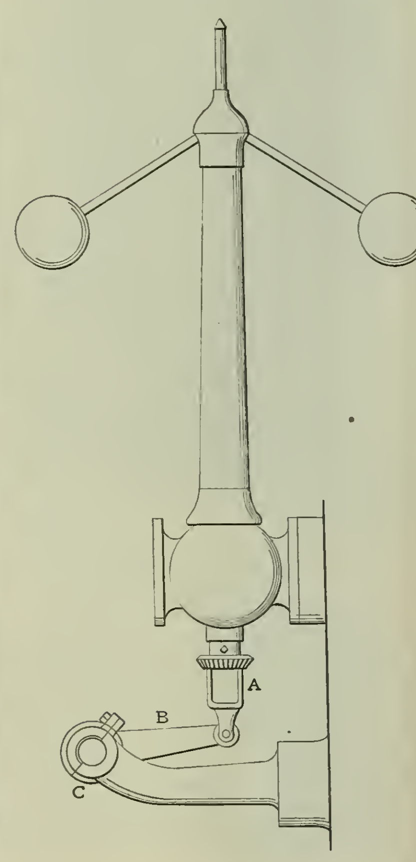


FIG. 1

The two pump governors shown in Fig. 2 are designed for 1½-inch pipe. The vertical central pipe is 2 inches, with a cross at its terminal, into each horizontal outlet of which a 1½-inch nipple was screwed, followed by a valve as shown. The connection between this valve and the pump governor on each side was originally 1½ inches, but proved to be too large for smooth running under existing conditions. A sediment catcher is located below the cross, also a trap for removing the water of condensation.

These governors control two duplex pumps, with 7½-inch steam pistons and 6-inch water cylinders, taking water under 20 pounds pressure and raising it to 45 pounds. As the area of a 6-inch circle is 28 square inches, and the actual pressure per square inch to be overcome by steam pressure is

$$45 - 20 = 25$$

pounds, the total resistance exclusive of friction is 700 pounds. The area of a 7½-inch circle is 44 square inches; therefore, it requires

$$700 \div 44 = 16$$

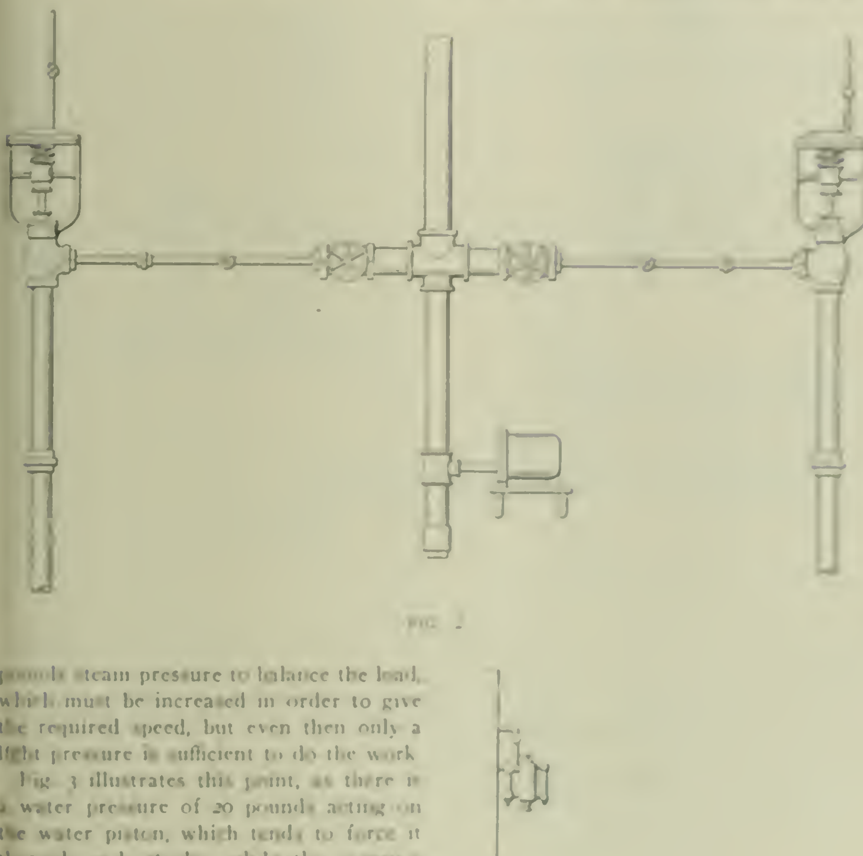


FIG. 2

pounds steam pressure to balance the load, which must be increased in order to give the required speed, but even then only a light pressure is sufficient to do the work.

Fig. 3 illustrates this point, as there is a water pressure of 20 pounds acting on the water piston, which tends to force it through each stroke, while the pressure on the opposite side is 45 pounds; therefore, only the difference is to be provided for. If the steam pistons of these pumps were 6 inches in diameter, the required pressure would be 25 pounds, and if they were only 5 inches it would be 37 pounds, which is about one-half of the boiler pressure. This would be more satisfactory for service in general, and for this case in particular. Only drip cocks are provided for the steam cylinder of each pump, and there is no drip pipe for the frame.

The 1½-inch pipe between the cross on one side and a governor on the other was taken out, bushings which reduced the openings to the right size for ½-inch pipe were substituted and a suitable connection as shown was made for one pump. The service rendered proved to be so much better that a similar change for the other soon followed, and both are now giving satisfaction. The reason for this is that when a large quantity of water was used, causing a sudden reduction of pressure, the governors responded quickly, giving a full charge of steam to the cylinders, as the pipe was large enough to supply the necessary quantity. The re[illegible]

[illegible] tolerated in that place.

The governors respond now as readily as before the steam pipes were reduced, because they depend on the water pressure, but the quantity of steam that can be admitted in a given time is much less than formerly; therefore, the pistons do not start quickly enough to cause pounding in the water cylinders and pipes, yet [illegible]

[illegible]

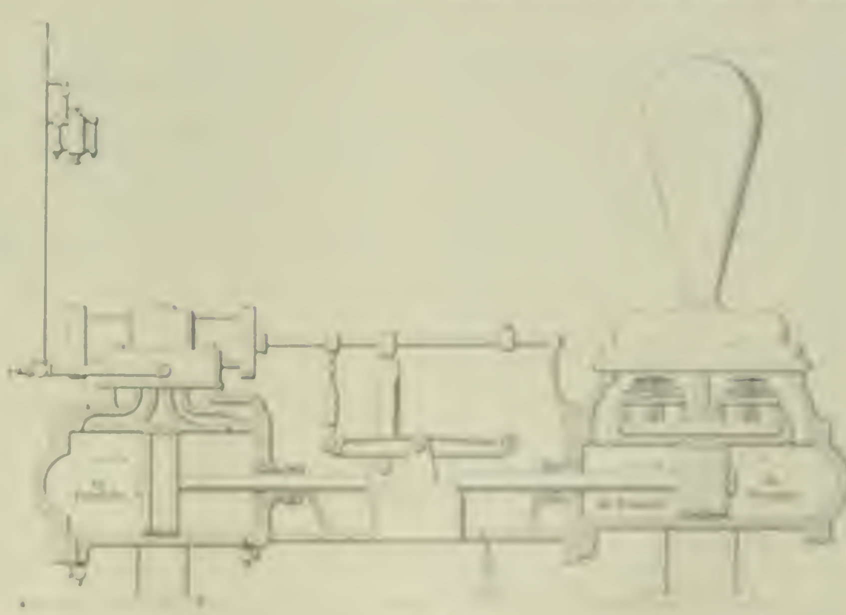


FIG. 3

[illegible]

small space with other valves and several pipes, making it inaccessible for cleaning and repairs. The overflow pipe was originally of small size and made as short as possible, with few fittings. Air would sometimes be trapped in this pipe, and thus prevent water from flowing away freely, causing it to spill on the floor and cause trouble. To prevent this action the pipe was increased from ⅜ to 1 inch, and a tee used in place of the first ell, as shown under the main lever. As the upper outlet was left open the air escaped freely, yet the water did not overflow, because the tee was as high as the small reservoir provided.

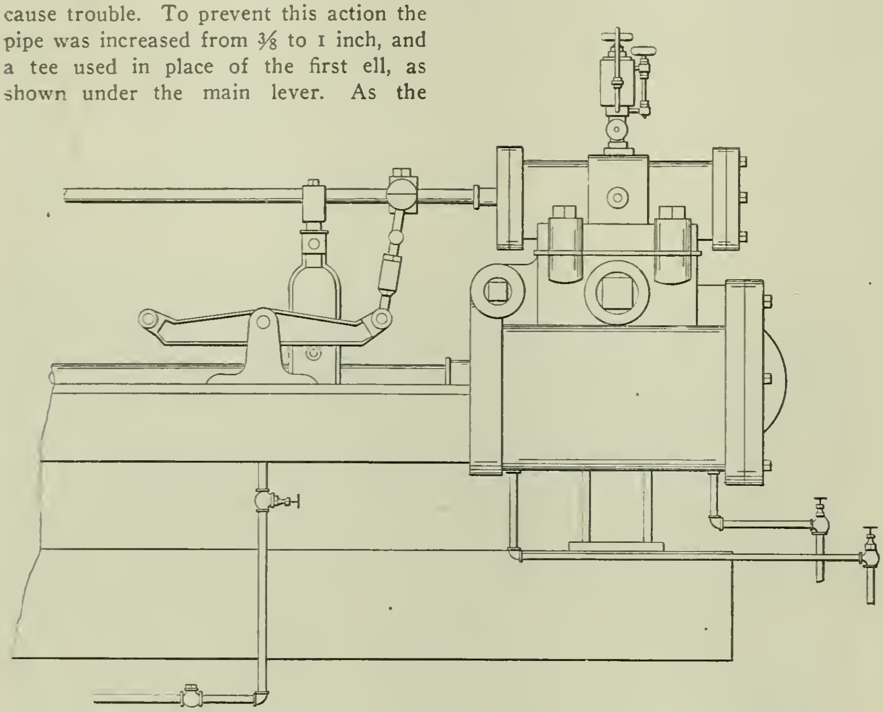


FIG. 4

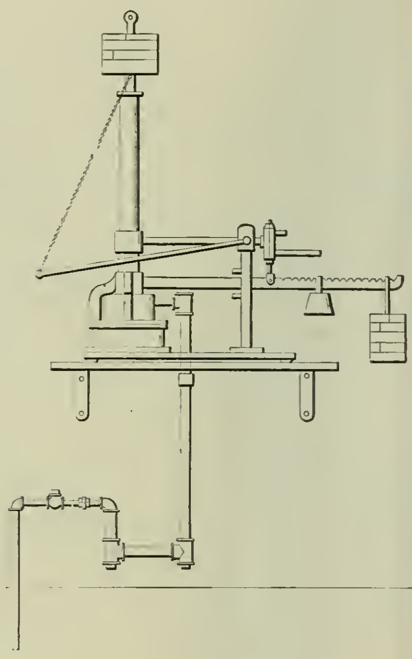


FIG. 5

The original small pipe became filled with sediment from the water used, at a point beneath the floor, but this objection was removed by making a pocket above the floor, using 1-inch tees and suitable nipples for this purpose. Two plugs were provided, the threads coated with graphite, and they were screwed in only lightly in order that they may be easily removed when the trap thus formed becomes filled with sediment. These are located high enough to admit of setting a pan under them to prevent staining the floor with muddy water when the pipe is washed out.

Fig. 6 illustrates a tilting steam trap located where it receives the discharge from three long drip pipes, which discharge water from different parts of a heating system. Sometimes this part of the system is noisy because the water resulting from the condensation of steam is warm in one drip pipe and cold in another; therefore, one kind of water hammer is the result. By throttling the discharge from the warm pipe, for which a valve is provided, this can be prevented, as it regulates the flow until there is little difference in the temperature of the pipes, resulting in smooth operation.

These three pipes discharge into a vertical header, on the top of which is a ⅜-inch angle valve that is opened one-sixth of a turn. This allows all air to escape to the return pipe, preventing excessive pounding, even when steam is first turned on, and keeping the pipes free from air at all other times; but it does not waste heat, because the return pipe is about 400 feet long, which is sufficient to allow the returning water to become cool; therefore, the small amount of steam that passes this valve, usually under 3 pounds pressure, goes into the feed water and gives it a higher temperature than it would otherwise have.

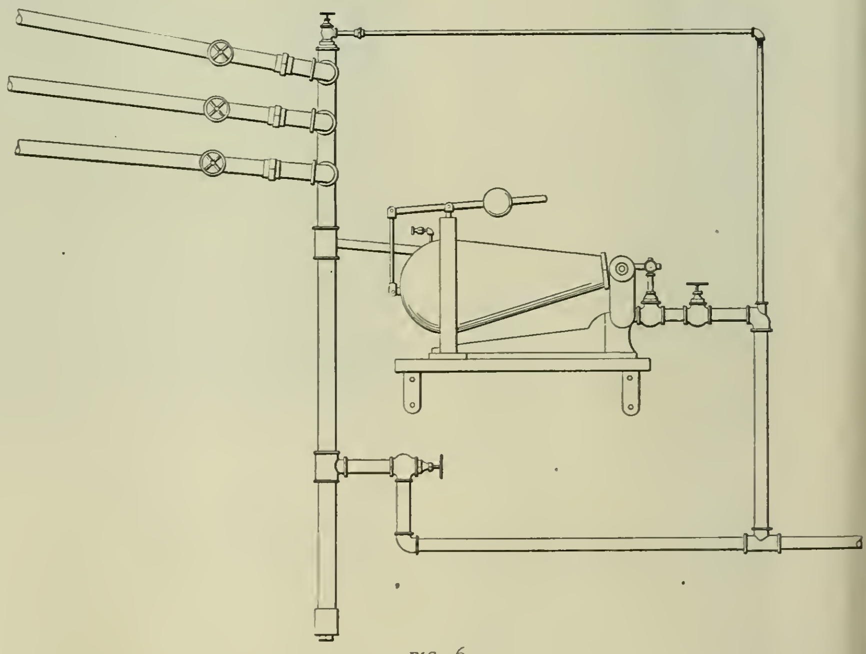


FIG. 6

The outlet from this vertical header to the trap is connected just below the lower inlet, while the bypass, or blowoff valve, is of the angle type, located lower down, with a dead end or pocket still lower, formed of the same pipe; consequently, if the incoming water contains sand, scale from the inside of the pipes and other foreign matter, it will lodge in this pocket instead of going into the trap. When pressure is off from the heating system, a plug at the lower extremity is unscrewed and all sediment removed. It is surprising to note how quickly such a pocket will fill with sediment. This arrangement of drip pipes, etc., was devised to take the place of connections that did not give good results on account of poor design and inconvenient operation.

Modern British High-Speed Steam Engine

Current British Practice, Giving Efficiencies, Methods of Governing and Lubrication and Principal Details of Standard Makes

BY JOHN DAVIDSON

The high-speed engine is largely used in England for all purposes, and it may safely be said that more high-speed engines for use on land are manufactured in England than in any other country in the world. The majority of these engines are for use at home, but a great number are sent abroad, English productions in this direction being used in almost every country.

The term "high-speed" is somewhat misleading—although no doubt generally understood—but "quick revolution" is a more correct definition of the type of engine under consideration, as it is high speed of revolution only which makes these engines differ from any other type. All engines running at speeds exceeding 120 revolutions per minute are generally spoken of as high-speed engines, and they are in general use running at speeds up to 700 revolutions per minute for the smaller powers, whereas the speed of the largest engines usually does not exceed 200 to 250 revolutions per minute.

Piston Speed

The piston speed of the engines is not much in excess of that of slow-speed engines, except in the case of the larger powers. The early high-speed engines were made with short strokes, and consequently with low piston speeds, but during the last few years there has been a tendency to increase the strokes and piston speeds. This has most probably been brought about by the necessity for economy in design necessitated by keen competition. In many instances the strokes have been increased 25 per cent. and the piston speeds accordingly increased 25 per cent. It will be readily seen that from almost the same weight of material 25 per cent. more power is then obtainable.

As illustrating general practice of the leading high-speed engine builders in England today the following table is given:

I.H.P.	Revolutions per Minute	Piston Speed
50	600 to 700	500
100	550 to 600	550
200	500	675
500	350 to 375	750
750	325	775
1000	300	800
1500	200	900
2500	160 to 180	1000

The Early High-speed Engine

Although the high-speed engine was first introduced for dynamo driving, it is now in use for almost every purpose, rapid strides having been made during the last few years despite the competition of the steam turbine. Even mill owners have at last recognized the simplicity, reliability and economical working of the enclosed type of engine for driving their mills, but the slow-speed Corliss engine has such a firm hold, and has done so well, that it will be many years before any other type of engine will be largely used. A number of mills, however, are now driven electrically, and as many of them have their own generating plants, another field for development is opened for the high-speed engine.

The early high-speed engines were of the single-acting type, as made by Brotherhood, Willans and others, but this class of engine has been entirely superseded by the double-acting forced-lubrication type of engine. Double-acting engines, with ordinary gravity lubrication, when running at high speed of rotation, are most unsatisfactory and will soon knock themselves to pieces, whereas the single-acting engine with its parts always in constant thrust overcame all these difficulties, but it was an expensive and inefficient engine.

FIG. 1. STEAM CONSUMPTION OF A TRIPLE-EXPANSION HIGH-SPEED ENGINE

The introduction of forced lubrication, however, did away with the necessity of single-acting engines and although large numbers of these engines were made after forced oiling was first brought into use, all engine builders of today use forced lubrication and double-acting engines, and none of the single-acting type is manufactured.

Advantages of the High-speed Engine

High-speed engines have many advantages over the slow-speed type. These may be summarized as follows:

A smaller engine is required for a given power, and thus it occupies less space, and reduces the cost of the engine somewhat. Smaller foundations and buildings are required; this again reduces the cost. The high-speed engine is of the simplest type manufactured, is reliable and is subject to a minimum of wear.

It may appear somewhat exaggerated to say that there is considerably less wear in a high-speed engine than in a slow-speed engine, but nevertheless it is a fact that with high-speed engines of the best makes less adjustments are required than with any slow-speed engine ever built. This is no doubt principally due to the fact that all the wearing parts of high-speed engines are large, and the system of lubrication is most perfect. These points will be more fully considered later, but as a proof of the statement just made with regard to wear, a few particulars are given below of a [illegible]-horsepower three-crank engine after running 7 years, 12 hours per day and 300 days per year:

[illegible]-HORSEPOWER THREE-CRANK ENGINE

Crank pins, greatest wear, inch	[illegible]
Main bearings, greatest wear, inch	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

After [illegible] years running the wear on parts of a [illegible]-horsepower two-crank compound engine are given below:

[illegible]-HORSEPOWER TWO-CRANK ENGINE

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

These are not isolated experiences, but are commonly found almost everywhere. It might here be mentioned that all [illegible] [illegible] and that together with [illegible] and the necessary perfection of workmanship put into the engine, accounts for their success.

Again, high-speed self-lubricating engines require much less attendance, and it is common practice to put one man in charge of from four to six high-speed engines in a generating station. This is only rendered possible by the automatic system of lubrication adopted, and is rarely found possible in the case of slow-speed engines.

Economy

There are also many points in their favor as regards economy, and actual tests of modern engines have shown that high-speed engines have at least as high economy and efficiency as any other type of engine manufactured. In Fig. 1 is shown the consumption of steam per indicated and per brake horsepower of a high-speed triple-expansion mill engine working with steam at a pressure of 175 pounds per square inch and exhausting into a condenser having a vacuum of 26 inches, the steam being superheated 100 degrees Fahrenheit. These are the ordinary present-day conditions as regards steam pressure and vacuum for ordinary slow-speed mill engines, so it will at once be seen that the results obtained leave little to be desired. A consumption of 11.8 pounds per brake horsepower, or 10.9 pounds per indicated horsepower being equal to the best Corliss engine results, and owing to the high efficiency resulting from the forced lubrication and throttle governing, the economical performance at light loads is relatively much better than in the case of slow-speed engines.

The type of engine cylinder, viz., piston-valve cylinders, also renders the use of superheat practicable, and great advantages are thereby obtainable. In Fig. 2 is shown the percentage of gain due to superheat ranging from 0 to 200 degrees Fahrenheit on a high-speed triple-expansion engine. From this curve the advantages of superheat are apparent, and 150 to 200 degrees Fahrenheit are quite suitable for high-speed engines. At 200 degrees Fahrenheit the saving in steam consumption is no less than 26 per cent., and although this cannot be counted as total gain, a large percentage of economy is derived from the use of superheat.

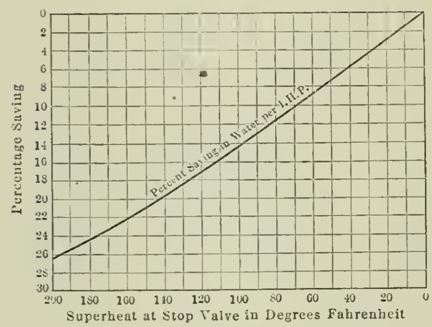


FIG. 2. GAIN FROM SUPERHEAT

Methods of Governing

The method of governing small high-speed engines is most generally by means of a plain centrifugal governor fixed to the crankshaft and acting directly on a throttle valve. In the case of lathe engines several makers are now fitting a governor which at light loads controls the speed of the engine by throttling, and at heavy loads by altering the degree of expansion in the high-pressure cylinders. This has been found the most economical method of governing. In the early days of high-speed engines, many makers used crankshaft governors which acted directly upon the steam-distributing valve and controlled the speed of the engine by altering the cutoff throughout the whole range. This type of governor is largely used in America, and with great success for medium-speed engines, but for high speeds it has been found impracticable and of very little advantage, except perhaps for small engines. The method adopted for governing by expansion in the case of heavy loads only, will be described in detail later.

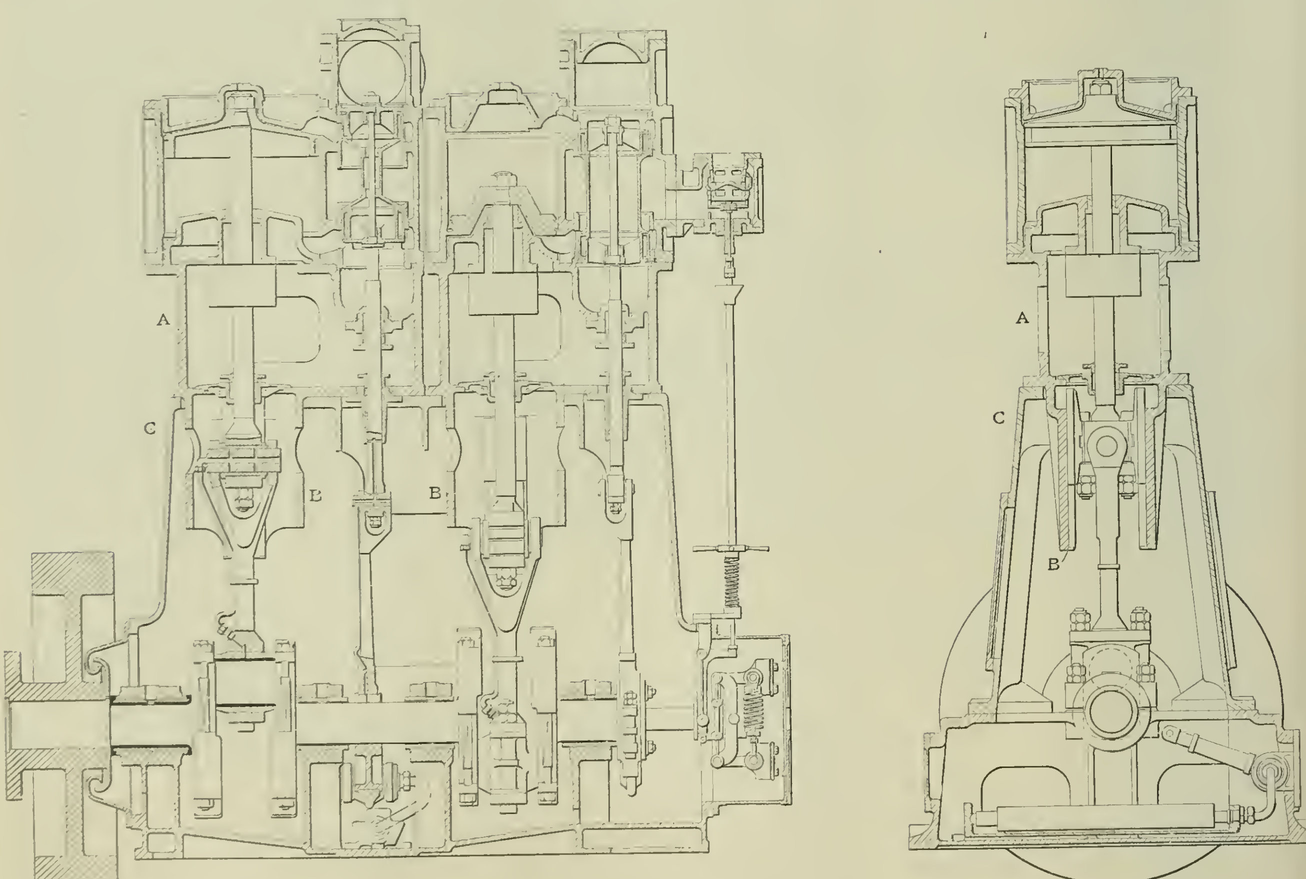


FIG. 3. BROWETT-LINDLEY VERTICAL ENGINE

Standard Type of Details

High-speed engines are built in all the usual varieties, viz., simple, compound and triple-expansion, and the principal British makers build engines in standard sizes up to 3000 indicated horsepower.

Cylinders. Piston valves for all cylinders are universally used, these being the only satisfactory type to suit all conditions of steam pressure and superheat. The cylinders are simple. In the case of two- and three-crank engines, each cylinder with its line of parts is usually quite independent of the other, that is to say,

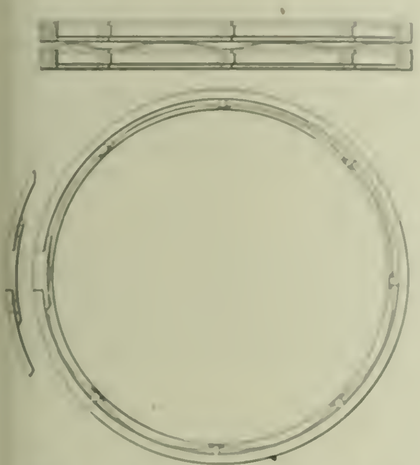


FIG. 4. TYPE OF PISTON RING IN COMMON USE

the cylinders are not stayed together in any way. This leaves each engine entirely free to be centered over its own crank, and also prevents distortion owing to unequal expansion due to the temperature of the steam. Steam jacketing has been tried, and no benefit being derived, it has been abandoned by most makers.

It may be of interest to note that all builders of this type of engine appear to have now adopted one standard design of engine, which consists of four main parts, viz., cylinder, distance piece with which is formed the crosshead guide, frame and bed or base. The arrangement referred to will be clearly seen by referring to Fig. 3, which shows in section the type of two-crank compound engine as manufactured

FIG. 5. ADMIRALTY TYPE OF RING

by Browett, Lindley & Co., Ltd., of Manchester, for powers ranging from 30 to 1000 horsepower, and this may be taken as typical of the best standard British design. In this engine the cylinders are supported their full length, but quite independently of each other, by a casting *A* with which is formed the lateral guides *B*. In this distance-piece casting are formed large openings, both back and front, to give easy access to the piston rod and valve-spindle glands. Above the guide, that is, at the top of the frame *C*, another set of stuffing boxes are fitted to prevent leakage of water from the cylinders getting down into the engine base, and so mixing with the oil in the crank chamber. The distance between these two glands is usually made a little more than the stroke of the engine, so as to prevent oil being

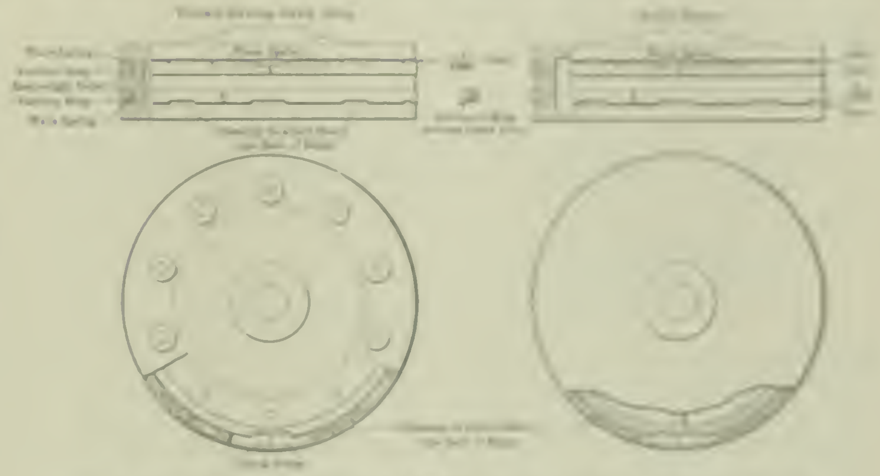


FIG. 6. [illegible] PISTONS SHOWING PATENT CHECK RINGS AND WAVE SPRINGS

carried up the rod and being drawn through the stuffing box into the low-pressure cylinders, when the engines are worked condensing.

It will be noted that the distance-piece casting also forms the bottom cylinder cover, and as this cover and the crosshead guide are bored out at the same setting and the cover afterward turned on a mandrel fitted into these two machined portions, the guide is self-centering when the cover is fitted into the cylinder.

Pistons. The design of pistons for small engines does not call for any comment, but the low-pressure pistons of compound and triple-expansion engines are usually made of wrought or cast steel. The type of piston ring almost universally used on account of its suitability for quick reversals, is one which consists of two cast-iron rings, Fig. 4, similar to the ordinary Ramsbottom rings, both being placed in one wide groove. Between these two rings is placed a strong wave spring, which keeps them against the piston flanges, and behind each ring another wave spring is fitted, which presses them against the cylinder walls. By suitably proportioning these springs excellent results are obtained. These rings, however, are not suitable for high-pressure cylinders when superheated steam is used, and most makers then adopt a restrained type of ring which is prevented from expanding beyond a predetermined amount by suitable locking tongues, pieces or lugs formed at the joint of the rings. For this purpose the Admiralty type of ring, shown in Fig. 5, has been largely used, and also the type of ring shown in Fig. 6. In this case, as will be clearly seen, check pieces are formed on the rings at the joints, and these engage with suitable recesses formed in the piston or carrier ring, as the case may be. A wave spring is also fitted to each ring to keep it against the piston [illegible] [illegible] The outward pressure is obtained by giving the rings a slight initial spring, and by allowing the steam free access behind the rings. The rings are thus steam expanded, but excessive outward pressure is prevented by the check pieces. These rings are practically self adjusting, owing to the very slight wear of the check pieces, and are working satisfactorily with steam superheated up to 300 degrees Fahrenheit.

Piston Valves. As already stated, the type of steam-distributing valve universally used is the piston valve, and what may appear surprising is the fact that almost all engine builders use either solid piston valves or valves fitted with solid floating rings. This type of valve, simple as it may appear, is very satisfactory and

FIG. 7. SIMPLE ARRANGEMENT OF [illegible] [illegible]

with the best of manufacturing [illegible] [illegible] results are to be obtained.

Valves with springs or adjustable rings are rarely used, although found to have a tendency to [illegible] [illegible] for the best [illegible]. The piston valve possesses many advantages, among which may be mentioned its simplicity and the accuracy with which it can be [illegible] owing to it being perfectly balanced. It is the usual practice to fit liners of hard, close-grained cast iron in the cylinder-valve chests for all except the smallest of engines. For compound engines up to 400 indicated horsepower, one valve placed between the high- and low-pressure cylinders is generally used. The arrangement is shown in Fig. 7, and it is certainly a very simple engine, only one valve and gear being required.

Motion Work. The marine type of crosshead and connecting rod is used by all builders, all wedge and cotter adjustments having given place to the simple cap and two bolts. For engines up to about 600 horsepower the crosshead and piston rod are usually forged in one piece, but for larger powers the two-bearing crosshead of the marine type is generally adopted so as to make it easy to withdraw the piston rods and crossheads, which would otherwise be a difficult matter. The design of these details is shown in Figs. 8 and 9.

The piston rods and crossheads are usually made of high-carbon steel, 0.4 to 0.5 per cent., mild steel being used for the connecting rods. The crosshead bushings are made of phosphor bronze, and these working in conjunction with hardened-steel crosshead pins of ample size, are very durable. The crank-pin bushings are lined with white metal in every case. Cast-iron crosshead slippers are always used. Experience has shown that even with the most perfect system of lubrication, large bearing surfaces are necessary; consequently the pressure per square inch is very low. General practice shows the maximum pressure per square inch on crosshead pins to be 900 pounds; on crank pins, 350 pounds, and on crosshead slippers, 40 pounds.

Although the piston speeds of these engines are by no means low, there has been very little tendency to cut down the weight of the parts. In the early engines the parts were made as light as possible, but apparently experience has shown that there is no necessity for this, and that it is far more advisable to make the parts of ample strength and thus to a great extent prevent buckling, should there be a slight rush of water into the engine. With a view to decreasing vibration, connecting rods are made of considerable length compared with the stroke, the average practice being between two and three-fourths to three times the length of the stroke. A few firms, however, make their connecting rods as long as three and one-fourth times the stroke.

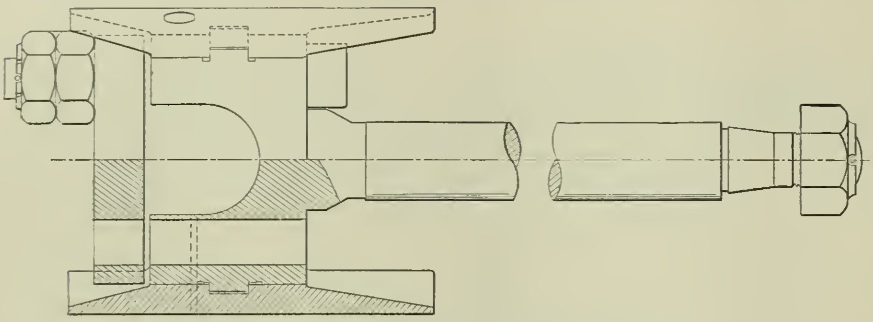


FIG. 8. CROSSHEAD AND PISTON ROD FORGED IN ONE PIECE

Valve Gear. The gear for driving the valves consists simply of an eccentric keyed to the crankshaft, driving the valve spindle through an eccentric rod in the usual way. In small engines the valve rods, together with the crosshead, are made in one piece, and the guide is generally formed by swelling out the valve rod at the bottom end, this working through a long bushing. The design of valve-rod end is similar to that of the piston rod, viz., marine type, a pair of phosphor-bronze bushings being fitted and made adjustable by cap and bolts. Eccentrics are made of cast iron, the latter being in all instances lined with antifriction metal.

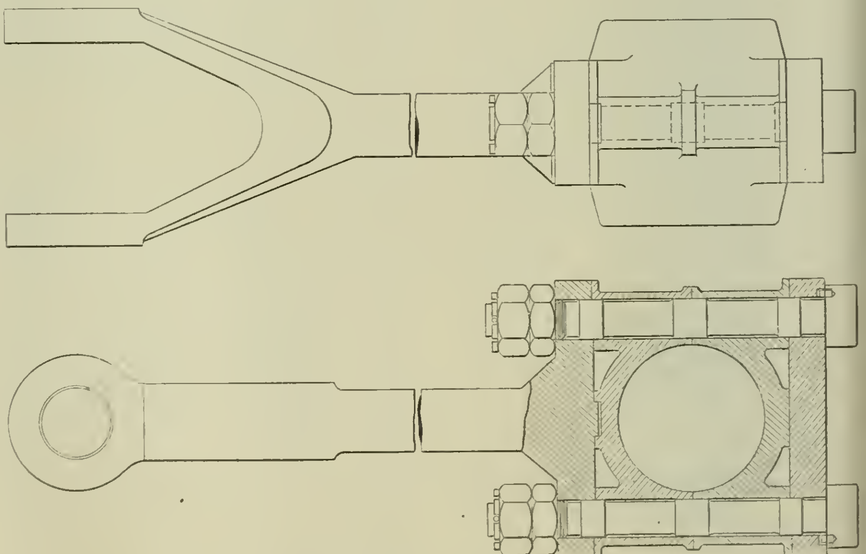


FIG. 9. TWO-BEARING CROSSHEAD OF MARINE TYPE

Main Bearings. The standard practice regarding these appears to be plain bushings of cast iron lined with antifriction metal, the bed with its caps being bored out to receive them. One large firm, however, does not fit loose bushings to the main bearings at all, but simply lines the bed and cap with antifriction metal, afterward boring the lining out in place. Gun-metal bushings for the main bearings are not fitted by any of the large firms except when specified.

It has been found in practice that cast-iron bushings are preferable, and when heating occurs due to foreign substance getting into the bearings, or want of lubrication caused by neglect, cast iron is less liable to close in than gun metal. It is the general practice not to fit liners to any of the bushings, but simply to adjust them, metal to metal, when the main-bearing bolts are tightened hard down. Owing to the ample surface provided in the main bearings of these engines and, as already stated, the excellent system of lubrication, adjustments are very rarely required and certainly not for several years.

Crankshafts. Crankshafts are made from solid forgings of Siemens-Martin acid steel to specification equal to that of Lloyds except for the largest-sized engines, in which case the crankshaft is sometimes built up of three equal parts, couplings being formed solid at the end of each portion. It is more general, however, to make shafts for engines up to 2000 horsepower in one solid piece. The strength of the shafts is somewhat greater than of shafts used in slow-speed practice, but this is principally brought about owing to the necessity for large bearing surfaces. To provide for this, with the ordinary type of shaft, would necessitate a great length of engine, and no advantage would be gained thereby. The pressure per square inch on the main bearings of engines rarely exceeds 200 pounds, this being calculated on the maximum pressure obtainable, as measured from the indicator diagram. This in most instances is the determining factor for the size of the crankshaft.

Flywheels. Owing to the high speed of rotation, the flywheels are necessarily of small diameter, the maximum speed on the rim usually not exceeding 6000 feet per minute. These wheels are made in plate form and never with arms, this design being most suitable for such small diameters and much stronger than could possibly be made with arms. Owing to the great number of impulses per minute, it has been found that wheels of a fairly good fit and simply keyed on soon work loose, and the practice today adopted by all firms of repute is to make the shaft a forcing fit for the wheel, the latter then being forced on by hydraulic pressure. In the case of large engines, if this system is adopted, the crankshaft and flywheel become a very unwieldly piece of machinery for transit, and owing to this it is usual to form a coupling solid with the crankshaft and carry the flywheel between this coupling and the coupling of the dynamo or extension shaft carrying the wheel in the case of rope driving. This arrangement was first introduced by the late Mr. Willans and it has the advantage of making a very simple flywheel casting. The flywheel practically consists of a heavy rim with an inner plate or rim suitable for attachment to the coupling.

Oil Throwers. In engines of the forced lubrication type there is a great amount of splash inside the crank case, although none of the working parts are allowed to dip into the oil. It is therefore necessary to provide means for preventing the oil leaking out at the point where the crankshaft comes through the engine base. In the early engines stuffing boxes and packing of every description were used with more or less success, but it has been found that by making a ring of the design shown in Fig. 3 oil leakage is entirely prevented. The arrangement is simple and at the same time perfectly effective. At the governor end of the engine there is no necessity for the crankshaft to come through the casing, and this is generally closed in by an oil tight door.

Causes of Engine Failure

By R. C[illegible]

When an engine gets a dose of water in the cylinder while running at full speed and, as a result, becomes more or less fit for the scrap pile, it is plainly seen that an unusual force was unexpectedly brought into action and it is interesting to look into the case a little closer and see "how it happened." The force in itself is, of course, the kinetic energy of the moving parts of the engine, principally the flywheel, the size of the energy depending on the weight of those moving parts and the velocity at which they were moving at the time of the accident. A hundred-pound weight resting on the floor does not possess energy, but in picking it up and placing it in a higher position a certain amount of work has been expended on it. This amount of work is now stored, so to speak, in the weight in the form of potential energy as long as held stationary at this higher level, but if allowed to drop back to the floor this potential energy is changed into kinetic energy and, in striking the floor, does the same amount of work as was expended in lifting it to a higher level. The same with a steam engine; when steam is admitted to the cylinder on starting up, a certain amount of work is done by the steam in bringing the engine up to speed, part of which is used to overcome friction and should not here be considered; the remaining part goes to give to the moving parts of the engine a certain velocity. As long as the engine is running at uniform speed the work done is simply stored in the moving parts in the form of potential energy, but the moment a sudden load or some obstruction, as water in the cylinder, tends to reduce the velocity of those moving parts, this stored-up or potential energy is instantly brought into play in the form of kinetic energy trying to overcome the resistance offered, the size of the force thus brought into action depending on the time during which the change occurs. In a heavy engine with a ponderous flywheel this force can easily be imagined, but consider a little 22x22-inch affair with light balance wheels, say 66 inches in diameter, running at 271 revolutions per minute. Suppose the face of the wheel rim is 14 inches and of an average thickness of 1 inch. If we disregard all the other moving parts and consider only the two wheel rims the weight of these would be

$$2 \times 66 \times 3.1416 \times 1 \times 14 \times 0.2[illegible] = 1486.606$$

pounds. With 271 revolutions per minute we get a velocity of

$$\frac{66 \times 3.1416 \times 271}{12 \times 60} = 78$$

feet per second, nearly. The available kinetic energy of the two wheel rims is then, according to the formula

$$\frac{W\ v^2}{2\ g} = \frac{1486.606 \times 78 \times 78}{2 \times 32.16} = 140,617.398$$

foot-pounds, where W = the weight of the moving parts, v = the velocity and g = gravity, 32.16. The action of this stored-up energy depends on the nature of the resistance to motion. As water is practically incompressible, if a volume of it should happen to fill the space between the piston and the cylinder head during the compression period of the stroke, when there would be no outlet for it, the action would be identical to the force of a blow. To determine the force of this blow it is necessary to know the time required to bring the moving parts of the engine to rest, if they actually come to rest, which is not at all likely, it resulting in only reducing the velocity the amount of reduction must be known. As such figures are not available, suppose for an instant that the different parts of the engine are of sufficient strength to withstand this blow, i.e., actually to stop the engine without straining the different parts beyond the elastic limit; but that the strain, such as bending of the spokes in the wheel, torsion in the shaft and compression of connecting rod and piston, allows of a movement at the wheel rim of, say, 3 inches or ¼ of a foot from the time the piston brought up against the solid body of water until all parts are at rest. The force developed at the wheel rim would then be the kinetic energy divided by the distance through which it acts in feet, or

$$\frac{140,617.398}{\frac{1}{4}} = 562,469.592$$

pounds. In the sketch diagram shown suppose this force is active at the end of a lever [illegible] feet in length (the radius of the wheel). As the crank pin is only 11

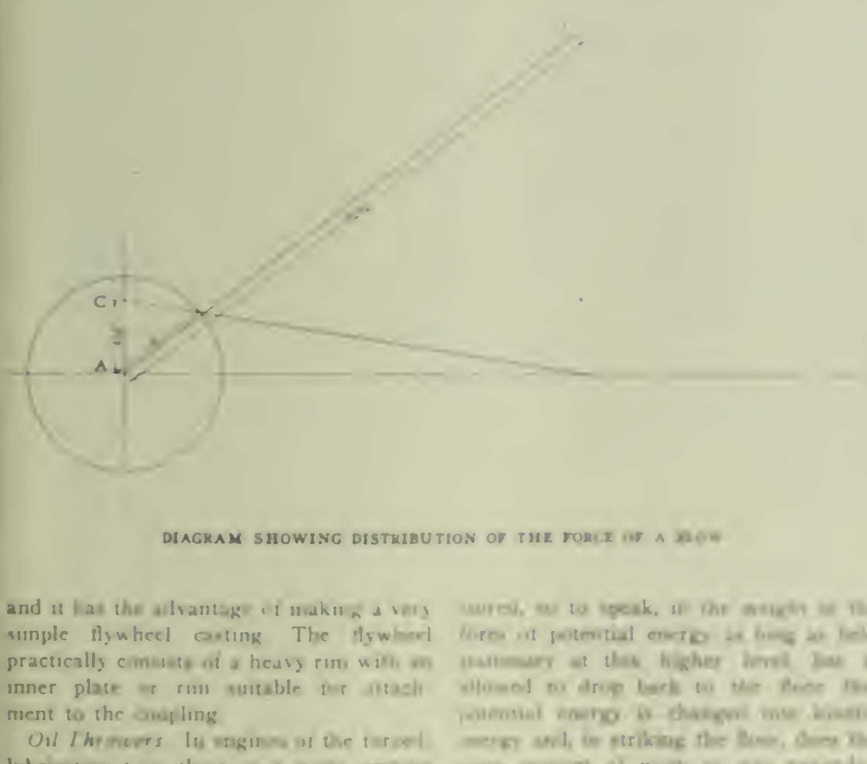


DIAGRAM SHOWING DISTRIBUTION OF THE FORCE OF A BLOW inches from the fulcrum of this lever, the force at this point is correspondingly greater and, the crank and connecting rod forming a toggle joint, the force or pressure is distributed toward the shaft journals as well as against the cylinder head, which explains the broken journals or split and cracked frame which are often a result from a dose of water in the cylinder. Considering the thrust against the cylinder head alone, if the crank should be in the position shown in the diagram, the distance *C A*, which we get by prolonging the line representing the connecting rod until it intersects the vertical center line, would be about 4½ inches. The thrust on the head would then be

$$\frac{562{,}469.584 \times 32\tfrac{1}{2}}{4\tfrac{1}{2}} = 4{,}062{,}280.329$$

pounds, or

$$\frac{4{,}062{,}280.329}{12 \times 12 \times 0.7854} = 35{,}918.233$$

pounds per square inch, all on the assumption that the engine was strong enough to withstand the shock. No engine, however, is built to do so and some part is smashed long before the full kinetic energy has been developed.

Cost of Producing Electricity

E. A. Ashcroft, in a paper recently presented to the Faraday Society, estimates the cost at which electricity can be produced in a 5000-kilowatt plant as £8 6s. 6d. per kilowatt-year for steam, £6 18s. for gas engines and £7 4s. for oil engines. The items are fuel, labor, upkeep (comprising maintenance and depreciation) and capital charges. He divides water power into two classes: first-class powers yielding an even supply all the year round without high cost of regulation or of development, with which sort of a plant he estimates that a kilowatt-year can be produced for £2, made up of fuel, 6s.; upkeep, 8s.; capital, 13s.; royalties on rights, 13s. The cost for water powers of the second class he estimates at £5 6s. per kilowatt-year, made up of fuel, 8s.; upkeep, 13s.; capital, £4 2s.; royalties on rights, 3s.

Mr. Ashcroft was quite aware that water powers of his first class are not often met with. He mentions a development near Vacheim on the Sogne Fjord capable of yielding 7500 kilowatts, or 1000 horsepower, which can be developed for less than £5 per horsepower, including payments for dam rights. At Meraker, near Trondhjem, 3000 horsepower had been sold at £1 5s. 6d. per electrical horsepower on a seven-year contract, and at Notodden (the Birkeland Nitrate Works) the price was £1 8s. per horsepower for 3000 electric horsepower. Water power is being more closely studied than it used to be; several governments, Swiss, Bavarian, Würtemberg and others, have now taken up the problem quite seriously.

A New Departure in Flexible Staybolts*

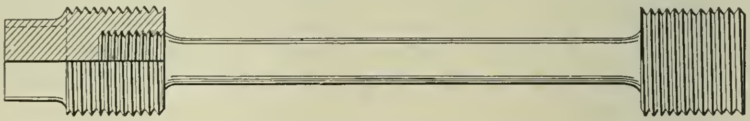
The increasing size and pressure of boilers makes this subject of vital importance to those who are responsible for the management of that type of boiler in which the firebox is stayed by a large number of bolts.

In recent years some form of flexible staybolt, that is, one having a movable joint, has been very extensively used in the breaking zone of locomotive boilers, but their high cost and the difficulty of applying them, their rigidity from rust and scale and the fact that their use throws an additional service on the adjacent bolts because of lost motion has militated against their more general use.

It is well known that staybolts fail not because of the tensional loads upon them, but from flexural stresses induced by the vibration resulting from the greater expansion of the firebox sheets than of the outside sheets; but notwithstanding the general acceptance of this theory, engineers have designed staybolts solely with respect to the tensional loads. It is quite general practice to recess the bolts below the base of the threads and this has effected a slight reduction in the fiber stress, but practically no effort has been made to design a bolt to meet the flexural stresses or even to calculate their magnitude. The stress increases in direct proportion to the diameter and decreases as the square of the distance between the sheets.

It is obvious that the remedy does not lie in the use of a slow-breaking material, but in the employment of a material of sufficiently high elastic limit to meet the conditions of service. It is also possible to reduce the diameter of the bolts greatly by the use of such a material, thus proportionately reducing the fiber stress in flexure.

Staybolt material, however, must possess sufficient ductility to enable the ends to be readily hammered over to make a steam-tight joint and to afford additional security against pulling through the sheets. To meet these conditions the bolt shown herewith has been designed, of the same grade of steel as that used in the manufacture of springs. It is oil-tempered and will safely stand a fiber stress of 100,000 pounds per square inch. Its high elastic limit makes it possible to reduce the diameter to ⅜ or 7/16 of an inch, or even less. The ends are of soft steel and it is thus possible to apply and head up the bolts in the usual manner.



FLEXIBLE SPRING-STEEL STAYBOLT

Tests were made of such a bolt in comparison with ordinary iron bolts by clamping one end of the bolt in a machine and revolving the other end through a radius of 3/16 of an inch, the specimen being 6 inches long from the end of the right head to the center of the rotating head. A tensional load of 4000 pounds was also applied to the bolt. A 1-inch iron bolt having an actual breaking strength of 32,500 pounds and weighing 20 ounces broke with 6000 such vibrations. An iron bolt ⅞ of an inch in diameter, having an actual breaking strength of 24,500 pounds and weighing 15 ounces, broke with 5200 such vibrations, while a spring-steel stem bolt, 1 inch in diameter at the end and 7/16 inch in the stem and with an actual breaking strength of 32,000 pounds and weighing 10 ounces, withstood 500,000 such vibrations without breaking. On some such bolts the test was continued to a million vibrations without failure. The paper contains a calculation to show that with staybolts spaced 4 inches apart and with a temperature of the inside sheet of 400 and of the outside sheet of 100 degrees, the expansion between two bolts will be 0.0079 of an inch and each bolt will deflect 0.00395 of an inch. This amount of deflection will stretch the usual type of bolt beyond the elastic limit. In practice, however, one bolt may hold rigidly, throwing the entire deflection on the adjacent bolts, or neither bolt may deflect and the sheet will then buckle. The author figures that under the conditions assumed and supposing the bolts to be rigid, the sheet would buckle ⅛ of an inch, which must ultimately lead to a crack in the furnace sheet. If, however, the bolt deflects, allowing the sheet to normally expand, the latter will be relieved of the extraneous load.

A bolt of sufficient flexibility to deflect under the forces following expansion and of material which will not be stretched beyond the elastic limit in resisting these forces will greatly assist in reducing the cost of boiler maintenance by eliminating broken staybolts and reducing the stresses in the furnace plates. If, in addition, the bolt has a smaller diameter, the life of the furnace plate should be farther increased, as such bolts will interpose less obstruction to the circulation of the water in the water legs.

*Abstract of paper by H. V. Wille presented before the American Society of Mechanical Engineers.

One advantage in using large boiler units is the reduction in heat units lost by radiation per pound of coal burned and pound of water evaporated.

[illegible]

The Installation of Direct-Current Motors

Plain Directions for Setting Up and Operating Motors, with Some General Rules, Observance of Which Will Insure Excellent Results

BY R. H. FENKHAUSEN

When installing motors of any type, one of the first requirements is a knowledge of the proper size of wire to use. Many excellent wiring tables have been compiled for this purpose, but in case none is available the following formula will give the correct size:

Let *c.m.* = Circular mils in required size,
D = Distance in feet one way,
I = Current in amperes at full load.

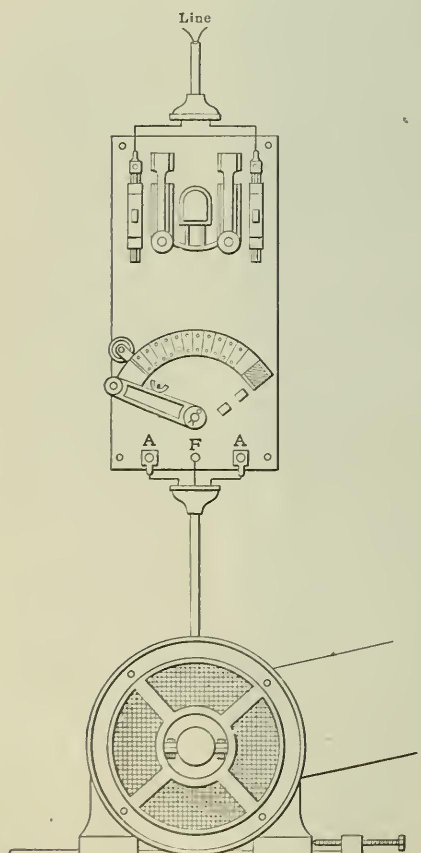


FIG. 1

V = Volts lost in line,
21.5 = Constant = resistance of a two-wire circuit 1 foot long, of wire 1 mil in diameter.

$$c.m. = \frac{I \times D \times 21.5}{V}$$

Example: Twenty-five amperes at 110 volts must be transmitted 300 feet with 5 per cent. drop; 5 per cent. of 110 volts is 5.5 volts. Substituting the known values for the corresponding letters of the formula:

$$\frac{25 \times 300 \times 21.5}{5.5} = 29{,}318.$$

This is the required cross-section in circular mils, and it will be found by reference to Table 1 to fall between Nos. 5 and 6 of the standard sizes; either of these sizes will be close enough for practical use, or one wire may be run of each size for closer results.

The full-load current taken by various motors may be obtained from Table 2, calculated by the formula

$$I = \frac{H.P. \times 746}{E \times e},$$

where
I = Current in amperes,
H.P. = Rated horsepower of motor,
746 = Watts in 1 horsepower,
E = Voltage of circuit,
e = Efficiency, varying from 50 per cent. in very small motors to 95 per cent. in large motors, 87 per cent. being an average efficiency for moderate-sized machines.

The result obtained by use of this formula should be increased by 25 per cent. at least, to allow for overloads on the motor.

The wiring may either be run open or inclosed in iron conduit, but around industrial plants open work will usually give better satisfaction when large-sized wires are to be run, owing to the greater facility in installing the wires and accessibility when repairs, alterations or extensions are to be made to the distribution system.

Separate Supply Circuits Desirable

Separate circuits should be run for motors; if they are supplied from lighting circuits the rush of current at starting will cause disagreeable fluctuations at the lamps. This applies particularly to elevator and other motors requiring frequent starting and having widely varying loads. In cases where the 110-220-volt three-wire system is used to supply both lamps and motors, no motors larger than ¼ horsepower should be connected to the neutral and one main wire, or serious unbalancing of the system will result.

The supply line to each motor should terminate at a starting panel containing the fuses or circuit-breaker, main switch and starting or speed-regulating rheostat. The fuses should be of the inclosed type and their proper capacity may be ascertained in the same manner as that of the line wires, except in such cases as where a starter with an overload release is used or where a circuit-breaker is used in addition to the fuses. In these cases the fuses are not intended to blow unless the

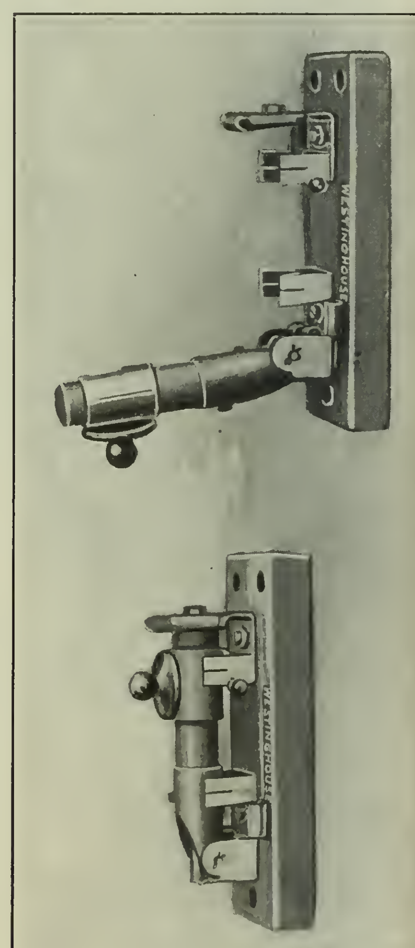


FIG. 2

overload-release or circuit-breaker should become inoperative, and therefore they should be of greater capacity than when they are used as the only safety devices. Table 3 gives the fuse ratings recommended by one of the largest controller manufacturers in the United States.

Switches and Connections

All switches for currents in excess of

25 amperes should be of the quick-break type, as the arc drawn by opening a direct-current circuit is much more destructive than one formed with alternating current. Self-contained motor panels carrying all necessary apparatus are on the market and their use is advisable, where the slight extra cost will not be a detriment. Fig. 1 shows such an installation. Fig. 2 shows a cheap but reliable single-pole carbon circuit-breaker recently placed on the market, and intended as a substitute for fuses. It is made in capacities up to 75 amperes at 250 volts, on direct current, and when installed one in each lead of

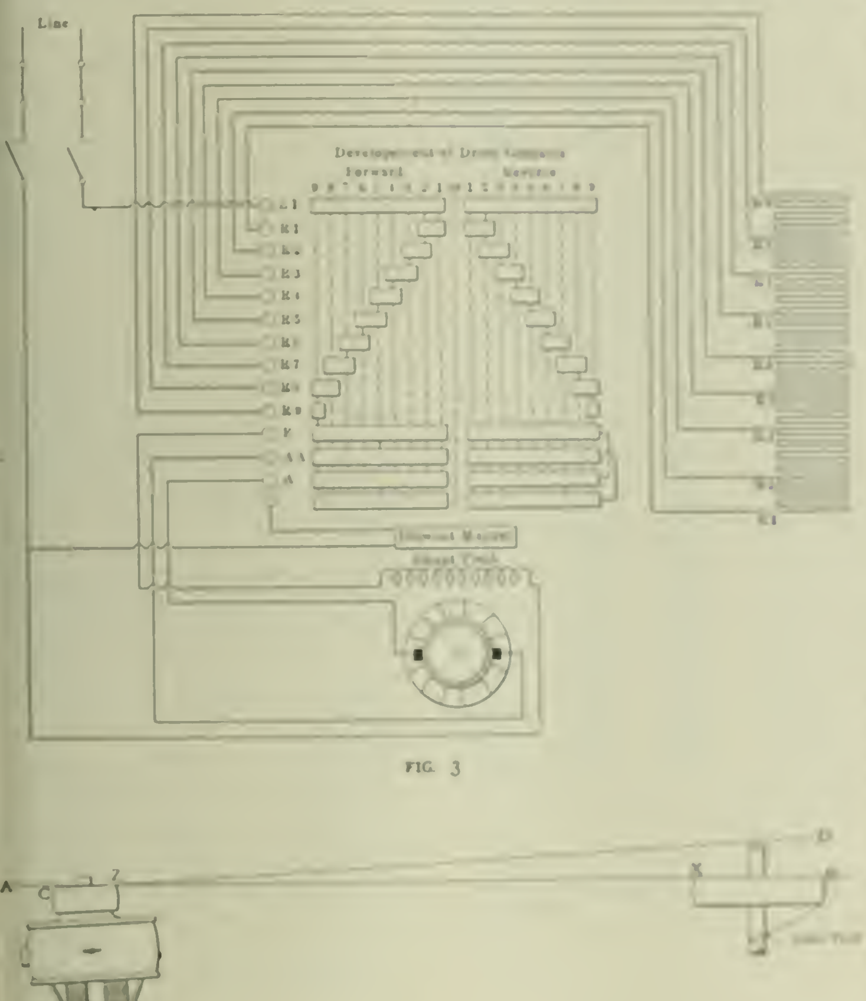


FIG. 3

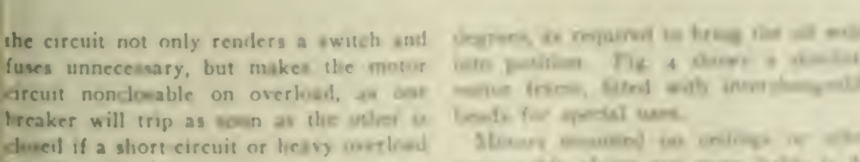


FIG. 5

the circuit not only renders a switch and fuses unnecessary, but makes the motor circuit nonclosable on overload, as one breaker will trip as soon as the other is closed if a short circuit or heavy overload is still on the line.

Fig. 3 shows complete connections for a motor with regulating and reversing controllers. When a large machine is driven separately by its own motor an ammeter should be connected in its circuit and mounted on the motor panel in order that the operator may avoid overloading the motor, by observing the ammeter indications. If this ammeter be of the record-ing type it will give a valuable record of the time the machine is idle, the load fluctuations and the manner in which the controller is handled; this will usually make the operator more careful, with a consequent decrease in power and repair bills.

Motor Frames and Location

The "heads" or journal brackets of nearly all motors are bolted on with four bolts or some multiple thereof, which allows the same motor to be mounted on the floor, wall, or ceiling simply by rotating the heads through 90 degrees or 180 degrees, as required to bring the oil wells into position. Fig. 4 shows a standard motor frame, fitted with interchangeable heads for special uses.

Motors mounted on ceilings or other inaccessible places are more liable to be neglected than if placed where they can be easily inspected; therefore, motors should, if possible, be located in a clean, dry and well-lighted place where any accumulation of dirt or grease will be readily noticed by the attendant. When a motor must be set close to a wall, the pulley side should always be away from the wall; this will not only make the commutator and brushes more accessible but allow the belt to be laced where it is out of the way. When locating a motor, especially a larger one, do not forget that it may be necessary to dismantle it for repairs some day, and leave room to remove the armature without shifting half the machinery in the shop; also bear in mind that the load that a motor can safely carry is governed by the allowable heating and that, therefore, a motor inclosed in a box without ventilation will only carry about three-fourths of the load that could be carried if the motor were given proper ventilation. The ratings of open, semi-inclosed and wholly-inclosed motors illustrate this very effectively. Because of the poorer ventilation of the two latter types they are given lower ratings by the manufacturers than open motors of the same size and windings.

Setting Motors on the Foundations

The frames of 120-volt to 250-volt motors should be insulated from the ground, but on circuits of 500 volts or over the motor frame should be well grounded to prevent injury to the attendant in the event of a ground in the motor

FIG. 4

winding. Before attempting to bolt a motor to its foundation one should make sure that the foundation is perfectly true and level, then locate the slide rails as close as possible, setting them with the adjusting screws at opposite ends, as illustrated in Fig. 4, but do not bolt them down. Place the motor in position on the rails and line it up with the driven pulley. A silk line should be procured and be tied of a bolt, stretched across the face of the driven pulley, as indicated by the line A—B, Fig. 5, one man holding the line taut at the point A and the other signaling to him when the line barely touches at the point B. The line is now secured at A and the motor moved until both edges of its pulley just touch the line. Some men go this far and call the motor lined up, but if satisfactory results are desired a line should be placed around the edges of the motor pulley and be tied of a bolt stretched away from the driven pulley. The line C—D shows the result (exaggerated), which must be corrected by shifting the motor around until the lines A—B and C—D coincide. If the two pulleys are of different width, an allowance of one-half the difference in the faces must be made when lining up.

After the motor is lined up the rails should be bolted down and the motor moved toward the driven pulley as far as possible before taking the belt measurement, which will allow maximum adjustment before it becomes necessary to shorten the belt. Whenever possible the driving stretch of the belt should be the lower one. The pulleys should be as far apart as conditions will allow; the belt may then be left slack and a large arc of contact with the pulleys obtained, decreasing the wear on the belt, bearings and shafting and materially reducing the friction loss of the drive and the motor current in consequence. The belt should preferably be endless, but under no consideration should a belt fastening be used that is thicker than the belt itself; if it is, a disagreeable jar will be felt each time the joint strikes the motor pulley. In putting on an endless leather belt care must be used not to run the belt against the laps; otherwise the thin edges of the laps will gradually loosen until the pulley catches them and rips the belt apart. Before starting a motor be sure that the bearings are filled with a good quality of engine oil, and see that all oil rings rest on the shaft and turn with it. If the brushes are not fitted to the commutator a piece of sandpaper should be held around the commutator with the rough side up and the armature rocked back and forth until the brushes are properly fitted, after which they should be set on the neutral point. The "no-load" neutral point is usually located at the factory by chisel marks on the rocker arm and frame. For reversing the motors the brushes should be set exactly on this point, but for nonreversing motors they should be moved back slightly in the direction opposite to the rotation of the commutator, until sparkless commutation is obtained with full load. When reversing motors are heavily loaded running in one direction and only lightly loaded when reversed, "back lead" should be given the brushes for the direction of rotation in which the motor is heavily loaded.

Starting Up and Shutting Down

In starting up, first close the main switch and then slowly cut out the resistance until full speed is reached. If the motor runs in the wrong direction it must be shut down and the brush leads reversed. In series- or shunt-wound motors, either the brush or the field connections may be reversed to change the direction of rotation, but for compound-wound or interpole motors, the brush connections alone may be changed; otherwise there is danger of reversing the series or compensating windings. For this reason it is well to adopt the rule of changing the brush connections, regardless of the kind of winding. If the series winding of a compound-wound motor is reversed, the application of a heavy load to the motor is liable to cause the series-field winding to overpower the shunt winding and possibly cause the reversal of the motor, with disastrous results. A sure test for the series-field connections is to put a light load on the motor and then short-circuit the series-field winding. If the speed of the motor increases the connections are correct, but if the motor slows down the series winding is reversed and should be changed immediately.

TABLE 1. UNDERWRITERS' WIRE TABLE.

MAXIMUM CURRENT.

B. & S. Size.	Rubber-Covered Wire.	Weather-proof Wire.	Circular Mils.
14	12	16	4,107
12	17	23	6,530
10	24	32	10,380
8	33	46	16,510
6	46	65	26,250
5	54	77	33,100
4	65	92	41,740
3	76	110	52,630
2	90	131	66,370
1	107	156	83,690
0	127	185	105,500
00	150	220	133,100
000	177	262	167,800
0000	210	312	211,600

TABLE 2. RATING OF DIRECT-CURRENT MOTORS.

FULL LOAD CURRENT.

H.P.	115 Volts.	230 Volts.	500 Volts.
1/6	1.9	0.95	0.42
1/4	2.7	1.35	0.62
1/2	5.0	2.50	1.15
3/4	7.5	3.75	1.70
1	9.2	4.60	2.10
2	17.5	8.75	4.00
3	24.6	12.30	5.60
4	32.0	16.00	7.50
5	40.0	20.00	9.20
7½	57.0	28.50	13.00
10	76.0	38.00	17.50
15	110.0	55.00	25.00
20	144.0	72.00	34.00
25	176.0	88.00	40.00
30	210.0	105.00	49.00
35	250.0	125.00	57.00
40	280.0	140.00	65.00
45	320.0	160.00	75.00
50	350.0	175.00	80.00
60	430.0	215.00	100.00
75	520.0	260.00	120.00
100	700.0	350.00	160.00
125	880.0	440.00	210.00
150	1056.0	530.00	245.00
175	1230.0	615.00	280.00
200	1400.0	700.00	325.00

TABLE 3. FUSES FOR MOTORS.

WITH OVERLOAD STARTING BOXES.

H.P.	115 Volts.	230 Volts.	500 Volts.
1/4	4	2	1
1/2	8	4	2
1	15	8	4
2	30	15	7
3	40	20	10
4	50	25	12
5	60	30	15
7½	90	45	20
10	115	60	25
15	175	90	40
20	225	115	50
25	300	150	60
30	350	175	75
35	400	200	90
40	450	225	100
50	600	300	125
60	700	350	150
75	800	400	200

When shutting down a motor do not pull the rheostat arm away from the retaining magnet, but open the main switch and the rheostat will release as soon as the motor slows down. Many operator are puzzled by the fact that the retainin magnet does not release the rheostat arn until the motor speed has dropped abou 50 per cent. This is due to the fact tha the retaining magnet is energized by th counter-electromotive force of the arma ture, which also keeps the shunt-fiel winding excited, until its speed is no lon ger sufficient to hold up the voltage.

The shunt-field circuit of a motor mus never be suddenly broken, even thoug the armature be stopped, as the sudde opening of a highly inductive circuit, suc as that of a shunt-field winding, causes a induced voltage greatly above the norma voltage at the terminals of the winding, the circuit is broken very quickly, an this may puncture the insulation of th motor windings. If the circuit must b broken it should be done by graduall drawing an arc until it breaks. Mo motor starters are so connected that th field winding discharges the induced vol age through the armature and resistanc when the rheostat arm flies to the "off position.

Curing Warm Bearings

In case the bearing of a motor becom too warm do not stop the machine, b cause the babbitt will contract and gr the shaft and necessitate rebabbittin keep the machine running slowly, with th load off, and keep pouring cool oil on th bearing until it cools down to a sa working temperature. The motor ma then be stopped and the bearings shou be removed and any slight roughness c the shaft or bearings removed with a fi or scraper; the bearings should then l calipered and if not too loose may be r placed. If, however, the bearings a badly cut, there is no remedy save r babbitting.

When the fuse or circuit-breaker in motor circuit opens the circuit, the ma switch should be opened the first thin Then the circuit-breaker (if there is on should be closed and again tripped l hand to make sure that burning of th contacts has not rendered it inoperativ The breaker should then be closed (or th fuse replaced) and the motor started usual. If the fuse or the breaker aga "blows," trouble must be looked for the motor, as will be explained in a subs quent article.

In plants where many motors are use, the various departments should divided into routes and these rout should be so laid out that one of th motor inspectors will visit each motor least twice each week. The inspect should carry an oil can and keep all wells filled to the proper hight, being car ful to remove the side plugs when fillin in order to avoid getting the wells t full. He should also inspect the bearin and by testing the air gap satisfy hims that they are not dangerously worn. T commutator should then be inspected a if necessary smoothed down with sandpaper (never emery cloth), after which the brush tension should be tested by raising each brush from the commutator, being careful that all brushes of the same group are in contact with the commutator before raising any brush of that group. If the commutator needs lubrication it should be lightly touched with a clean, slightly oily rag (never use waste) and the surplus oil immediately removed with a dry cloth.

Lubricants for Cylinders

By John M. Sewell

A perfectly smooth surface exists only in theory. With the most modern appliances it is possible at the best to produce only a comparatively smooth surface and when two surfaces of this kind come together in sliding contact, their roughness is evidenced by the frictional resistance to the motion and the wear of the surfaces in contact. The interior surfaces of the cylinders fitted with the reciprocating pistons, together with pistons themselves, form excellent examples of surfaces in sliding contact. Lubricants are used to reduce both the frictional resistance and wear. This is accomplished by interposing a thin layer or film of the lubricant between the two moving surfaces, filling up the minute depressions and preventing the very small projections of one surface from engaging with and dislodging similar projections on the other surface.

The question of cylinder lubrication is an attractive one, and it is one that is extensive in its scope. However, for the purpose of discussion, all cylinders requiring lubrication may be grouped under four heads or classes: First, the cylinders of the steam engine; second, the cylinders of explosive motors or gas engines; third, the cylinders of air compressors and ammonia compressors; fourth, the cylinders of pumps and hydraulic machinery. These classes may be farther distinguished by the position of the cylinder, whether vertical or horizontal.

It has been argued that oil, or its equivalent, need not necessarily be used on sliding surfaces, but that water will serve the purpose. This cannot be denied, for when water is used, it forms a film between the moving surfaces and reduces the friction. But water cannot by any means replace oil or grease as a lubricant.

Water lubricant has been used in several types of engine, but without much success, and in every case where other lubrication is practical, it would be advisable to inquire into the effect on the coal pile before coming to any definite conclusion regarding the economy of that kind of lubrication for use in engine cylinders. It is clearly impossible to avoid the use of some sort of lubrication in a majority of cases, no matter how easily water may work under certain conditions.

The Conditions to be Met

The question is, then, to obtain the lubricant for the existing conditions and no one can tell these conditions better than the man in charge of the machinery, for the conditions are not always the same in all cases. Some conditions to be met with are: First, the iron of which the cylinders are made is different and needs better lubricant; second, the location of the valves may be different, which would make necessary a better kind of lubricant; third, high temperature, due to heat of steam, the heat caused by compression, or the heat generated by the combustion of the charge in the explosive chamber; fourth, water due to the condensation of steam on account of the cooling effect of the cylinder walls; fifth, water retained by the steam and carried over from the boilers into the cylinders, which may often contain many troublesome impurities; sixth, friction due to the pressure of the pistons and valves against the walls of the cylinders and steam chests.

As a consequence of these conditions, a cylinder oil or other lubricant to be valuable must possess the following characteristics: First, it must have a high flashing point or point of decomposition under the effect of the heat; second, it must possess sufficient body to keep the surfaces free from contact under pressure; third, it must be as fluid as consistent with pressure conditions; fourth, it must be capable of resisting the action of the atmosphere; fifth, it must be free from corrosive action upon the metals of which the surfaces are composed. It can therefore be seen at a glance that the conditions cannot be met with any simple lubricant, but must be compounded.

The selection of a cylinder lubricant therefore necessitates a study and long experience of the conditions of the temperature, pressure, speed and condensation, and a great deal of watchfulness. In the first place if you have a poor oil the damage is done before you are aware of it.

It is not an easy matter to determine what lubricant is best adapted for the particular cylinder, but when this has once been determined, this grade should be used persistently, as long as it gives satisfaction. Much of the trouble due to the cutting and scoring of the valves, pistons and cylinders is due to the use of poor cylinder lubricants.

It has come to be a generally accepted statement, upheld by years of experience, that the best lubricant for cylinders is a mineral compounded oil of good body with high flashing point, for a purely mineral oil contains a great number of good qualities which go to make a suitable cylinder compound.

The Different Classes of Oil

Oil is divided according to the sources from which it is obtained into three classes: Mineral oil, such as produced from oil wells and bituminous shale by the process of distillation; vegetable oil; animal oil. Vegetable and animal oils possess certain properties which make them totally unfit for a cylinder compound. They decompose easily and if the atmosphere is warm and moist, the decomposition becomes greatly increased. These conditions of heat and moisture exist in every steam cylinder, and to a certain extent in the cylinder of explosive engines. Hence the use of either of these oils must be regarded as contrary to good practice.

Let us note just what takes place when either of these two oils is used in the makeup of a cylinder compound. Tallow is a compound of stearic acid, or a stearine compound of carbon, hydrogen and oxygen. When it meets with steam or hot water the action of the heat decomposes the tallow to a certain extent and a portion of the decomposed atoms, combined with a portion of the hydrogen and oxygen of the water, form new compounds, so that where originally there were stearine and water, there are now stearic acid and glycerin. This stearic acid being in a free state is now left to attack the metal of the cylinder, which it does with great vigor, pitting the surfaces of the cylinder, pistons and valves until they are ruined or, as in many cases, to such an extent that the cylinder is blown to pieces. The same action would take place if palm, vegetable or lard oils were used. For in palm oil we get palmitic acid and in the lard or vegetable oils we get oleic acid set free. Both of these acids would attack the cylinder just as stearic. These disadvantages precluding the use of fatty oils leaves the field open chiefly to mineral oils.

As previously stated, mineral oils for lubrication are obtained from crude oil by the process of distillation. The heavy oils used for cylinder lubricants are those left in the stills after the distillation is almost complete; they represent the least volatile components of petroleum. When a quantity of crude oil is placed in the still and subjected to the action of the heat, the first product vaporized and driven off is crude benzine. This product is from 100 to 300 degrees Fahrenheit. If the temperature is then raised, a second series of distillates will be formed, including illuminating oils. These are driven off by raising the temperature from 300 to 575 degrees. There then remains in the still a thick heavy residuum [illegible] from which paraffin [illegible] lubricating oil and [illegible] it is common to use [illegible] the following [illegible] cylinders, and the lubricant [illegible] to some of the engines [illegible] where a greasy lubricant can be used with efficiency.

Specific Gravity and Viscosity

At first the ordinary lubricant oils were obtained from the residuum by further heating and distillation, but this destroyed many of their valuable lubricating properties. At present, this residuum is treated in a vacuum, or in superheated steam, which prevents decomposition of the distillate and preserves its lubricating properties. The first products of this final distillation are the higher machine oils and the last products are for the heavy machine and cylinder oils. At one time the specific gravity of an oil was made the criterion by which it was judged and selected. That is, the oil possessing the highest specific gravity was thought to be the best suited for cylinder lubrication, but this theory was soon exploded when it was found that some of the machine oils possess more specific gravity than the more viscous oils.

Then viscosity was made the standard of comparison and this to a great extent is the characteristic which influences the selection of oils at the present day. But even this properly cannot be relied upon, for the very reason that the viscosity may not be due to the friction and cohesion of the oil molecules alone, but to the presence of paraffin, in which case its value as a lubricant may be even less than that of an oil of less viscosity but possessing a smaller per cent. of paraffin. Farther than this, the viscosity of an oil changes with its temperature, the higher the temperature the less viscous it becomes. What is desired, then, is an oil the viscosity of which at the actual working temperature will still be sufficiently great to prevent its being squeezed out from between the rubbing surfaces under the effect of the pressure.

Another impurity in oil which lowers its efficiency as a lubricant is sulphur. This may be present owing to the improper methods of refining. To determine whether sulphur is present, heat a very small quantity of oil, say for fifteen minutes, at a temperature of 300 degrees Fahrenheit and then allow it to cool. When cool, compare the color of the treated sample with that of the untreated oil and if the treated sample shows perceptible darkening, it may be safely assumed that sulphur is in the oil.

Requisite Qualities for Cylinder Lubrication

This brings us, then, to a consideration of the qualities of the oils required for lubricating the four kinds of cylinder referred to: In selecting an oil for steam cylinders the viscosity should be proportional to the weight and the speed of the piston. The flashing point must be governed by the steam pressure carried. If this is high, then the oil should have a correspondingly high fire test. The flashing point should not fall below 400 degrees Fahrenheit in any case; and the more animal fat the lower the fire test which ordinarily calls for from 500 to 600 degrees Fahrenheit. It is most difficult to obtain a much higher test. Although cylinder walls of an explosive engine are cooled with water jackets, it is nevertheless a fact that the lubricants are subject to the evaporative effect of the intensely hot gases. To withstand this successfully an oil of high fire test is required, and for general use a pure mineral oil is the best.

For compressor work the cylinder lubricant must withstand not only great heat or cold but, probably, ammonia influences. This means either a high fire test or a low cold test, or both; and the purely mineral oil fulfils these requirements. If ammonia is used it is imperative that only pure mineral oils be used, since any animal oil in conjunction with ammonia will form soap, which in turn will cause no end of trouble in the machine and the condensing coils. Another mineral that is regarded as a good cylinder lubricant is graphite. In a finely divided or flake form it gives an exceedingly smooth skin to the metal-rubbing surfaces and at the same time considerably lowers the coefficient of friction. The main trouble with the use of graphite formerly lay in the fact that it could not be fed into the cylinder like oil, and it could not reach all the surfaces that needed lubrication. This disadvantage restricted the use of graphite for a long time to special cases for emergencies. At first an attempt was made to mix the graphite with the cylinder oil so as to get it into the cylinder at the required points. The difficulty met with, however, was that the graphite would not stay mixed with the oil and would settle to the bottom, in which case it became not only useless as a lubricant, but very troublesome. After much experimenting this difficulty has been overcome by the application of a new principle in the mixing of the graphite and oil.

Properly speaking, two oils are used at about the same specific gravity, but of such natures that they will not mix together, as oils usually do; that is, they repel each other somewhat as do water and oil. In one of the oils, called the developing oil, the graphite is thoroughly mixed and ground until every particle of the graphite is surrounded and incased by a film of oil. This mixture is added to the other oil and the grinding and mixing continued, until the distribution of the graphite is complete and uniform throughout the mixture. It has been found that this compounded lubricant works well in cylinders if properly mixed, with the right quality of oils.

In conclusion, it should be said that there is no part of an engine where so much risk is taken in changing lubricants as in the cylinders. Therefore, it is advisable, where a lubricant is giving good service, not to change a certainty for an uncertainty.

Hudson-Fulton Celebration

We have received a synopsis of the plan and scope of the Hudson-Fulton celebration, which will begin on September 25 of this year and will continue for eight days in and around Greater New York and the following week in the cities along the Hudson river, as far north as Troy, with general participation throughout the State. It will surpass anything ever attempted in any city of the Union.

The commission in charge of the celebration is incorporated and consists of 365 members appointed by the governor of the State of New York and the mayor of the City of New York. Its membership includes the mayors of all the 46 cities of the State and the presidents of 38 incorporated villages along the Hudson. The president of the commission is Gen. Stewart L. Woodford, 18 Wall street, New York, and the presiding vice-president (also acting president) is Hermann Ridder, 182 William street. The headquarters is in the Tribune building, where the secretary, Henry W. Sackett, is to be found. The treasurer is Isaac N. Seligman, 1 William street, New York City.

The purpose of the commission is to arrange for the celebration of the three-hundredth anniversary of the discovery of the Hudson river by Henry Hudson, in 1609, and the one-hundredth anniversary of the successful application of steam to the navigation of the river by Robert Fulton in 1907. Because the two historic events occurred on the same river and their anniversaries came so closely together, it was deemed advisable to postpone the 1907 anniversary and celebrate both together.

The plans for the celebration have been formulated with a view to the international, national, interstate, State and local significance of the events to be commemorated.

Saturday and Sunday, September 25 and 26, will be religious-observance days; Monday, September 27, will be reception day; Tuesday, September 28, will be historical day: Wednesday, September 29, will be general commemoration day; Thursday, September 30, will be military-parade day; Friday, October 1, will be Hudson river day; Saturday, October 2, will be general carnival day in New York City.

In all the cities, October 2 will also be Children's Day, devoted to fetes in public and private parks and playgrounds.

The upper Hudson week, which will begin Sunday, October 3, will be somewhat in the nature of an Old Home Week. Each county has been assigned a day, as follows: Dutchess county, Monday, October 4; Ulster county, Tuesday, October 5; Greene county, Wednesday, October 6; Columbia county, Thursday, October 7; Albany county, Friday, October 8; Rensselaer county, Saturday, October 9.

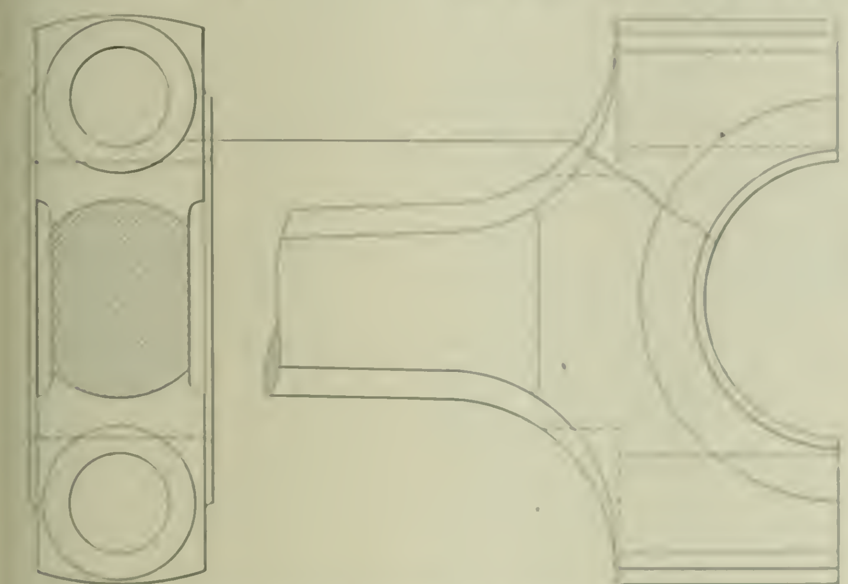
Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Connecting Rod Design

The accompanying illustration shows the end of a connecting rod which frac-



SHOWING THE FRACTURE IN A CONNECTING ROD

tured in service about as indicated. The side view of the rod presents an appearance of great strength, which on closer inspection is found to be misleading. The shaft blends into the enlarged end with a curve of large radius, but the good effect of this construction is neutralized by the recesses for the bolt heads, which are of such large diameter relative to the width of the rod end that but a slight amount of metal is left on each side to reinforce the weak section.

A thin wall of metal such as this, introduced for the purpose of strengthening a heavy member, in many instances does more harm than good since, while it increases the stiffness of the member, it may for that very reason render it less able to resist shock. The stress developed will be high in the thin portion, and may cause a crack which would not have occurred but for the presence of such a thin web.

In this instance the bolts were made quite large, for the reason that they had been giving trouble by breaking frequently, the break occurring under the head and not, as might have been expected, at the root of the thread. Bolts for such service as this should be made of tough, refined wrought iron or nickel steel, and should be annealed at frequent intervals.

The drawings from which this rod was made showed the cap and bolts in position, from which to study the proportions of parts.

George E. [illegible]

Pittsburg, Penn.

Chute for Handling Wood

I can suggest to J. D. [illegible] a scheme which I have found very successful. Make a chute about [illegible] feet long and 6 feet wide, into which the wood is delivered. As the lower sticks are removed, the wood will keep sliding down.

The great expense would be the grading of the [illegible] road to the top of the chute and the cost of the chute, but it would soon pay for itself.

W. H. H. [illegible]

Philadelphia, Penn.

Boiler Setting

The sketch shows the setting of a boiler in a plant where I am employed. As originally set, considerable smoke and soot were produced on the bottom of

MR. [illegible]'S BOILER SETTING

[illegible]

[illegible]

making the change the smoke and soot have disappeared.

I am not in a position to state the amount of gas that has been saved, because the boiler is connected on a 6-inch main with a number of other burners. However, it is safe to say that there is a saving of gas because of the more perfect combustion.

C. S. Robinson.

Independence, Kan.

An Emergency Packing Ring

The packing ring gave way in a Corliss engine, with no new ones nearer than the factory, and the engine was needed very badly. The type of ring is shown in Fig. 1.

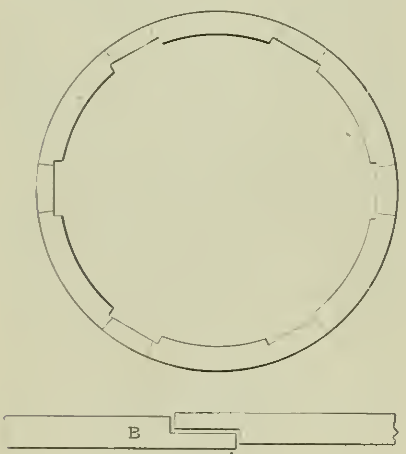


FIG. 1

Such a ring is placed in the slot of the bull ring, and held against the action of coil springs by small pins, which are inserted through holes in the rim of the bull ring, and also pass through holes in the packing ring (not shown in the sketch). These coil springs press outward against a tee-shaped piece of iron,

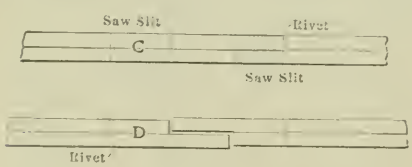


FIG. 2

the stem of the tee being inside the coil spring and the cross piece pressing against the slots shown on the inner surface of the ring. At *B* is shown how the sections overlap, making a steam-tight joint.

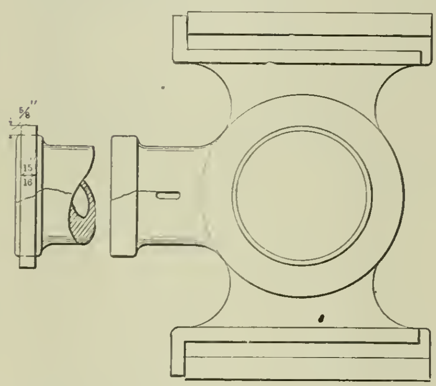
To make such a ring as is made at the factory is difficult, but a substitute may be easily made as follows: Two rings are bored and turned to the proper diameter for the finished rings, and the sides machined perfectly true. The two rings are then riveted together forming a single ring. At least two rivets should be placed in what is to be one section of the ring. The ring is then cut with a hacksaw, as shown at *C*, Fig. 2, after which the different sections may be separated as shown at *D*. Slots should be cut on the inner surface of the ring before the ring is sawed into its different sections. Holes should be drilled in the proper places to receive the pins for holding the ring in position on the bull ring while it is being placed in the cylinder. It is hardly necessary to state that after the bull ring is in place the pins must be removed to allow the springs to force the packing ring outward against the cylinder walls.

C. L. Greer.

Handley, Tex.

Crosshead Repair

The accompanying sketch shows the method employed by which a cracked



HOW A CRACKED CROSSHEAD WAS REPAIRED

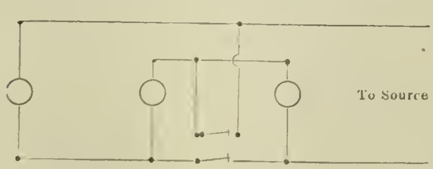
crosshead was repaired. The band, which was made of swedish iron, was, after being finished on a lathe, $1\frac{5}{8}$ inch wide, $\frac{5}{8}$ inch thick and of $6\frac{1}{32}$ inches inside diameter. It was made with $\frac{3}{64}$-inch shrinkage fit and put on hot.

C. D. Dispenette.

Greenville, O.

Throwing Lamps in Series and in Parallel

On page 71 of the January 5 issue, E. J. Williams asks for a diagram showing how to throw three lamps from series to parallel and *vice versa*. The accompanying diagram indicates a method using only one double-pole single-throw switch



MR. DURAND'S SUGGESTION

which, on closing, connects the lamps in parallel and on opening puts them in series.

W. L. Durand.

Brooklyn, N. Y.

I am submitting two wiring diagrams by which three battery lamps may be switched from parallel to series and *vice versa*, by means of standard switches.

The diagrams are the same except that in Fig. 1 two four-point pole-changing switches are used, while in Fig. 2 two double-pole double-throw knife switches are used. In both cases l_1, l_2 and l_3 are battery lamps; *S* and *S* are the switches. Fig. 1 shows the lamps in series using the pole-changing switches; Fig. 2 shows them in multiple, using the knife switches; *a* and *b* are common wires between the lamps.

This arrangement of wiring, for automobile sidelights and taillight makes it possible to economize on battery current while the machine is standing at the curb on the street.

It is required by law and is necessary,

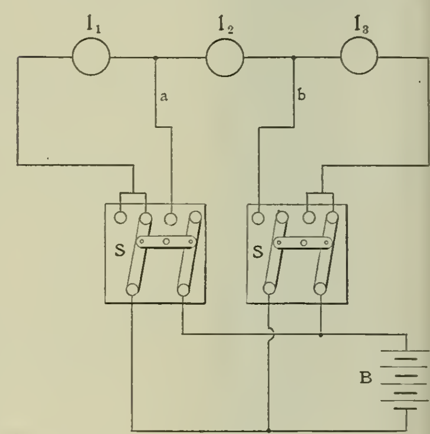


FIG. 1

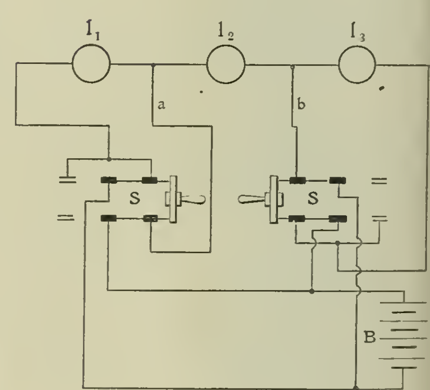


FIG. 2

to prevent accidents, to have these lights burning. When the lamps are thrown in series they draw only one-third the amount of current as when in multiple; however, the candlepower is reduced in the same proportion, but it is only necessary to have a light even though it is not brilliant. A special lever switch mounted on the dashboard of the automobile would be ideal for this wiring scheme.

J. E. Washburn.

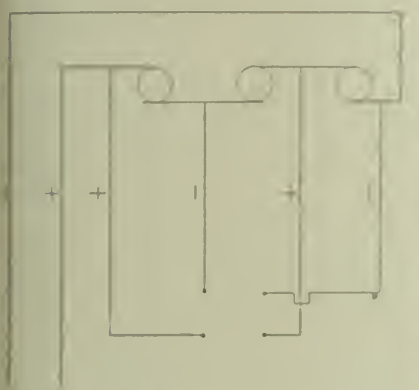
Cleveland, O.

I think the sketch herewith will solve Mr. Williams' problem, using the same source of current. If he wishes to use two different currents, however, he may employ a double-point double-throw knife switch. The switch shown in the sketch is a double-point single-throw switch.

JAMES F. DRYDEN.

Pocomoke, Md.

I inclose a rough sketch of a method



MR DRYDEN'S SOLUTION

MR. BENJAMIN'S DIAGRAM

which could be extended to any number of lamps, but would evidently be most desirable if only a few were needed.

As shown, the lamps are in series; if the switches were closed they would be in parallel.

C. A. BENJAMIN.

Philadelphia, Penn.

Effect of Scale in Boilers

If the furnace temperature of boilers averages 2000 degrees Fahrenheit, it is quite clear that the escaping gases would be 240 to 300 degrees higher before scaling than after scaling, if it were true that the scale caused an increase of from 12 to 15 per cent. in fuel consumption; otherwise, as Hilton Williams inquires, where does the extra heat go? It is very certain that 1/16-inch scale does not cause any such rise in temperature of escaping gases, and that the direct effect of scale on fuel bills is small.

But there is no justification for letting scale form in boilers, as all the deterioration and repairs to boilers arising from scale can be prevented and all the labor of scaling boilers avoided, by the use of an open heater fitted with accessory soda treatment, whereby the scale-forming impurities are arrested at nominal cost, so that the boilers can be cleaned by merely washing out with a hose.

We have installed large numbers of such heater-softeners, with the greatest success with all types of boiler, so that no occasion arises for the use of boiler compounds or tube scrapers, but the fuel saving due to heating the feed with exhaust is far more important than the fuel saving arising directly from scale prevention.

ERITH'S ENGINEERING COMPANY, LTD.

London, England.

Commutator Trouble

In reply to A. L. Baker's letter for commutator advice, I will suggest a few causes that could produce his trouble. It is understood that the smallest details are fully known, but in nine cases out of ten that is where the trouble is found. As he does not say what his load is when the bad sparking occurs, I take it for granted that he is carrying the full load.

As the machine was designed for 250 volts and only 220 volts are being carried, the proper field density is not obtained. The speed should be cut down and the field current increased. If the brushes are radial, see that each set are perfectly so. If they are angle brushes and the commutator runs against the toe, take the holders off the studs and reverse them, making the commutator run against the heel of the brush. See that there are the same number of commutator bars between the sets of brushes, and adjust the rocker arm to get the proper lead for sparkless commutation. No amount of adjusting will help if the trouble is in the brushes. Have the brushes work free in the holders and do not have them too long. A brush a little too short will work better than one too long. Adjust the tension on the brush springs to hold the brush snug to the commutator. If the line voltage drops at full load, adjust the shunt resistance to get the correct voltage [illegible].

From the nature of the trouble, I should not think it was in the armature; however, it would be well to test for opens and grounds if such has not been done. I am inclined to think the trouble is a weak field if the brushes and lead are absolutely correct.

L. E. [illegible]

[illegible], Ala.

Compression

I have often read articles for and against compression as a means of economy in the use of steam. Some engineers say they have tried it, but they do not show indicator diagrams taken with no compression while they do show diagrams taken with what they call medium compression. I judge by these diagrams that engineers are inclined to expect too much from a slight change in the closing of the exhaust valve, say 2 or 3 inches before the end of the stroke.

The accompanying sketch shows very plainly what may be expected at two points of closure. I divide the cylinder into ten equal parts, and assume one of these parts to be equal to the clearance and steam passages, designated by the space A A.

FOR [illegible] COMPRESSION

In practice the exhaust pressure is, say, 2 pounds above the atmospheric line D. Suppose the exhaust valve closed at three-tenths before the end of the stroke; the pressure would be [illegible] pounds when the piston has arrived at the end of its stroke. The pressure at the first and second points is also shown. What might be expected if the exhaust valve closed at one-half stroke is also shown.

Taking this as a standard of comparison for the compression had on an ordinary engine, how do the cards generally illustrate compression? They do not show compression to an extent that would make any difference in the [illegible] [illegible] [illegible] [illegible] pounds by compression [illegible] [illegible] all of the points, that is, compression, admission, cutoff and exhaust, [illegible] [illegible].

C. E. [illegible]

[illegible], Tenn.

Do Crank Pins Always Wear Flat?

An old crank of the center-crank type was brought into the machine shop. It had evidently been in use for a long time, for the crank pin was worn so small that the owner felt that it was no longer safe. One of the men measured the crank with his calipers and then told another of the men to measure the flat spots on the pin and tell which way the crank turned.

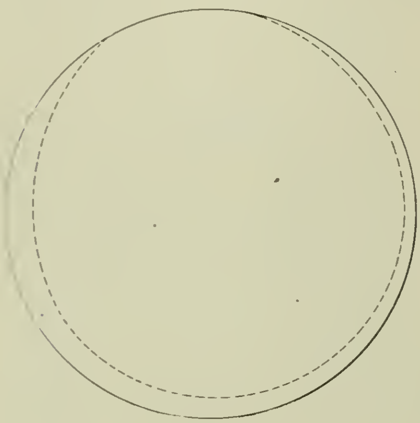


FIG. 1

That seemed tolerably easy to do, and the man took his calipers and went to the crank. A glance at the pin and bell showed which side of the pin received the pressure, for the pin was badly out of center with the bell, but the most careful calipering failed to show that it was out of round; neither could any flat spots be found.

In a discussion which had taken place about the wear of crank pins, the apparent fact that pins would always wear out of round had not been questioned, but the talk had been confined to the ultimate shape and position of the results as compared to the original position of the pin. The same question came up in another place some time later. A crank pin was examined that measured ⅜ inch closer to the bell on one side than on the other, and yet this pin was round as far as the ordinary measurements could detect.

The usual assumption is that crank pins should wear flat, and the assertion is often made that they do wear flat in steam-engine practice. The cranks referred to were from small steam engines of not over 40 horsepower, but for some reason they were round.

If it is proper and natural for a steam-engine crank pin to wear flat, it would seem even more natural and proper for a gas-engine crank to do so. I measured some worn gas-engine cranks to see how they wore. One from a 40-horsepower engine had been in hard service for about four years. It had run dry, had become cut several times and had been redressed by filing. It was practically ¼ inch smaller than when new. Two experts measured it carefully with a micrometer and pronounced it out of round not to exceed 0.002 of an inch.

One from a 20-horsepower gas engine had been in use for thirteen and one-half years. Measuring with a scale from the pin to the washer that had been faced on the bell to give the brasses a bearing showed that the pin was a full ⅛ of an inch nearer to it on one side than it was on the other, yet the micrometers showed that the pin was round within 0.0015 of an inch. This pin was 7/32 smaller than the original size.

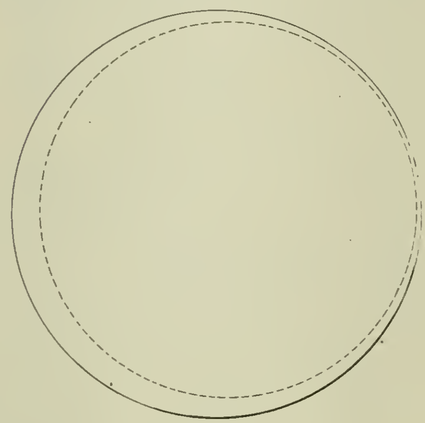


FIG. 2

A crank from a 15-horsepower gas engine had been in use more than ten years. It was more than ¼ of an inch smaller than the original size. It was 3/32 of an inch removed from its original center and was practically round, being out but 0.001 of an inch. These pins had not been carefully used and should have shown the effects of wear in a marked and unmistakable way.

It takes constant attention and careful work to have pins turned on center-throw cranks so perfect that the micrometer will not find any variation from round. Pins were measured on cranks where the engines had always received good care, and where there were no signs of cutting, and they were found to be round. Pins have been pronounced out of round by men who were not skilled in using measuring instruments, when experts found the trouble in the men and not in the cranks.

Pins from side-crank engines, if taken out and revolved on the original centers, often will not run true where the brasses bear, but this does not prove that they are not round there any more than it would prove that an eccentric is not round because it does not run true when put on a mandrel that causes the hole to run true. It may be that crank pins on larger or smaller engines than these mentioned will show different results, and it may be that engines designed differently may also do so, and if such is the case it will be interesting to know it.

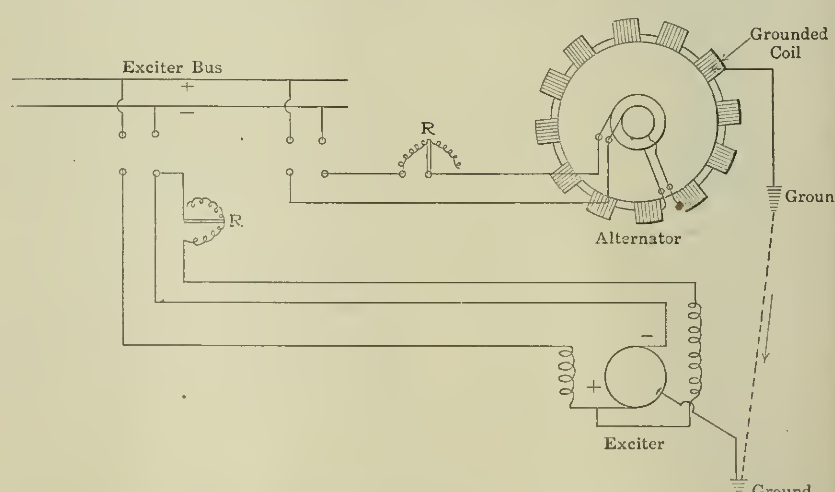
In Fig. 1 the full circle represents the original pin and the dotted lines represent the shape it was thought it would assume from wear and its position in relation to the original. In Fig. 2 is shown in outline the original pin, the dotted circle representing the pin, which has been worn round but not flat.

W. O. Platt.

Oil City, Penn.

Trouble Caused by a Ground

The equipment in the generator room of a paper-mill power plant consisted of three 500-kilowatt three-phase 440-volt revolving-field alternators, direct-connected to water turbines. The alternator shafts were extended for driving the exciters and various other machinery. There were two 37.5-kilowatt exciters, belt-driven. No. 1 alternator carried No. 1 exciter; No. 2 alternator carried a low-pressure centrifugal pump, direct-connected and a high-pressure power pump, belt-connected; No. 3 alternator carried No. 2 exciter and the mate to the centrifugal pump. To complete the "mess" there was a gallery switchboard stuck up under the roof and a spiral stairway lead-



SHOWING HOW TROUBLE WAS CAUSED BY A GROUND ing to it. One night I went to the generator room and found the attendant acting rather dizzy. I first thought he had got a series of hurry calls up the winding stairs, but a whiff of his breath was sufficient proof that the stairs were not wholly to blame.

Soon after taking charge I found that the commutator of No. 2 exciter was damaged in a rather peculiar manner, the insulation between the bars being burned all around the outer end, and extending from one-fourth to one-third the length of the bars. A test showed the armature to be grounded and the commutator ran too warm, but the machine generated all right.

One Sunday morning the attendant wished to shut down No. 1 alternator and, therefore, changed over to No. 2 exciter. Soon after doing so he noticed that No. 2 alternator was vibrating back and forth on the base with each revolution of the field. My first impression was that the anchor bolts were loose, but a trial with a wrench showed them to be tight.

As the exciter was known to be grounded, I started testing the alternator field circuit for a ground, and discovered that about one-third of the field coils were warmer than the others. The circuit was then broken between the cool coils and the warm ones and a test showed the ground to be among the cool ones, and the first cool coil proved to be "it." When the coil was removed it was found that the insulation, although very heavy, had been punctured and a hole as large as a quarter of a dollar burned in it, thus grounding the coil on the pole piece.

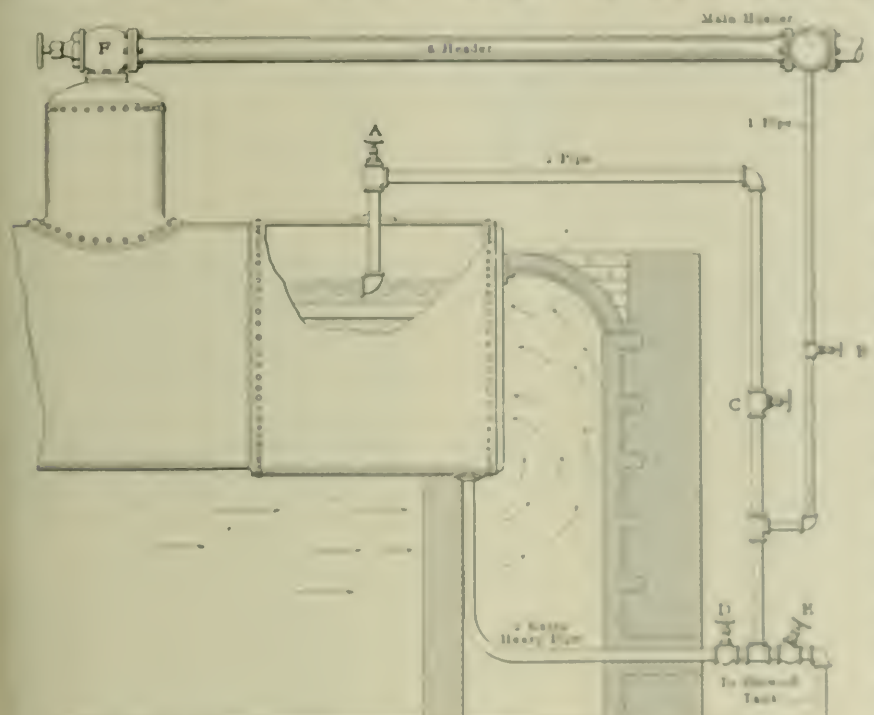
The sketch (on page 290) shows how the trouble occurred. The grounded exciter and grounded coil short-circuited some current from a part of the coils, making them weaker than the others. Undoubtedly the primary cause of the trouble was that at some time the field insulation had been punctured by inductive discharges, and the grounded exciter did the rest.

H. L. STRANGE.

Portland, Me.

A Blowoff Arrangement

The sketch illustrates a blowoff arrangement I have been using for five years. At *A* is a 2-inch angle valve on the scum blowoff, to be used in case of repairs on the blowoff valve. The scum blowoff leads into the boiler at the top and extends down just below the normal water line, with an ell facing toward the front of the boiler. At *D* is a 2-inch gate valve, and at *E* a 2-inch Y valve.



SHOWING MR. FINLEY'S BLOWOFF ARRANGEMENT

While the boiler is in use the valves *B*, *C* and *D* are open and valve *E* is closed. When I blow off the boiler, about every six hours, I close valves *B* and *C* and open valve *E*. When I have blown down enough I close valve *D*, open valve *C* and blow off the scum; then I close valve *C* and open valve *B* in the line leading to the main steam header.

With *B* open, I get practically dry steam, and the circulation in the blowoff pipe removes any mud or particles of scale away from the disk of the valve *E*. With valve *B* open, valve *E* closed and valves *C* and *D* open the condensation in the steam header flows through the 1-inch pipe by gravity and back to the boiler through the blowoff, which causes circulation enough to keep the blowoff pipe clear of mud, etc. I have not been troubled with the blowoff being stopped up in the last five years, and I do not have to renew the disk in valve *E* oftener than once a year. I am using the arrangement on two 125-horsepower return-tubular boilers.

E. R. FINLEY.

Buffalo, N. Y.

Recognizing the Staff

The editorial, "The Line Recognizes the Staff," on page 174 of the January 19 number, is in keeping with the average marine engineer's view of the matter. "Fighting Bob" Evans certainly deserves no little credit for forgetting the usual standing of the navigator so far as to admit that "the man who brought the fleet around the Horn is the man who boiled the water in the fireroom and the man who peeled the potatoes." The effect of this magnificent statement is to a certain extent spoiled, however, by the additional remark that "they have done as much to take it, step by step, as the keen-eyed officer on the deck or the gray-haired captain on the bridge." It would have been more in keeping if the admiral had compared the men boiling the water and peeling potatoes with the men on lookout and at the wheel. Other comparisons could have followed.

Who can explain the antagonism which exists between officers of the deck department as a whole and those of the engine department? Is it that the deck officer lived and had his being centuries before steam propulsion was thought of? Can it be that it exists because the engineer is in a position to command a salary in keeping with his increasing responsibilities and is at present much better paid? Then, again, it might be the engineer's natural aggressiveness that is to blame, or the fact that the engineer's uniform when on duty is a suit of overalls.

That the captain of a vessel seeking an exceptionally nice run is looked and found is due, to a great extent, to the fact that the newspaper men just report callers on the chief engineer, and, at least, we get little information on their doings, whereas the deck officers are easily reached and are ever so prone to talking. Engineers do occasionally get credit, however, as in the case of a vessel completing in New York harbor, when one of the leading papers referred to the quickness of the captain's eye and the smart work of the engineers at the levers in the matter of saving a ship. So let us be thankful for small mercies.

I want to relate a little incident that happened on my ship not so long ago.

We were hustling through the usual routine of boiler-room work in port. There were men cleaning smoke boxes, others wheeling ashes to the boiler-room at work on the furnaces and the hundred other jobs requiring doing in the short time the ship would be in port. Needless to mention, all was noise, dirt and seeming confusion, and myself in the thick of it. As the men were preparing to swing open another smokebox door I was surprised to see them hesitate and look over my shoulder and on turning was even more surprised to see the third mate, Mr. Smitzer, standing watching operations in the company of a stranger. This third mate was one of those men who, having failed in the battle of life, are fond of telling yarns of the time they were "in command," and have no little idea of their importance. He condescended to recognize my presence with a brief nod. I noticed one of my men at this point mutter to his mate and they both grinned maliciously. It occurred to me that Mr. Smitzer had had this same man logged for throwing some scraps of food in the scuppers.

On a question from the stranger Mr. Smitzer approached me with a supercilious air. The conversation that followed was interesting.

"How many boilers have we, Mr.—er —er?"

"Six." This from me.

Smitzer, turning to the stranger, who was listening to my answer, said: "We have six boilers!"

"And, how many fires in each boiler, Mr.—er—er?"

"Eight." This to the stranger, who originally asked the question.

"We have eight fires to each boiler!" This from Smitzer, impressively.

"How many men are on duty at a time?" asked the stranger, pleasantly.

"How many men have we on duty at one time?" anxiously parroted Smitzer, getting ready to enlighten the stranger in my stead.

"Twenty-four."

"We have twenty-four men on duty down here at one time. Think of it! You see," explained the garrulous Smitzer to the stranger, "we have to drive her all the time!" *We* have to!

At this moment the stranger walked across the boiler room to look into the uptake of a clean boiler, Mr. Smitzer staying behind to gaze around him with arms akimbo. Suddenly a startled yell rang out and the stranger and I turned in time to see a great stream of ashes pour from the opened smokebox. The air was filled with ashes and soot at that end of the boiler room and in the midst of it all scrambled the unfortunate third mate.

Of course, I saw to it that the men were severely spoken to, and that some of the ashes were removed from Smitzer's clothes before he returned to the deck. What is the moral? Why, there are several of them.

B. Slattery.

New York City.

Some Vertical Centrifugal Pump Troubles

We have a vertical, centrifugal, belt-driven pump in our plant, used for circulating water. As the sand which freely mixes with the water is very sharp, the casing of the pump is provided with removable liners in order to protect the interior. These linings have to be renewed every six or seven months.

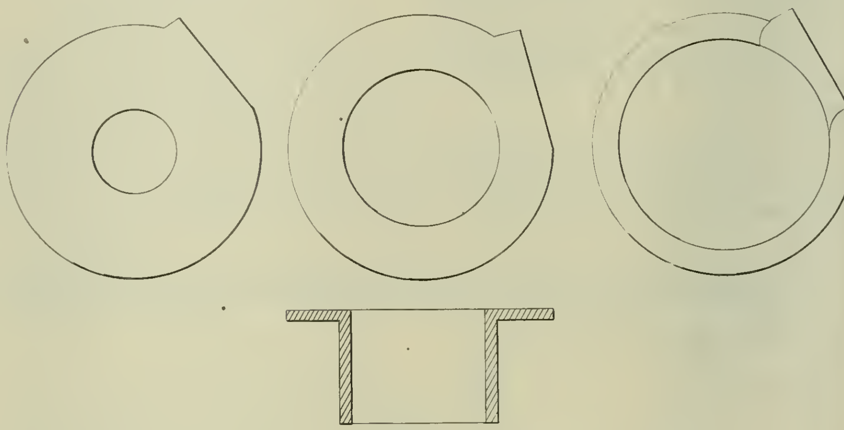


FIG. 1

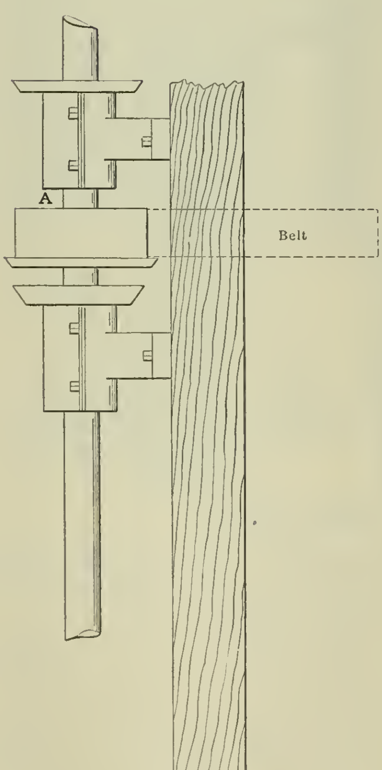


FIG. 2

Referring to Fig. 1, the first two liners are the protectors for the top and bottom of the casing, while at the right is a ring for protecting the sides.

One of the most common troubles with this type of pump is that it may not throw enough water, due to a slipping belt. The pulley on the shaft of a vertical centrifugal pump is usually placed between two shaft bearings, as shown in Fig. 2. If the operator is careless and puts too much oil in the top bearing the oil will run to the pulley, then onto the belt, causing it to slip, and ruining the belt. In order to prevent this trouble we put an oil guard around the shaft at the lower part of the top bearing as at *A*.

At one time the pump failed to pick up water. After disconnecting a flange in the discharge pipe it was found that the pipe was full of sand to the end of the outlet. As there was not ample pressure in the pump to force the sand out of the pipe, it was not able to pick up.

A common trouble experienced with vertical centrifugal pumps is that the impeller will work down, due to the support holding the shaft and impeller wearing or working loose, when the bottom side of the impeller will rub against the lower lining plate, thereby wearing this lining and lower part of the impeller out in a short time, besides causing more friction, which takes more power.

We have a gage at a convenient point on the vertical shaft by which we can see when the impeller is going too low, when it is adjusted again. Here is where an electric motor would be the thing for driving a vertical centrifugal pump, because should the impeller work down too low and rub against the lower lining, or any of the bearings wear, or be carelessly adjusted and out of alinement, the increased friction would be indicated at once by a meter connected to the motor.

H. Jahnke.

Milwaukee, Wis.

Neatsfoot Oil on Belts

In the January 5 number, page 70, Charles Haeusser writes regarding the detrimental effect of neatsfoot oil on belts. We have seven belts in our plant ranging from 4 inches to 22 inches in width, and neatsfoot oil is applied to each with gratifying results. It is in my opinion the best belt dressing one can use.

Joseph H. Jacobucci.

Rawlins, Wyo.

New Method of Equalizing Cutoff

The two sets of diagrams shown in Figs. 1 and 2 were taken from the same Corliss engine. Fig. 1 was taken with the governor as sent out with the engine; Fig. 2 was taken after I had put my improvement on. It will be seen that an even cutoff is obtained on both ends of Fig. 2, even with a variable load.

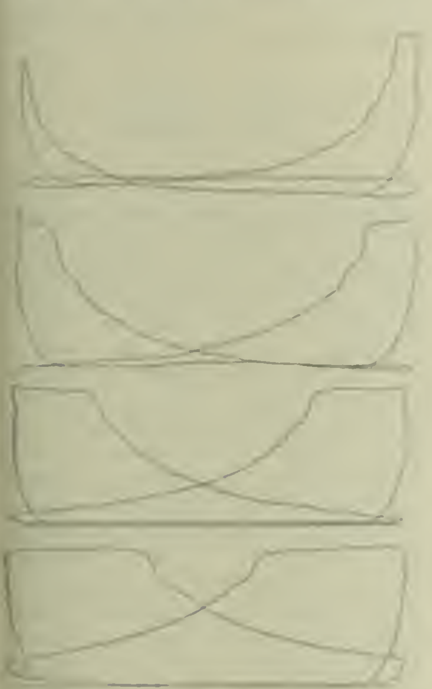


FIG. 1

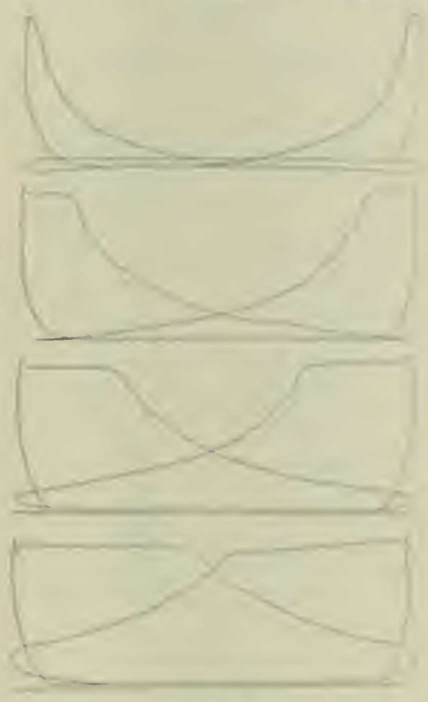


FIG. 2

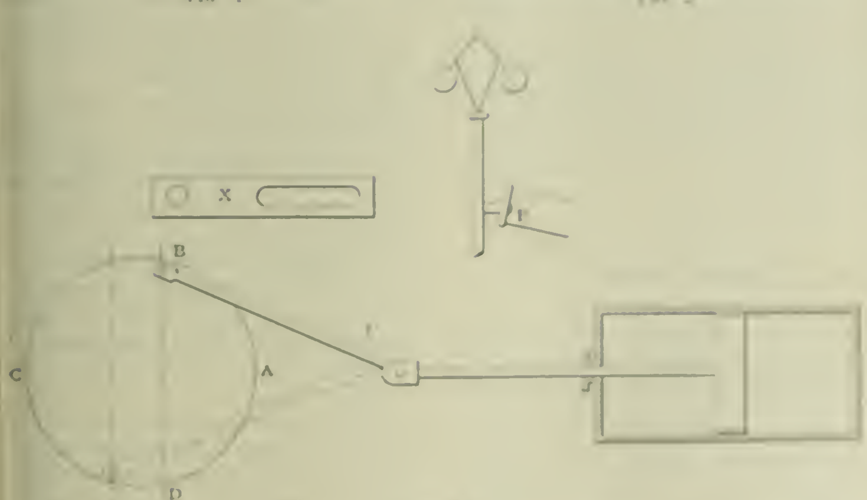


FIG. 3

By referring to Fig. 3, it will be seen that when the piston is at half stroke the pin has traveled from A to B, and the eccentric has moved the same as the pin, not quite 90 degrees, due to the angularity of the connecting rod. On the return stroke the pin travels from the outer center C to D in order to place the piston at half stroke. The eccentric has traveled a greater distance on this return stroke, as when the pin is at E the eccentric has moved the same distance as when on the outstroke from A to B, but the piston would not be at half stroke, as shown by the dotted lines. To overcome this difference in the eccentric travel the crank head valve must be left open longer at full load and close sooner at light load.

In order to do this I lengthened the lower end F of the governor rocker arm operating the cam of the crank-end valve. To determine the length I took a piece of iron, as shown at X, about [illegible] inch thick by [illegible] inch wide and [illegible] inches long, and drilled a hole in one end to bolt to the arm, and a slotted hole in the other in which to attach the reach rod. By taking a diagram with a light load and one with a heavy load, I determined the proper length and then had a new rocker arm cast and fitted to replace the old one. The longer the connecting rod in the engine, the less is the angularity, and the less should the arm be lengthened. In my case the arm was made 1½ inches longer than the original rocker arm.

G. D. Livingston.

Minneapolis, Minn.

Municipal Ownership

The editorial entitled "Municipal Electric Light Plants" in the issue of December [illegible] seems to have been written on the assumption that the conditions under which both plants are built and operated are ideal, or can easily be made so.

Those who are most familiar with municipal plants know that so far from this being the case the actual conditions are such as to put the municipal plant at a serious disadvantage in comparison with private plants. This is the case even if graft be left out of consideration.

The business men of a city may discuss municipal ownership as a business proposition, but as soon as it passes from the field of discussion into that of construction it passes at the same moment from the domain of business into that of politics. There lies the weak point in our argument. The affairs of our cities are not conducted in a business-like way, and until they are, all municipal undertakings will be heavily handicapped both by red-tape methods and political considerations. This is admitted freely by everyone who has occupied a municipal office and whenever a business man has had a term of office he has invariably emphasized the unbusiness-like conditions which he has found to prevail in the conduct of municipal affairs. Red-tape methods are responsible for the well known fact that, even where there is no graft, the construction of a municipal plant costs from 25 to [illegible] per cent. more than that of a private plant of the same capacity. This extra cost starts with the purchase of the land, follows through each stage of the construction and equipment, and much more than offsets the slightly lower rate at which cities can borrow money. This is a net result quite to be usually accepted [illegible] "honest graft," but favoritism and influence which are at work leading not always to criminal practices, but always resulting in the municipality paying more than a private party would pay.

Nor does this cost stop when the plant is made. It affects unfavorably the cost of fuel and supplies of all sorts, and thus increases the operating expenses above those of a private plant.

The political considerations are more far-reaching in their injurious results. The acceptance of plans, the making of contracts, and the appointment of labor are in the hands of [illegible], the members of which start with no knowledge of the business and usually remain in office too short a time to acquire more than a superficial knowledge.

The manager, to start with, is apt to owe his appointment to his political activity quite as much as to his technical and executive ability, and this is to be expected; or if this is not the case, he knows that a change of administration may bring his career to a sudden and undeserved end. His salary is always lower than it would be under private ownership, and there is not the opportunity for promotion which exists in private companies. The best class of managers are therefore not permanently attracted to municipal plants, the proof of this statement being that municipal managers are constantly seeking employment in private companies, while there is no tendency the other way. It is not true, therefore, that municipal office attracts technical ability of the highest order; just the contrary is apt to be the case.

Similar considerations affect the minor employees in the same way all along the line with the result that cities rarely get the best class of workmen, and do not get as much or as good work per employee as do private employers. Most of them know that they are not employed solely on their merits, and act accordingly, especially as the power of summary and permanent dismissal is rarely in the hands of the manager, who, by the way, is properly called a superintendent rather than a manager. It is notorious that the productive capacity of a city workman is not usually over one-half of what a private business expects to obtain and does get.

If the employees, from top to bottom, are inferior to those of a private plant of like capacity, and take a less personal interest in their work, it follows that the plant will not be run at its greatest efficiency and economy, nor will the machinery receive the same care as in a private plant. This means that there will be larger bills for repairs, that operating expenses will be heavier, and that depreciation will be greater. And experience has shown that these expected unfavorable results are fully realized in all particulars.

You say that "graft, ignorance and incompetence are not inevitable" in city undertakings of this character. That is true; there are exceptions, but they are rare. But at least two of these three disgraces are prevalent in the great majority of our American cities; and until there is a complete revolution in our methods of city government, they will continue to be the almost universal rule. The cases are so few where municipal electric plants have been operated on business lines for any extended period that the editorial referred to seems likely to be productive of serious misapprehension on the part of such of your readers as are not familiar with the conditions that actually prevail in the great majority of such plants—conditions far removed from the ideal.

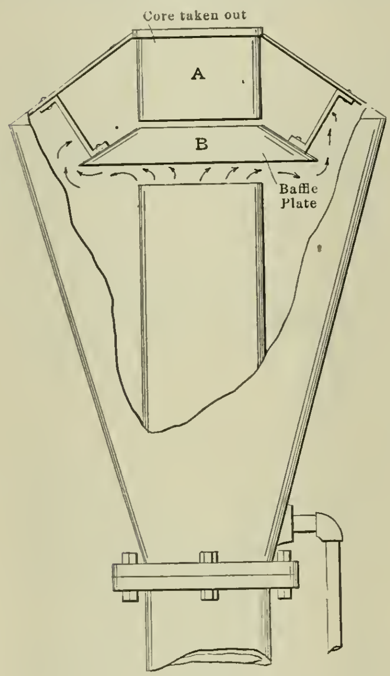
ARTHUR WILLIAMS.

New York City.

Reduced the Back Pressure

I once had charge of a plant having one engine, the indicator cards of which always showed a back pressure of 4 pounds when the back-pressure valve was up. In my hunt for the cause I examined the exhaust head and found the core *A* extended down to within ¼ inch of the baffle *B* (see illustration).

In this case, the exhaust pipe being 6



SHOWING HOW CORE IN EXHAUST HEAD INCREASED BACK PRESSURE

inches in diameter, the baffle plate should have been at least 1½ inches from the core *A*. I removed the core *A* and thus reduced the back pressure 3 pounds.

A. WALDRON.

Lynn, Mass.

Electric Discharges

In regard to George A. Raymant's article in the December 22 issue, page 1045, he will find that if he thoroughly insulates himself from the ground and stands in a cloud of steam issuing from a leak in a high-pressure steam pipe and brings his hand near the ground or pipe, he will invariably obtain sparks. If he will get in a dark place where steam is escaping from a pop safety valve or other large leak directly into the air, he will see a halo of sparks and blue light around the leak. In fact he will see a miniature thunder storm. In his case the calking chisel was the lightning rod and it was struck with miniature lightning bolts. The electricity is generated by the friction of the steam passing through the air.

HOWARD GLUYS.

Richmond, Ind.

Natural Gas for Fuel

I noticed an article in the December 22 number by W. D. Ranney, on natural gas for fuel, wherein he says he obtains a boiler horsepower on 27.95 cubic feet of gas. Now, 27.95 cubic feet of gas is equivalent to only 27,950 B.t.u., and a boiler horsepower is $966 \times 34\frac{1}{2} = 33{,}327$ B.t.u., hence his figures must be wrong. I am assuming Ohio natural gas to contain 1000 B.t.u. per cubic foot.

EDWARD H. LANE.

Kansas City, Mo.

Steam Piping

Having read the article, "Steam Pipe Connections," by Fred Dubell, on page 1099 of the December 29 number, I am led to call attention to that part of the article under the subhead, "Steam Pipe Should Drop Toward Boiler." This is a statement I challenge. As steam on leaving the boilers begins to condense, the water falls to the bottom of the pipe and is carried along with the steam, and it is impossible for the water to return to the boilers against the flow of steam.

I have in mind an instance of a ¾-inch vertical steam pipe 96 feet high, piped direct from a battery of boilers. This pipe ran horizontally for about 15 feet to an elevator shaft, then up 96 feet to a temporary bathroom. This pipe, contrary to expectation, always stood full of cold water, except when the valves were open at the upper end, although the boilers carried a steam pressure of 100 pounds.

In steam pipes dropping toward the boilers the water accumulates in slugs, and when the flow of steam is sufficiently obstructed it passes on to the engine cylinder, washing out the oil. Valves and valve seats are cut, also the cylinders and packing; piston rings are broken and engines are wrecked.

In twenty-five years' experience, several of which were spent in inspection service, I have never known an engine wrecked from water in steam piping, except when the pipe dropped back toward the boilers.

Steam piping should always drop toward the engine. When erected in this way the condensation is carried along with the steam, and even if allowed to go into the engine, does but very little harm. It is better practice to connect to the engine through a steam separator, or receiver, with a good steam trap to carry off the condensation. It is certainly safer, and better for an engine to operate with even wet steam all the time than to have a cylinder full of water occasionally and saturated steam the remainder of the time.

In practice the steam main dropping from the boilers to the engine in calorimeter tests always shows drier steam at he engine than where the pipe drops toward the boilers.

T. J. Bloss.

Chattanooga, Tenn.

Combustion Formulas

In the December 15 number Mr. Neely contributed an article of real value. I have checked his charts with a number of analyses of my own, and some from various authors, and find that No. 2 chart gives results as accurately as samples can be taken in a mine.

The classifications attempted by the fuel-testing plant here at St. Louis showed that the hydrogen-carbon ratio was the most satisfactory one, and that fixed carbon alone was not reliable except in true anthracites. We used to have a rule-of-thumb method of estimating heating values for Mississippi valley coals, which was to add the fixed carbon and volatile percentages and multiply by 150. This gives too low results on the best bituminous coals and too high on the poorest.

Mr. Neely's chart is practically exact on coals of the Appalachian range, but varies somewhat in some of the Western coals. Unfortunately, the results as published by the fuel-testing plant give only two each of Colorado and Wyoming coals and these are among the poorest of the two States. For comparison I will quote three with which I have had some practical experience; two are from the past-carboniferous period of the Rocky mountains, and the third is a well recognized bituminous coal of Illinois:

	Rock Springs, Wyo.	Trinidad, Col.	Big Muddy, Ill.
	Per Cent.	Per Cent.	Per Cent.
Moisture	5.65	1.32	7.50
Volatile matter	36.96	38.23	30.70
Fixed carbon	55.70	55.86	55.80
Ash	1.80	3.59	6.00
Total combustible	92.66	94.09	86.50

According to Mr. Neely's table the combustion values would be, respectively, 14,600, 15,000 and 12,600 B.t.u., whereas the values given by the respective analyses are 13,240, 13,680 and 12,420 B.t.u. The explanation for the differences shown is that the volatile matter of the Appalachian coals is usually marsh gas (CH_4), and that of the Western coals is composed of oxygen compounds, which rob the volatile matter of a large part of its hydrogen in combustion. On the other hand, the Western coals make an excellent showing in gas producers, as the oxygen of the volatile matter is readily converted to carbon monoxide and their comparative freedom from ash and sulphur prevents the formation of clinkers. In the Wyoming coals of the southern field the sulphur content averages less than 1 per cent., and is usually present as gypsum instead of pyrite. Another characteristic is their hard structure which enables them to stand transportation and handling without crumbling. This is particularly noticeable in the Trinidad field, some of the coal closely resembling anthracite in appearance and hardness, though usually containing less than 60 per cent. of fixed carbon.

Kent's table, given by Mr. Neely, gives approximate results for most steam coals, but I do not like any estimates based on coal, dry and free from ash. It has been said that one could prove anything by statistics. The situation here in St. Louis is this: A representative coal of Illinois has a formula something like the following:

Moisture, 12 per cent.,
Volatile matter, 33 per cent.,
Fixed carbon, 41 per cent.,
Ash, 14 per cent.

This is not the best nor the worst coal in the State; in fact, its composition is about as fair an average as can be had. The sum of its combustible ingredients is 74 per cent., which makes it fall below Mr. Neely's chart, but its heating value per pound of coal is 10,580 B.t.u., so it falls in line with Mr. Neely's straight line, if it were extended. According to Kent's formula, by interpolation, it would have 13,680 B.t.u. per pound of combustible and 10,123 per pound of coal. The actual results show 10,580 B.t.u. per pound of coal and 14,600 B.t.u. per pound of combustible, a difference of nearly 40 per cent. The moisture and ash contents are 26 per cent., or one-fourth of the whole, or a total of 520 pounds in every ton which has to be transported and handled before it is delivered to the boilers, and again, 280 pounds of ash have to be raked out of the ashpit for each ton consumed, and, in a city, removed at a considerable cost. Yet on comparison of "heat units per pound of coal dry and free from ash," it compares favorably with hand-picked Buck mountain or Pocahontas coal.

The real test of a steam coal, from an economical point of view, is how much steam it will make for one dollar. Many look at the analysis of a coal to see what its fixed carbon content is, and gage its value by that. Theoretically this is a poor way, as a certain amount of volatile matter is an advantage, provided it can be completely burned. With the usual run of furnaces, though, a large amount of volatile matter is allowed to go to waste as chimney gases or soot, hence a classification based on fixed carbon is not so bad after all. The cheapest fuel that we get here in St. Louis is slack or screenings from the nearby mines. It has about one-third each of volatile matter and fixed carbon, and one-third waste in the form of moisture and ash. Its calorific value is about 9000 B.t.u., a little over one-half that of the best coals of the Appalachian range, yet it can be delivered at the boilers for less than one-fourth of the price of any Eastern coal. On the other hand, it requires a larger boiler installation and greater expense for the removal of the ash and clinker formed, and greater depreciation of the plant, so the net gain is not as great as might be supposed at first sight.

It has often been said that analyses of Rocky mountain coals, such as I have quoted, are those of picked samples and do not fairly represent the mine. In three years I took many samples of Wyoming coals and found the following range of contents: Moisture, 4 to 10 per cent.; volatile matter, 30 to 38 per cent., and fixed carbon, 52 to 58 per cent.; ash, less than 5 per cent.; sulphur, less than 1 per cent. One car of coal, or 80,000 pounds, burned under a return-tubular boiler yielded 1800 pounds of coarse ash, or 2.25 per cent.

LeRoy Baker.

St. Louis, Mo.

A 500 or 250 Volt System for Motors

The article under this caption, written by A. Chisholm, in the December 15 number, must be very misleading, or else I have misconstrued his meaning. If he has intended his motor connections to be made in a 500-volt three-wire system, well and good; but if intended, as I imply, to be a common 500-volt system I cannot see that it is at all practical.

I would call his attention by way of friendly criticism to the all too common error of expression of electrical terms which appears in the second paragraph: "C and D are two ordinary starting boxes such as would be used for motors running at any voltage." Now there is no such thing as an ordinary starting box for any voltage. If you think so just put a 5-horsepower 250-volt starting box on a 5-horsepower motor using 500 volts and see how it works.

L. F. Sawyer.

Ensley, Ala.

The Modern Surface Condenser

Referring to C. A. Orrok's reply in the issue of December 29, page 1054, to Mr. Mueller's remarks on Mr. Orrok's surface-condenser article, Mr. Orrok states that he fails to understand how surface efficiency can be obtained by excessively large air pumps in the [illegible] installation. To the writer this seems to require no explanation whatever, inasmuch as the surface efficiency depends to an enormous extent on the amount of air in contact with the tubes.

It is not so much a matter of how much the air pumps remove, but of the quantity they leave behind in the condenser, blanketing the tubes. The amount of air removed by the air pump while at work depends on its volumetric capacity and efficiency. As regards the various [illegible] cient as an air remover than an ordinary air pump, but the amount of power required is at present, I believe, an open question, and not to be recommended, except a high vacuum is required, as in turbine work.

W. VINCENT TREEBY.

Stratford, England.

Wrenches

On page 15 of the January 5 number, Mr. Collins gave some sensible advice in regard to the use of wrenches. With an extended experience in charge of men and tools, I have had all the trouble enumerated by the author in the misuse of wrenches.

There is one statement, however, that is not absolutely correct, and that is where he says a pipe wrench should always be used close to the fitting the pipe is being screwed into. On extra-heavy pipe and generally on butt-welded iron pipe this will do, but on standard pipe the wrench should be at least one and a half times the diameter of the pipe from the fitting; if it is a close nipple, a nipple driver should be used. The reason is that the wrench distorts the pipe and the oblong frets bind in the fitting. This is especially so where it is necessary to remove a light nipple from a fitting, when it will be found that it will start more easily if the wrench is a proper distance away. There is a strap wrench made that will not crush even the lightest brass pipe, or injure the surface of studs or pipe, that Mr. Collins did not get into his very complete list of wrenches.

PETER H. BULLOCK.

Concorn Junction, Mass.

Turning a Worn Turbine Shaft

While putting a new guide bearing in one of our 5000-kilowatt Curtis turbines we found the shaft worn badly on one side. We proceeded to put the guide bearing in, but before putting up the dies, we took measurements in order to make a turning tool with which to turn the shaft down. The accompanying sketches show how we did the job.

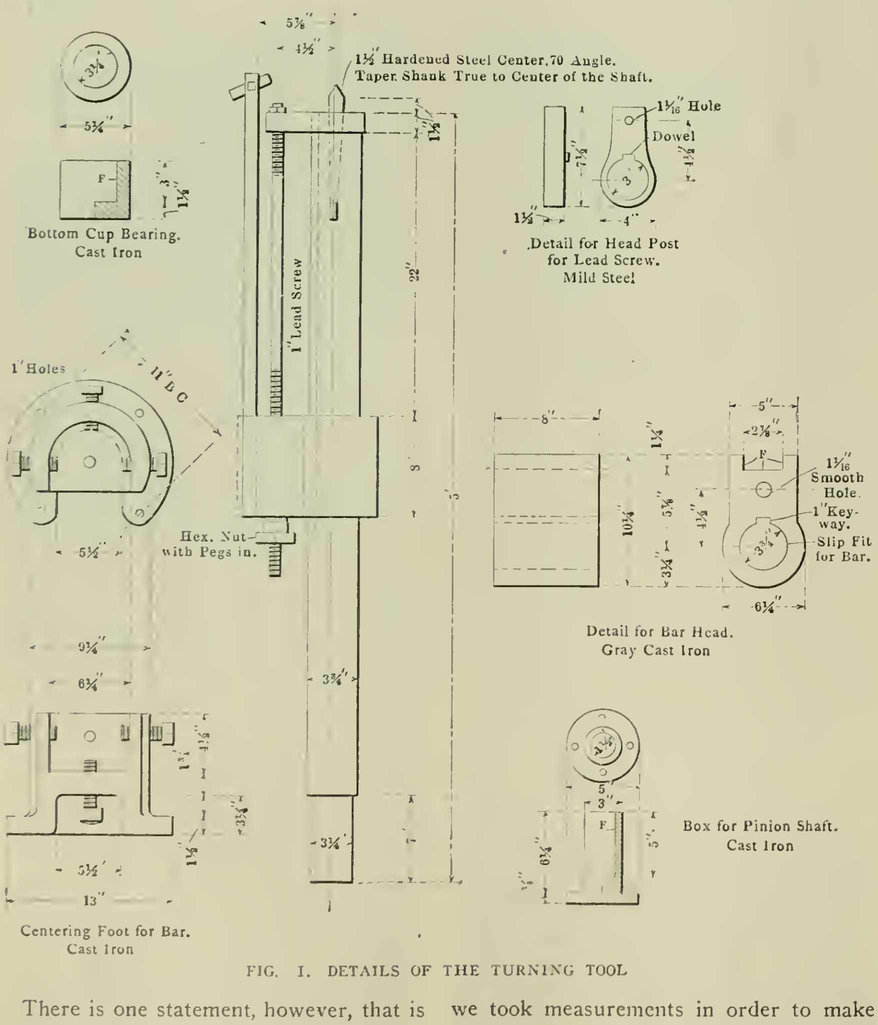


FIG. 1. DETAILS OF THE TURNING TOOL

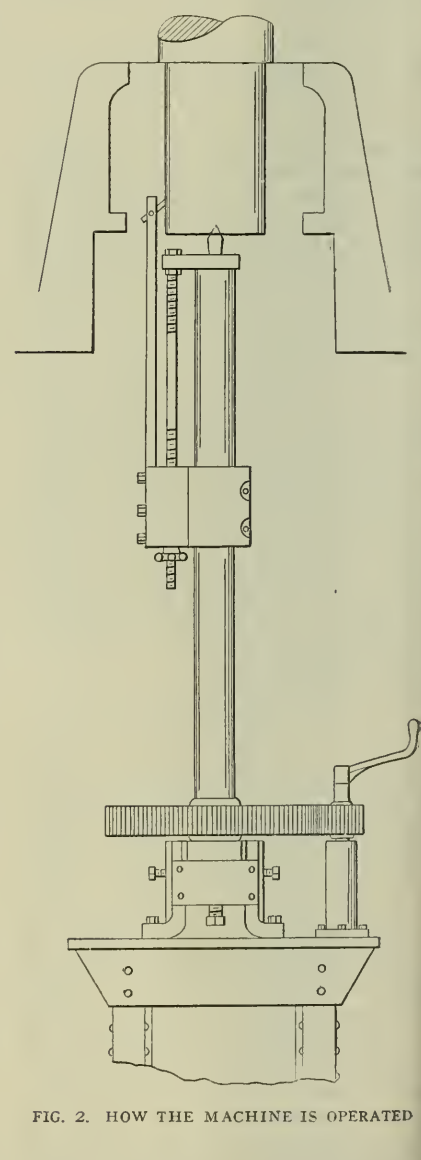


FIG. 2. HOW THE MACHINE IS OPERATED

In Fig. 1 are shown the details of the turning tool. Fig. 2 shows the machine in operation. I would suggest, however, to anyone desirous of using this machine, to substitute a worm gear for the gearing shown, use a small motor for a drive and mount it where the crank is shown.

As we were pushed for time we took the crank from a drill press and turned the turning tool by hand. It took only three days to remove 0.09 inch from the diameter of the shaft, the shaft being 11 inches in diameter and the cut 17 inches long.

In order to center the bar we used the center in the end of the turbine shaft. About 16 inches from this end we found a place where there was an oilway in the box, hence the shaft was not worn at this point. We could not get a very smooth finish with the long toolholder we had, but we got the finishing touches on by placing a piece of ⅜x1½-inch band iron in the place of the toolholder, with an emery brick fastened to the end. By putting a set screw in the lower end of this strap-iron, we could work that end away from the head and thus increase the tension on the brick. We used water on the brick.

As the space betwen the shaft and bearing case was too close to get an ordinary incandescent lamp in we mounted one of the oil-switch pilot lamps on a broomstick and used it for a lamp.

EDWARD H. LANE.

Kansas City, Mo.

Development of the Surface Condenser

Descriptions of the Various Types of Surface Condenser, Beginning with Watt's and Including the Most Modern Apparatus on the Market

BY WARREN O. ROGERS

To James Watt belongs the distinction of designing the first surface condenser, although it is true that Savary condensed steam in the cylinder of his engine, if engine it may be called, by pouring cold water over it to produce a more rapid vacuum.

In Newcomen's engine, which was the first reciprocating engine put to practical use, the steam was condensed from the bottom end of the cylinder. The piston was kept tight by a small amount of water on its upper surface. When the piston

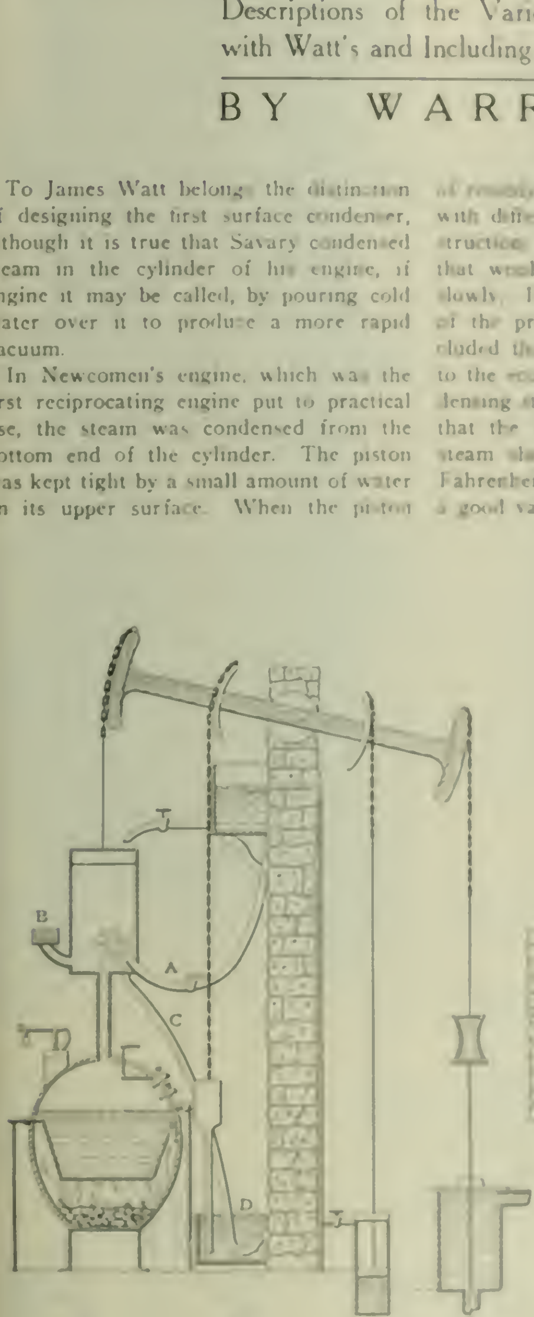


FIG. 1

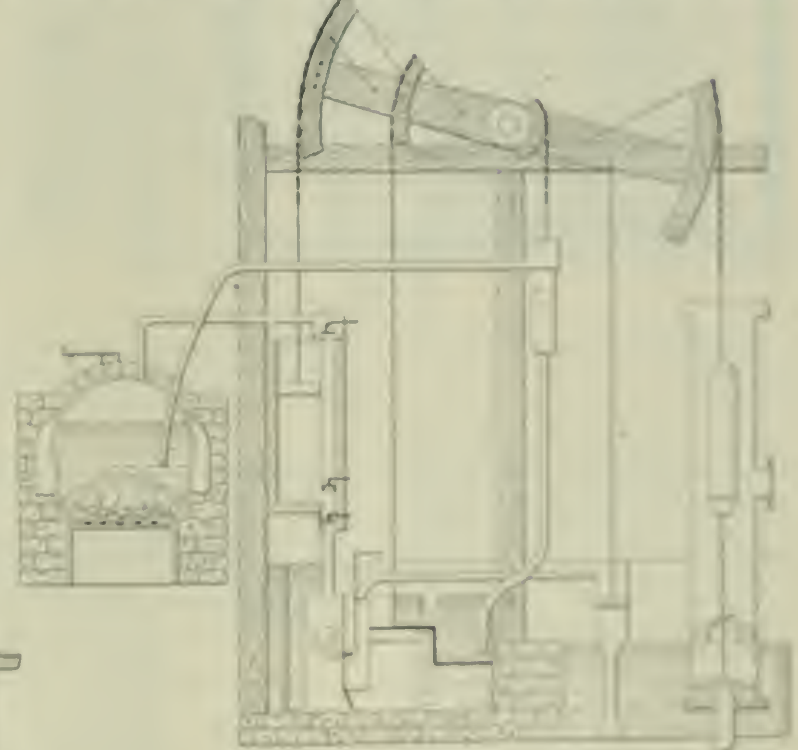


FIG. 2

reached its highest point of travel, the injection valve A was opened and water admitted to the cylinder, as shown in Fig. 1. This supply of water condensed the steam, the air escaping through the vent B, while the condensed steam and injection water passed out through the pipe C to the hotwell D. From this it is evident that the first condenser was of the jet type, which was also the type first designed by Watt, although it must not be assumed that the idea was the growth of a moment. When Watt observed the wastefulness of Newcomen's method of condensing steam he tried various means of remedying the defect by experimenting with different materials for cylinder construction, in order to find a substance that would take in and give out heat slowly. It was only after an examination of the properties of steam that he concluded that two conditions were essential to the economical use of steam in a condensing steam engine, one condition being that the temperature of the condensed steam should be as low as 100 degrees Fahrenheit, or lower, in order to maintain a good vacuum, the other, that the cylinder should be as hot as the steam entering it.

In 1765 Watt conceived the notion that by condensing the steam in a separate vessel these two conditions could be maintained and the idea was put into practice. Fig. 2 shows the design of this condenser. It consisted of a small cistern [illegible] the engine into which the exhaust steam from the cylinder was allowed to flow through the opening in the top. The steam was condensed by cold water surrounding the outside and also by a jet of water on the inside. An air pump removed the condensed water as well as the air in the condensing chamber. The inlet between the condenser and the air pump was fitted with a swing foot valve, and as the plunger was fitted with valves the water was forced up through them to the top of the plunger on its downward stroke, and expelled through the discharge pipe on its upward stroke. This condenser embodies the principles of both the jet and surface condenser in a crude form. This invention was not patented until four years later, and it was three years more before steam pressure and vacuum were applied to both sides of the piston. Even with the vacuum acting on but one side of the piston the gain over the old method of condensing the steam in the cylinder is said to have been 50 per cent.

The specifications of the patent granted to James Watt, January 5, 1769, read in part as follows:

"In those engines that are to be worked wholly or partially by condensed steam, the steam is to be condensed in vessels distinct from the cylinder, though occasionally communicating with them. These vessels I call condensers, and while the engines are working, [illegible]

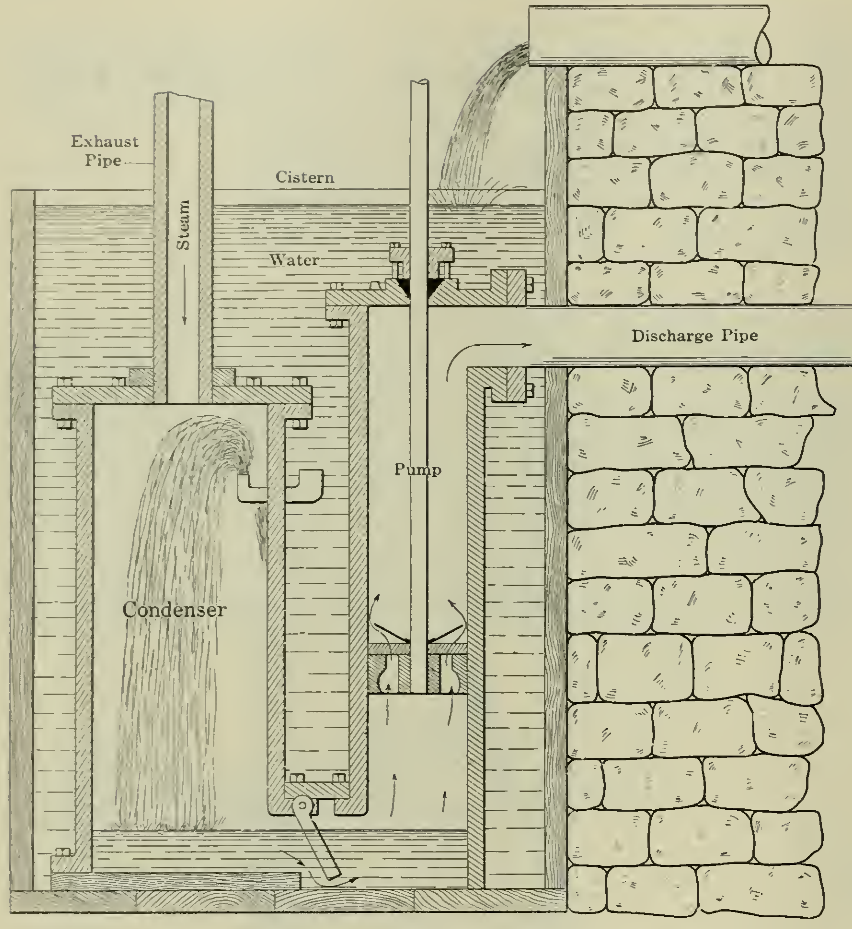


FIG. 3

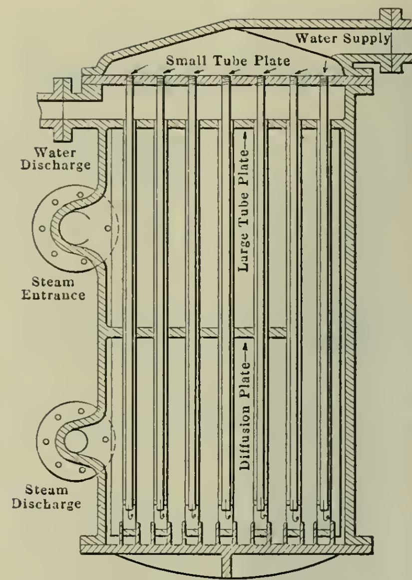


FIG. 6

as cool as the air in the neighborhood by the application of water or other cold bodies."

There were no drawings attached to the specification papers, but from fragments of Watt's experimental apparatus it is evident that the design shown in Figs. 2 and 3 is approximately the arrangement of the first separate condenser, from which grew the surface condenser, although the jet type was employed by Watt in connection with his subsequent engines, and became almost universally used during the years preceding 1831. Fig. 2 shows Watt's engine and condenser of 1769.

In 1831 Samuel Hall invented a commercial surface condenser. In the specifications of Hall's patent the following may be found:

The condenser "consists of an improved mode of using a system of metallic surfaces, which may be composed of vessels, channels, passages, or pipes, of any convenient form and arrangement for condensing the steam and cooling the water resulting therefrom on its passage from the condenser to the air pump."

Two years later Hall obtained a second patent in which the circulation of the condensing water is described as passing through a cistern containing the tubes, the cold water entering the cistern at the top at the end of the cistern nearest to the air pump, and escaping at the bottom of the other end next to the working cylinder. In the Hall condenser the *steam* flowed *through* the tubes, the cooling water flowing about them on the outside. With this exception this condenser of seventy-six years ago was practically the same, as far as construction goes, as many of the surface condensers of today.

A type of this condenser is shown in Fig. 4, in which the general arrangement of the condenser and air pump is illustrated. It is seen that the steam passes downward through the tubes to the air-pump suction. The circulating water was circulated upward by a centrifugal pump. Strange as it may seem, the design of surface condensers remained almost the same as it was in 1831, up to within a few years. The most important change made

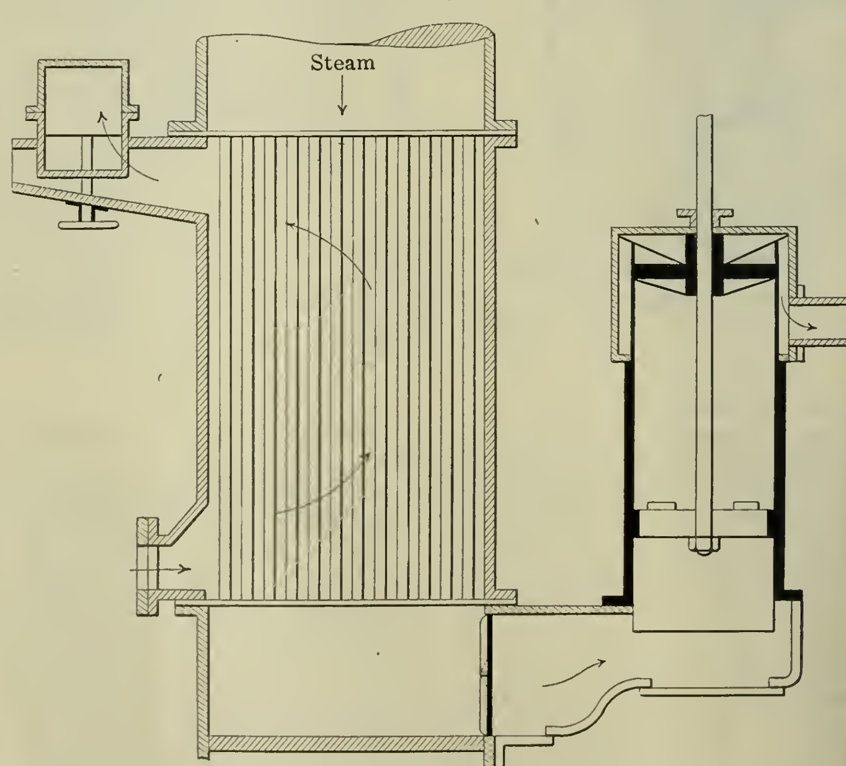


FIG. 4

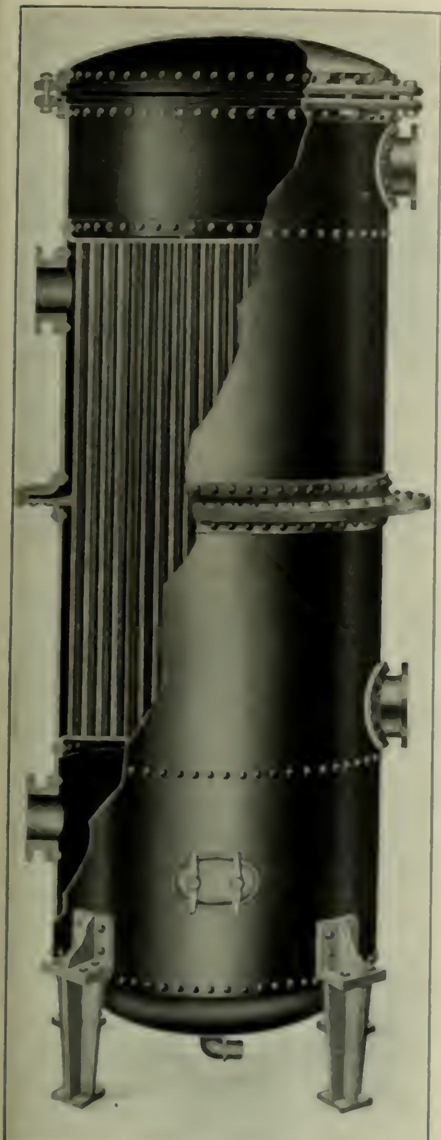


FIG. 13

has been that of circulating the cooling water through the condenser tubes instead of the steam; this change is preferable, and is now invariably adopted. Probably J. F. Spencer took as active a part as anyone in introducing this latter method of circulating the cooling water.

In Fig. 5 is shown a condenser designed and built for commercial use more than thirty years ago. It will be seen that the condensing surface consists of two nests of tubes with a baffle plate central in the inlet-water chamber. The cooling water coming in at the bottom and passing to the left through the lower bank of tubes enters the chamber at that end and, reversing its direction of flow, passes through the upper bank of tubes to the outlet. The steam from the engine cylinder enters at the top inlet and passing down over and surrounding the tubes is condensed, the water of condensation passing to the air pump through the bottom outlet.

The first double-tube surface condenser was designed by an American named Miller in 1862. In this design, Fig. 6, small tubes were placed inside of large ones. The condensing water entered the water chamber through the bottom inlet, from whence it passed through the small inner tubes, returned through the large outer tubes, and then discharged into the air pump. This is practically what is found in the modern type of surface condenser, with the exception that they are generally made to be placed in a horizontal position, the steam entering at the

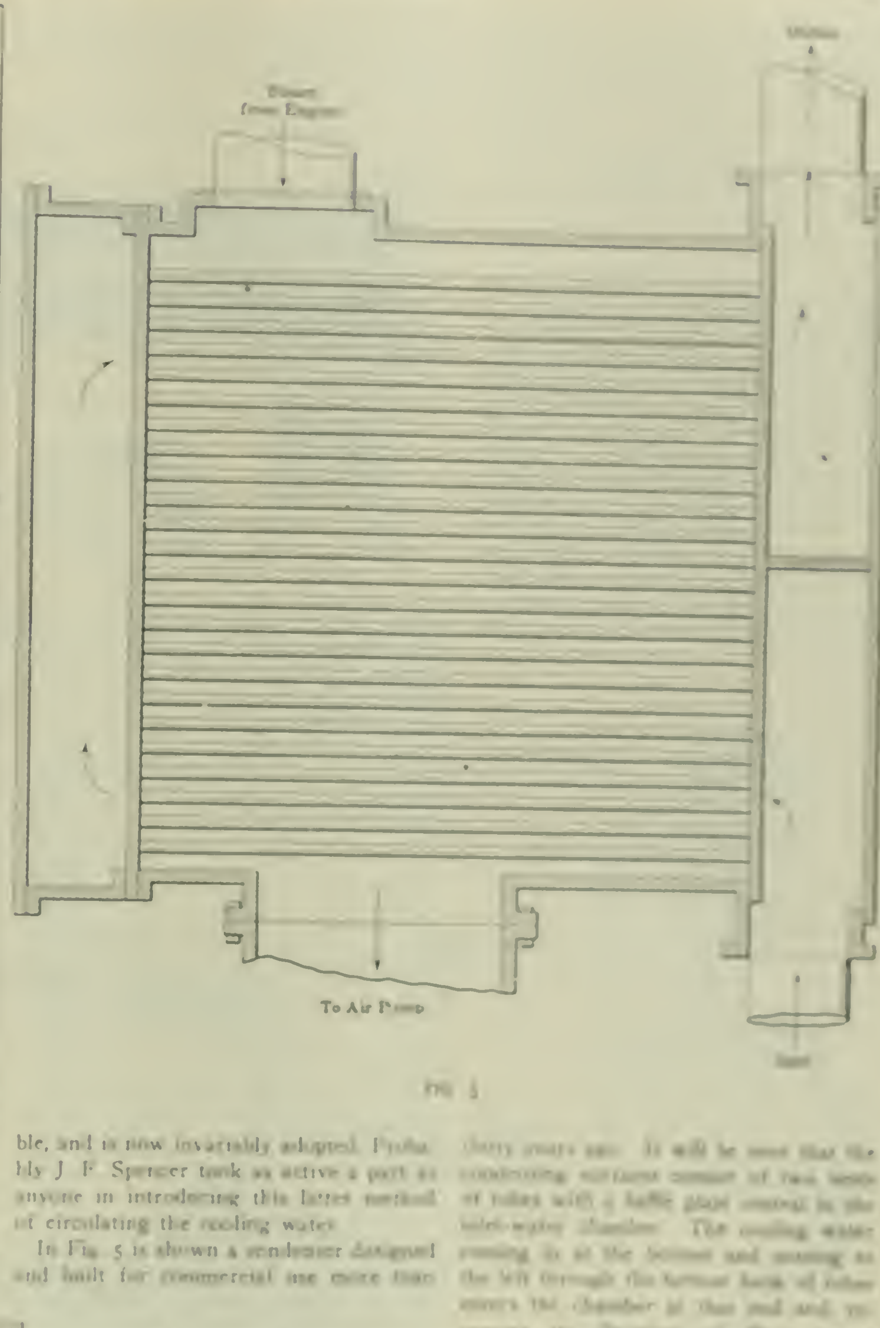


FIG. 5

FIG. 7

top and the condensed steam discharging at the bottom.

In Fig. 7 is shown the modern type of double-tube condenser. A comparison with Fig. 6 shows but a slight difference in construction. No ferrules, washers, or packing of any kind are used, the tubes screwing firmly into the tube heads at one end, as shown, thus taking care of the expansion. The arrows designate the path of the cooling water, also that of the steam and products of condensation.

Fig. 8 shows a type of single-tube condenser familiar to all. The design allows of a good distribution of steam, and each tube is supposed to do its share of work. The arrangement of the air and circulating pumps is also shown. In the condensers shown in Figs. 7 and 8 the weight of the condenser rests on the air and circulating pumps. While this does not interfere with the attendant getting at the valves of each, it does necessitate an extra amount of work when it becomes

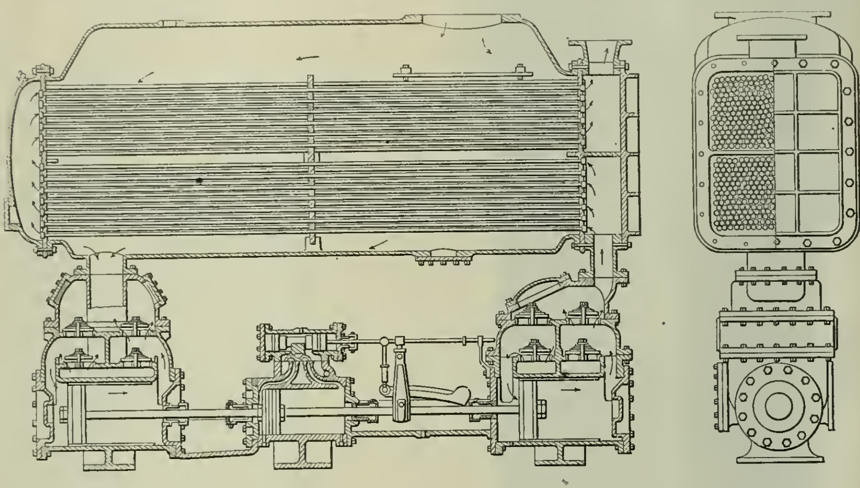


FIG. 8

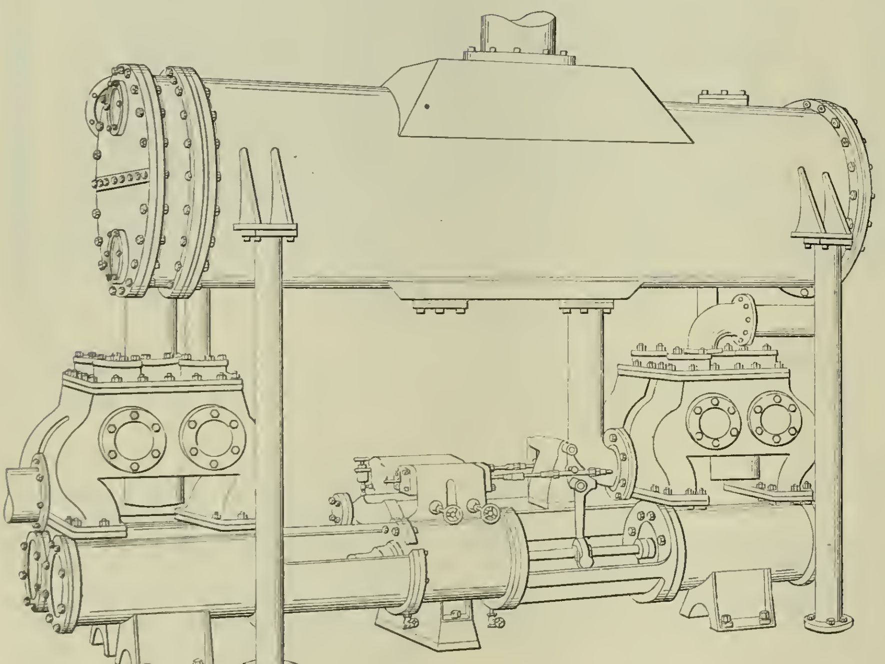


FIG. 9

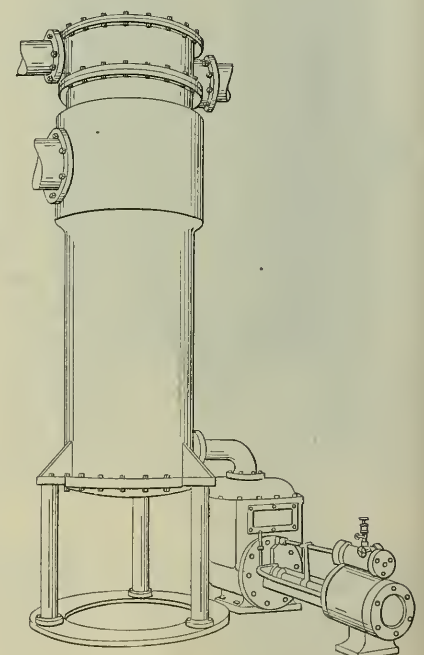


FIG. 14

necessary to remove the air or circulating pumps. To obviate this, some builders of surface condensers manufacture a design which is supported independently upon four or more supporting columns.

In Fig. 9 such a type is shown. It is manufactured by the Epping-Carpenter Company. By breaking the connection between the condenser shell and the pipe connection to the pumps, either the condenser or duplex pump may be removed without disturbing the other. The interior construction of the condenser is shown in Fig. 10. The tubes are held in place by means of screwed glands on one end and so made that expansion and contraction are taken care of. Fig. 11 shows the construction of the tube packing and glands. The arrows indicate the path of the circulating water; in this case two passes of the water are provided for, but as many as desired may be provided.

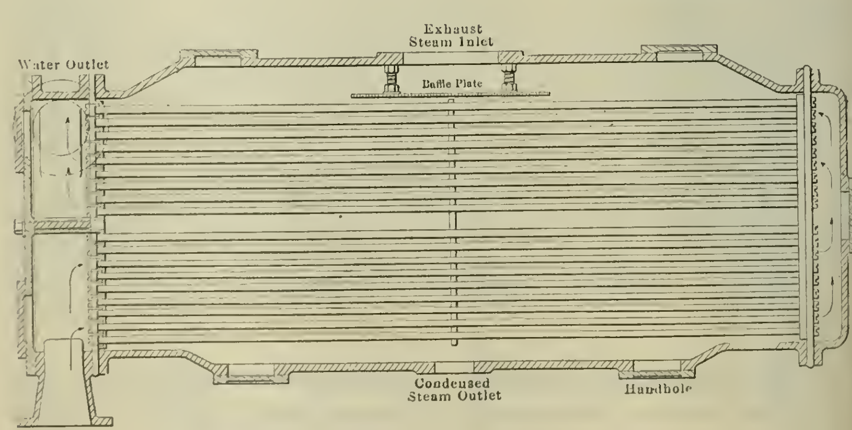


FIG. 10

The application of the surface condenser is varied. That they may be attached to the individual auxiliary is shown in Fig. 12. This represents one type of surface condenser manufactured by the Union Steam Pump Company. It is a most convenient arrangement under certain conditions. An independent air pump is used to remove the water of condensation and maintain a vacuum. The water handled by the pump is forced through the condenser tubes and, as the amount of water passing through them is

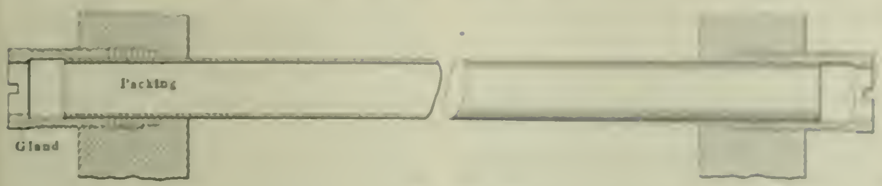


FIG. 13

FIG. 14

many times greater than that necessary to condense the steam, it is evident that the condenser is very efficient. The water passages are made large, and the resistance to the passage of the water is slight.

A condenser of entirely different construction as regards expansion and contraction, is shown in Fig. 13. The tubes of this condenser, which is manufactured by William [illegible] & Son, are expanded solidly into the tube sheets, the expansion being provided for by the [illegible] [illegible] in the shell as shown. This condenser is of the vertical type, although it is also made in the horizontal form. In the vertical type the top head is removable and, as the lower end contains a chamber which is fitted with a manhole, the tubes are accessible at both ends for cleaning. The upright position of the tubes, which are made with a large area, insures a natural circulation. In [illegible] area is restricted, this type of condenser has its special advantages.

In Fig. 14 is shown another type of vertical surface condenser. It is manufactured by the C. H. Wheeler Manufacturing Company. The cooling water enters at the top and, passing down through one bank of tubes to the bottom of the condenser, reverses its direction of travel and passes up through the second bank of tubes and out at the opposite side of the shell. The exhaust steam enters the [illegible] large opening at the top of the shell and the water of condensation is removed by the air pump [illegible] of the condenser.

Cooling Towers

By H. F. [illegible]

Cooling towers and cooling ponds [illegible] represent a comparatively recent development in engineering practice. While their adoption has been rapid, the question of design and efficiency is in a somewhat chaotic state. Comparatively little is known by the average engineer in regard to the relative efficiencies of the different types and their respective advantages for special installations.

Cooling towers today serve simply one purpose, in a variety of applications: To cool water in industrial operations where large quantities of water are required for any purpose whatever and the necessity of the water being cool is a prime requisite. Thus in all steam-power plants of any type whatever, cooling towers are used in conjunction with the condenser for furnishing a continuous supply of cold water to it. In all refrigerating installations and ice-manufacturing plants they serve the same purpose and supply cold water for the operation of the ammonia condensers, in which a large amount of cold water is used. In any of these installations the cooling tower is necessary wherever the water supply is restricted, limited in amount or too impure for use. They take the water from the various condensers after it has become hot through the condensation of steam, and cool it economically so that it can be used over again for the same purpose. They serve essentially the same purpose in any plant where the water is used to absorb heat and hence loses its ability to do so when it becomes hot.

Classification of Cooling Towers

Cooling towers may be divided into two classes, the natural and forced draft. Both of these operate on the principle of air, which is obliged to absorb water vapor under certain conditions to produce cooling. Water vapor exists in the air in amounts depending largely upon the temperature and the [illegible] [illegible]

[illegible]

readily by mechanical means, since the pressure of the latter under ordinary conditions is quite small. The ordinary water vapor in the air is in an unsaturated condition, due in a great measure to the fact that the air or water vapor has become heated some time after its contact with a water surface. When brought in contact with this, however, it absorbs additional water in the form of vapor until it becomes saturated. Air in reality generally possesses the remarkable property of absorbing large quantities of water vapor from a water surface with which it is brought in contact. It can only do this, however, when the water vapor present is in an unsaturated condition.

Very seldom in actual practice, except during periods of rain or great humidity, does the air or the water vapor approach the saturation point. Under these latter conditions, however, the air does not absorb water vapor, and therefore possesses very little cooling effect on the water. This cooling effect under ordinary circumstances is very large, since every pound of water evaporated by this means is accompanied by the absorption of heat from the remaining water, equivalent to the latent heat of vaporization of the water changed into the vapor. Cooling towers are quite variable in their action as dependent upon the condition of the atmosphere in regard to humidity, since the actual loss of heat by conduction from the water to the air is quite small under all circumstances.

This variability of cooling towers with atmospheric conditions has led to the development of the two types. The amount of cooling produced depends primarily upon the condition with respect to humidity of the air and, secondly, upon its temperature. The capacity of the tower depends upon these factors and upon the amount of air brought in contact with the water per unit of time. This latter feature is the main determining factor in the development of the two types. These are known respectively as the closed and open types of tower.

The Open-type Tower

The open type consists of an openwork iron structure, with a standpipe for the conveyance of the supply water to the top, and possesses a spraying device at this point and various devices installed throughout the tower for the separation of the water into small particles with large surfaces for evaporation and its retardation throughout the descent. This mechanism furnishes a very large water surface for contact with the air, and assures complete saturation of the air in the tower.

By great retardation of the descending water very large quantities of air can be brought in contact with a given water surface, therefore the amount of water abstracted from it in the form of vapor can be made comparatively large and the cooling produced by this means considerable. Such a tower is open at the sides and depends for air circulation upon the natural air circulation in the atmosphere. Its efficiency varies with the velocity of the wind, its humidity and temperature, and also upon the design of the tower for separation and retardation. Various interesting problems in constructive details have arisen, and the deterioration factor in this type is quite large, since the destructive effect of air and water under these conditions is most pronounced.

The Closed Type

The closed type of tower is practically identical with the open type in construction, with one important modification. The walls of the tower are inclosed and air is supplied at the bottom and forced upward throughout the tower by means of a fan. The air supply under these circumstances can be varied by mechanical means and the resulting cooling effect made practically independent of temperature and humidity variations of the outside atmosphere. The operation of the tower is further independent of the existence of winds for its efficient operation. Such a tower, however, costs considerably more in regard to installation and its operating factor is much greater, since expense of operating the fan must be added to that of water circulation.

However, as an engineering unit, it is considerably more reliable and, as has been said, can be made in its operation absolutely independent of external conditions. It further eliminates another serious difficulty which has arisen in the open type: When high winds exist during the operation of the latter, the water cannot be restrained within the confines of the cooling tower, and a fine spray covers all the surrounding objects. This has often proved a considerable annoyance from lawsuits in regard to the nuisance produced by this means. Farther, the deteriorating effect on the other units in the installation cannot be overlooked.

These two types of tower represent practically the sole developments in this field. They exist in a wide variety of designs, however. The chief open types on the market consist practically of drip pans installed at regular intervals, allowing free access of the air between them, and possessing holes in these at regular intervals for the equal distribution of the water. Shavings, boards, mineral wool, tile and even slate have been used with greater or less success in this type and in the closed type as well. The question is largely one of expense of installation and the consideration of the deterioration factor. Almost any device for satisfactory distribution and separation of the water with adequate retardation is thoroughly sufficient for the purpose.

Where Each Type is Used

The result in the development of these various types of tower is that there has been a distinct specialization of the various designs. Thus, in installations where reliability is a matter of prime importance and cost of installation a matter of minor significance, the closed type is invariably installed. The majority of large power plants use the closed type. In some developments these towers are used as an integral part of some other device, such as a condenser, and are operated along with it.

On the other hand, in plants where the cost was a matter of the greatest importance, and the possible isolation of the tower a simple problem, the open type has been developed. In the majority of small refrigerating and ice-manufacturing plants where the question of cost is a matter of prime consideration, the open type is almost invariably installed. Similar conditions hold in regard to the small steam unit and this subdivision of the two types and their developments as dependent on related conditions is a general one.

A wide variety of different types from a constructive point of view have been in existence, but a more and more complete standard of constructive details is steadily developing. Much more is known today in regard to capacity and efficiency of such towers. Cooling towers under average conditions are more thoroughly known, and the size and cost of the installation depends primarily upon the locality and amount of water to be cooled and the range of temperature required. Very seldom in summer can the water be cooled much below 75 degrees Fahrenheit. The higher the temperature of the initial water, however, the more efficient is the tower in its operation.

Condenser water from steam condensers is furnished at a temperature ranging from 110 to 165 degrees Fahrenheit down to 80 degrees Fahrenheit, and their operation under these circumstances is very efficient. Refrigerating plants have a range of temperature depending simply upon the pressure maintained in the condenser and seldom rises above 120 degrees Fahrenheit for initial temperature in the cooling tower. The evaporation of the water in the cooling tower must, of course, be re-supplied, and this represents a certain loss. In steam-condenser work, if the condenser is of the jet type, the water is more than re-supplied from the condensed steam and a constant overflow must exist. In refrigerating plants the loss of the water is from 5 to 15 per cent. for each circulation, and this loss must be re-supplied.

The efficiency of a cooling tower, of course, depends primarily upon the cost and availability and character of the water supply. It must not be pumped too great a distance, or too great a hight. Practically every individual plant presents special conditions for consideration in regard to its availability, and the efficiency of the type is practically dependent upon these special conditions.

Some Useful Lessons of Limewater

Hard Water and Boiler Scale; How to Make Carbonic Acid Gas Water; the Action of Limewater Upon Litmus Paper; Acids, Alkalies

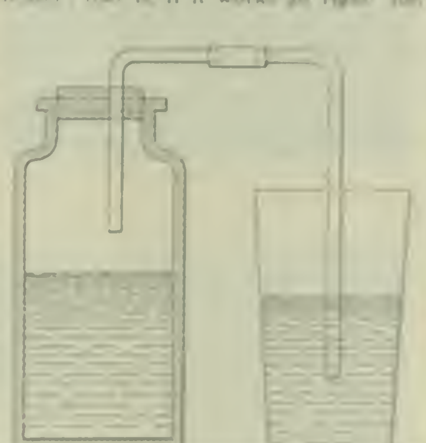
BY CHARLES S. PALMER

In the first shift, Mr. Furnaceman, you got the idea that lime will dissolve somewhat in water; that the lime can be thrown out of solution as plain carbonate (which is not soluble in water) by the carbonic acid of the breath, and by the same thing from the burning of common coal; it was also noted that by adding more of this carbonic acid from the breath, or from the gases of the burning coal, to the water with the insoluble plain carbonate of lime, you got the fairly soluble extra or bicarbonate of lime. You saw that this solution of somewhat soluble extra or bicarbonate of lime, after filtering, is the same thing as artificial temporary-hardness water; for, on filtering it to get it clear, and then on heating it, the extra carbonic-acid gas goes off, and down comes again the insoluble plain carbonate. You saw quite a little of this insoluble plain carbonate, both as a sediment in the bottom of the glass, and also as a scum or thin flaky crust floating on the surface of the water. If you shake this and let it settle, you will get enough to show that this plain carbonate of lime would make trouble if it were in any great quantity. This plain insoluble carbonate of lime is what makes the soft scale of temporary-hardness water; in contrast to the hard sulphate of lime scale, which makes the scale of permanent hardness water, which will be studied later. There are also compounds of the metal, magnesium, in many hard waters, and they will be taken up later on, also, after the lime compounds are disposed of.

Now, the thing to get clearly in mind is this: That even a *little* scale is a bad thing to have on the boiler tubes. It may not take a layer as thick as your hand to make both danger and extra cost in firing the boiler. And it is costly, not only for the management that pays for the coal, but also for you, the man who must handle it all.

Of course, we may shrug our shoulders when the books try to tell us just how much heat is lost by scale of such and such thickness; for if one is not rushing the fire, and if there is more than enough heating surface in the boiler and tubes to absorb the heat of the furnace, the scale, especially if it is not very thick, may not do much damage. But if your boiler has none too much heating surface, and if you are forcing the fire, that may be an entirely different matter, as you may know from actual experience. So we will not tie ourselves down to any special figures on the heat loss from scale of any particular thickness, but we must all agree that any scale is liable to cause both waste of coal and waste of the fireman's own good strength, not to mention some danger. That is why we are trying to get together on this eternal riddle of hard water.

To get back to the first solution of filtered limewater, the stuff that tastes slightly bitter-sweet, that throws down plain insoluble carbonate of lime, both from the breath and from the gases from the burning coal. This sediment was fairly soluble in extra carbonic acid, making the double or bicarbonate, which is somewhat soluble, and this is thrown down by heating, just as the temporary-hardness water is cleared up by your heater; that is, if it works all right. But



FOR MAKING CARBONIC-ACID WATER

it takes time to throw out the lime from the hard water in the heater, and it takes time for it to settle, and that will set you to thinking of some way to handle the heater, so that it will always do its work in softening the water, as it may not always do.

Make Some Carbonic-acid Gas

We have found out, in the foregoing, four things about the lime: the solubility, the insolubility, the resolubility and the reinsolubility. But you want to know more about this carbonic-acid gas which picks up the lime from the insoluble limestone bed and carries the extra, or double or bicarbonate of lime, down to your boiler room. You can see that if this carbonic-acid gas should get into the water which seeps through the limestone bed, it will naturally take some of the plain carbonate from the bed and carry it along. For there is some carbonic-acid gas in the air; and so, of course, this gets into all natural water, more or less.

If you pour some of the filtered solution of limewater out into any open dish, as a glass tumbler, in a few minutes you will see a thin scum form over the solution. This scum will form a thin skin over the surface of the limewater, and this white skin is the same plain insoluble carbonate of lime that you got by putting the gas from the burning coal and from breathing through limewater. As you look at your bottle of filtered limewater, you will note that with all your cleaning, the cork and neck of the bottle are smeared with the same white, plain carbonate of lime; indeed, some of it has got into the bottle of filtered limewater, especially if you have allowed the water to get low in the bottle so that there is quite a little air in the bottle above the filtered solution. This means that you will have to filter the limewater again from time to time, for the air about us is always at hand and it is always getting in its work on the filtered limewater. There is not much carbonic-acid gas in the air, only about one part in thirty-five hundred, but this is quite enough to show with so sensitive a chemical as limewater and with the insoluble carbonate so ready to form.

You are probably quite well acquainted with this carbonic-acid gas; you may know it very well as "soda water," or as the "fizz" which is used to mix with other things. It is kept in that strong "siphon" bottle, and the thick walls of the siphon bottle, the readiness with which it squirts out as you press the lever on the top, together with the strong foaming in the drinking glass, all show that the carbonic-acid gas in the siphon bottle is under strong pressure; indeed, the water in the siphon bottle is quite a strong solution of this carbonic-acid gas.

If you should take some of this water from the siphon bottle and pour it into some limewater (very little of it, for this is a strong solution of the carbonic-acid gas), you would get the same white insoluble plain carbonate of lime. And if you should again add to this plain white, pour a little more of the water from the siphon bottle, you would make the same fairly soluble extra or double or bicarbonate of lime as before, with the [illegible] coal. In this way, you would make the temporary-hardness water; and, after filtering it, because the bicarbonate of lime is not quite soluble enough in water to dissolve entirely, you would have a clear solution. which would throw down the plain carbonate, as before, by heating.

How to Make Carbonic-acid-gas Water

It may not be handy to get a siphon bottle of carbonic-acid-gas water, but all the same you want some of it. So you will make it yourself. Just rig up an apparatus consisting of a bottle, a tumbler and tubes, as shown in the accompanying sketch. Take a wide-mouthed bottle, say a common horse-radish bottle, and a common tumbler. The bottle is closed with a flat cork, pierced by one hole for the tube to carry the carbonic-acid gas to the tumbler. The tube is made of two pieces of glass tubing, joined with a bit of rubber tubing (which you can get with the outfit mentioned in the first lesson). In the bottle are placed some lumps of common white marble, which is nothing more than plain carbonate of lime (or calcium). Pour over the marble about two or three inches of water, and then about one-fifth as much hydrochloric (muriatic) acid. If you do not have the acid, you may use vinegar; but in that case, do not add any water, and have the vinegar warm. Hydrochloric acid is more active than vinegar and cuts the marble quicker than the vinegar does. You will see quite a foaming; clap on the flat cork and lead the carbonic-acid gas which comes off through the tube, passing through the flat cork, into the tumbler, which contains some of the original filtered limewater. As the carbonic-acid gas comes over and passes through the limewater, you will get the same white insoluble plain carbonate of lime (or calcium), and if you keep the current of gas going, pretty soon you will see the same change in the precipitated limewater which you got from blowing your breath through limewater, and from sucking the gas from glowing coal through limewater. Thus you see that you can get this carbonic-acid gas from the breath, or from burning coal, or from limestone. The carbonic-acid gas is locked up, "fixed" the old chemists used to say, in the limestone, which is carbonate of lime; and when you add some strong acid to limestone, this acid displaces the carbonic acid, forces it out and, as carbonic acid happens to be a gas, you can grasp the explanation of the action of this apparatus.

If you use vinegar, take about a cupful, for vinegar is only a diluted, or thin, solution of acetic acid in water. You might use nitric acid, also, but that usually costs more than muriatic (or hydrochloric) acid; but you will not use sulphuric acid, because this acid in acting on limestone makes sulphate of lime (or calcium), and this is so insoluble that it coats over each lump of limestone and shuts off the action. But to go back to the experiment:

You were driving the carbonic-acid gas over into the limewater; you had got the same plain insoluble white carbonate-of-lime precipitate (a "precipitate" is anything thrown out of solution when two clear liquids are mixed, and one liquid is said to "precipitate" the other; also, the thing thrown out of solution is said to be "precipitated") as with the breath and limewater, or with the gas from glowing coal and limewater. And, as in those cases, with more carbonic-acid gas led into the precipitated insoluble lime carbonate, you get the same extra, or double, or bicarbonate of lime. Keep the liquid in the tumbler shaken up, as the gas bubbles through, so the carbonic-acid gas can act on the insoluble carbonate of lime in changing it into the extra carbonate of lime. When it shows the change of beginning to be more soluble, as though you could almost see through it, take the tumbler and filter the contents, and you will have the same solution of extra, or double, or bicarbonate of lime (or calcium) that you had before; in fact, some of the temporary-hardness water.

If this is warmed, down comes the same insoluble plain carbonate which makes the scale. If you don't happen to have any pieces of marble, you may take instead a handful of common cooking soda from the kitchen at home; only in this case, you will have to add it a little at a time, because the acid will act on it almost as soon as it is thrown into the wide-mouthed bottle, which has strong acid in the water. If you keep right at these homemade experiments you will begin to see how easy it is to follow one thing up after another, and these tests that you are making are just the sort of thing that the thinking man has to use and study everywhere.

The Action of Limewater on Litmus Paper

But there is one fact about limewater that you ought to know by this time. That is its action on litmus. You have a sheet of this litmus paper or a little package of it cut into strips, with your outfit. If it came in one sheet, cut some of it into little strips about a ¼ of an inch wide and 2 or 3 inches long, and put them in any clean, wide-mouthed bottle, which you will keep corked and handy for use.

This litmus paper, so say the books, and they are useful occasionally, is turned red by acids and blue by alkalies. As Long Jack said to Harvey Cheyne (in Mr. Kipling's "Captains Courageous") about shiptackle, this is one of the things that "ivry man must know, blind, dhrunk, or asleep." This must be learned once and for all. Litmus, *acids red, alkalies blue*.

All right, but what about limewater? Just try it. If you have red litmus to start with, it turns *blue* in the limewater, and if you have *blue* litmus paper, it *stays blue* in the limewater. So, then, our limewater is an alkali. This is a big piece of chemistry, and it is a leading fact by which to find out thousands of other facts which are worth dollars to the man who will have the sense to use them. *Limewater is an alkali!*

Acids and Alkalies

Let us take a little excursion among the common things over on the boiler-room shelf, or in that interesting old pantry, and you will find it just bursting with information which it is a thousand times better for you to find out in this practical way than merely to read about in the books. There are salt, pepper, spices, sugar, soap, soda, vinegar, ammonia water, and perhaps a lemon, a sour orange, or an apple. Now some of these are active chemicals, and some of them, while having plenty of *taste*, are indifferent to litmus or useless for our purpose. But you will soon find that the soap, the soda, and the ammonia will each turn the litmus paper *blue* like the limewater, so they are all alkalies, or have some alkali in them, while the vinegar, the sour lemon and orange, and even the apple, will all turn the litmus *red*, and hence contain acids.

This division between *acids* and *alkalies* is as old as Mother Nature, though chemists did not begin to get onto this important fact until two or three centuries ago; but it is just as Long Jack said about his shiptackle, it must be riveted into the mind of attention and into the finger of testing. You cannot afford ever to forget it, or to think that it does not matter particularly whether or not you make the test, even if you think you know about what it is without testing. Make the test; do it; and then you can explain why it was that something happened that you were not expecting, as it always does in the long run. That waste water over there in the corner may be chewing out your pipes; litmus may tell something; but that story comes later.

But you must stop awhile with the soap, the soda, the ammonia, and the limewater on the one hand, and with the vinegar, the sour fruits and the like, on the other. As you go on you will find that there are several other acids: sulphuric, nitric and hydrochloric (or muriatic, as it is still popularly called). You will also find several other bases or alkalies, such as caustic soda or sodium hydroxide (or hydrate), caustic potash or potassium hydroxide (or hydrate, chemists are generous with names), sodium carbonate, and so forth.

Suppose we experiment awhile with our litmus, and the acids and bases; it is well worth the while. You note that *any* strong acid will turn the litmus *red*, and *any* strong alkali will turn the litmus *blue*; though it may take more of it and more time in some cases than in others. Then you take a little of some acid, vinegar for instance, in a tumbler. Slip a strip of litmus down the side, and pour in limewater. Soon the one will "kill" the other, and you can get both dead (or "neutralized" as the wise folk say) by mixing just enough of acid and alkali together, though at first you may pour in too much limewater to the vinegar, or not enough, and you will have to coax and tease the solutions back and forth until you get them so that perhaps a drop or two will do the trick, and the litmus is neither red nor blue, but a sort of purple. That is the *neutral* point. Now if you taste these neutralized solutions, you will get neither the sharp taste of acids, nor the flat but peculiar taste of alkalies, as a rule, you will get a taste something like common salt, as tastes run; in fact, the things made by mixing acids and alkalies (or bases, for alkalies are only the more soluble and stronger bases) are "salts," and common salt is only the commonest salt.

This common salt can be made by mixing some soda with hydrochloric acid, until the exact point of neutrality is obtained, and, of course, it is a simple thing to evaporate some of the mixed and neutralized acid and alkali down to dryness, and thus collect some of it. Now there are millions of possible salts, and some thousands of these are known, and some hundreds of thousands remain to be found and to be used; but we will not bother about more than a few of them. We have too much to do with that bad boiler water to fool time away on what does not concern us. What we want to get at is that hardness, and to find out whether it is of the temporary kind or of the permanent kind, and whether we can help the "boss" get rid of it in some cheap and practical way. For you will find out that there are two or three principal kinds of salt that bother the poor [illegible] almost to death, and they are mostly salts of this alkaline base, lime, that you have started to study.

Ingenious Automatic Cutoff for Rope Drive

The W. F. & John Barnes Company, of Rockford, Ill., having a limited space [illegible] was forced to put a rope drive between the engine and the blower (as shown in Fig. 1).

In order to take up the slack in the rope caused by its natural stretch or the changes in atmospheric conditions, one strand of the rope was carried over a sheave wheel on the carriage *A*, which is mounted on a track above the engine. The weights *B* were hung on a rope that was passed through the pulley *C* and attached to the carriage *A*. This keeps the proper tension on the rope drive.

As the engine was not watched very closely, but was left to run itself, there was danger of the rope breaking, which would cause the engine to run away when relieved of its load. To overcome this an ingenious arrangement of sprockets *D*, *E*, *F* and *G*, with their chains and rods, was rigged up. If the rope in the drive broke, the carriage *A* would be run back to the fork *H* by the weights *B*. The carriage striking the fork *H* would move the rod levers *I* and *J* and these in turn would release the sprocket wheel *D* and its shaft, which would allow the weight *K*, that is fastened to the chain, to drop to the bottom of the sprocket wheel *F*. When the weight *K* drops it carries the chain with it and transmits this motion back to the throttle at *G*, Fig. 2, thus closing the throttle and cutting off the steam, which will cause the engine to stop.

This is a simple and cheap rigging that can be easily installed, but it does its work perfectly and might be useful to others if placed in a similar position through lack of space.

FIG. 2. CONNECTION ON THROTTLE

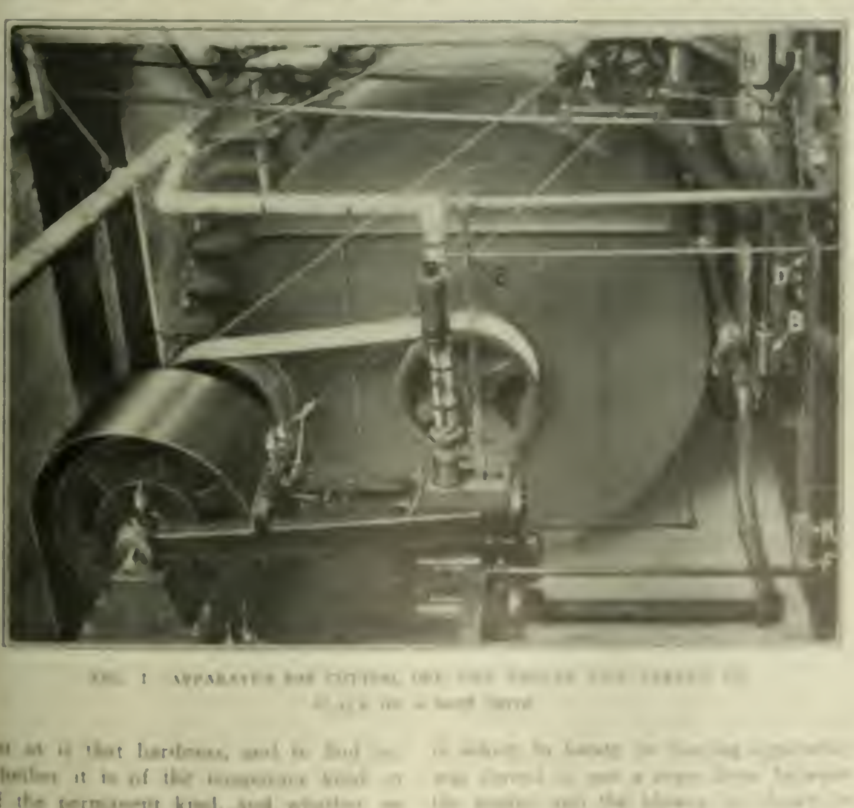


FIG. 1. APPARATUS FOR CUTTING OFF THE ENGINE [illegible]
[illegible]

Power Costs in a 5000-Kilowatt Central Station

By H. S. Knowlton [illegible]

The study of power costs in a modern central station throughout a period of years usually affords opportunity to determine the factors of chief importance under the prevailing conditions, in their bearing upon the efficiency of current production. An example of this is afforded by the following record of four years' cost of power in a New England central station of about 5000 kilowatts rated capacity. The figures cover consecutive years from [illegible] to [illegible], inclusive. During this period the equipment of the plant remained substantially unchanged until [illegible], when a new station was begun by the company on a site adjoining the older installation. Part of the output for the [illegible] was generated by the new plant, which will ultimately supersede the older station.

The equipment of the plant in [illegible] consisted of [illegible] boiler installations of [illegible] horsepower, and an engine equipment of [illegible] horsepower. There were [illegible] Babcock & Wilcox boilers, with [illegible] setting, each having [illegible] and [illegible] inches in diameter [illegible], and operated at an average steam pressure of

120 pounds per square inch. The engine equipment was as follows: One Harris, 22 and 22 by 48-inch, 78 revolutions per minute, 750 horsepower; one Harris, 18 and 30 by 42-inch, 84 revolutions per minute, 500 horsepower; one Harris, 18 and 30 by 36-inch, 96 revolutions per minute, 450 horsepower; one International Power Company, 19 and 44 by 48-inch, 100 revolutions per minute, 750 horsepower; three Brown, 22 and 40 by 48-inch, 100 revolutions per minute, 750 horsepower. The electric-generating equipment of the plant consisted of 10 generators ranging in size from 135 to 675 kilowatts.

The total energy generated in the plant during 1905 was 5,354,000 kilowatt-hours. The company sold 1,409,000 kilowatt-hours for power purposes, which was an important factor in economical generation through its effect on the station-load factor as a whole. The company burned 7857 tons of New river coal, costing on the average $4.28, the fuel consumption per kilowatt-hour being 3.29 pounds. The operating force of the station consisted of three engineers, four oilers and cleaners, three firemen, two coal passers, three dynamo and switchboard men, two repairmen and one station clerk. The operating cost was as follows, omitting cents in total figures:

Coal or other fuel	$33,622
Rentals, station real estate	120
Oil and waste	561
Water	1,056
Wages at station	17,020
Station repairs	5,594
Steam-plant repairs	9,655
Electric-plant repairs	621
Station tools and appliances	1,562
Total	$69,814

Per kilowatt-hour the principal costs are fuel, 0.63 cent, and wages at station, 0.318 cent.

The equipment of the station was the same during the next year as in 1905. The cost of coal per ton increased to $4.42, and the plant consumed 8328 tons. The output was 6,038,000 kilowatt-hours, and the power sales 1,772,000 kilowatt-hours. The company's efforts to increase its power business enabled the machinery to be run at better loads during the daylight hours, when the demand upon the plant for lighting current was the least. The station force was practically the same, with the addition of one man, as in 1905. There was a saving in fuel consumption of about 0.2 pound of coal per kilowatt-hour. The total fuel cost was $36,820, or 0.61 cent per kilowatt-hour. The wages cost was $17,296, or 0.286 cent per kilowatt-hour, and the total cost of manufacture was $71,021, or 1.18 cents per kilowatt-hour. There was a saving of about $5000 in station repairs compared with the previous year.

In 1907 the equipment of the plant was practically the same as in the preceding two years. The output increased to 2,196,000 kilowatt-hours. The station was operated by seventeen men and the cost of coal rose to $4.55 per ton. The total fuel consumption was 9869 tons. The total fuel bill came to about $45,000, or 0.635 cent per kilowatt-hour. The labor cost was about $17,450, or 0.247 cent per kilowatt-hour, and the total cost of manufacture was $69,000, or 0.975 cent per unit produced. There was a reduction this year of about $9000 in steam-plant repairs. Other items showed less variation. The total repairs of station, steam and electric plants came to about $3400.

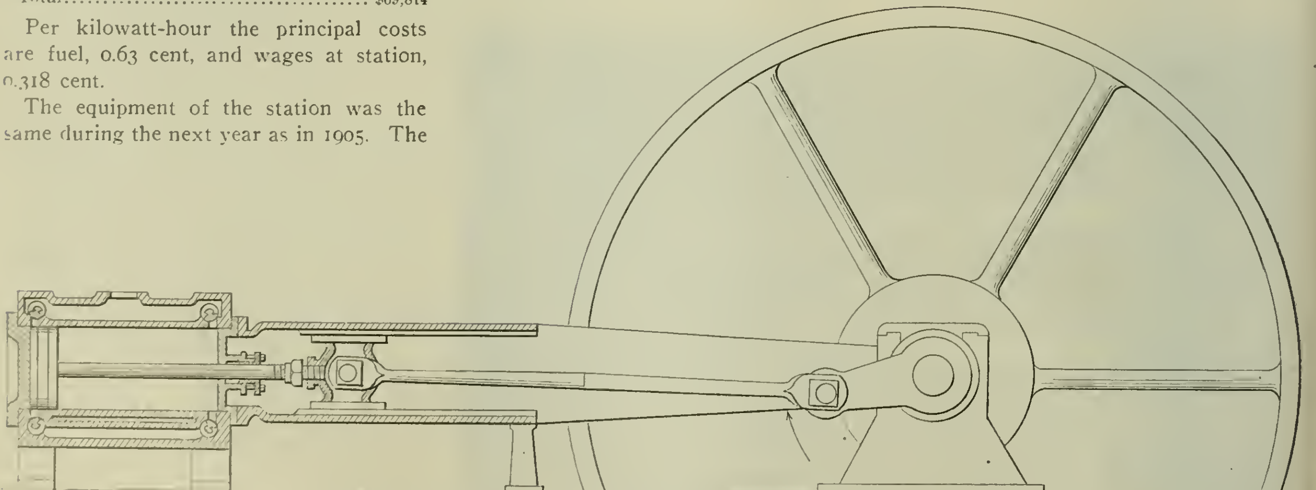
For the last year of the station record, 1908, the cost of fuel per ton increased to $4.75. In this year the initial installation of the new plant was opened for service, and this consisted of a 2000-kilowatt Curtis steam turbine, with three Stirling boilers having each three hundred and ten 3¼-inch tubes, operated at 180 pounds and rated at 526 horsepower. The total boiler capacity was thus increased to 3229 horsepower, and the total engine and turbine horsepower to 7200. The coal consumption was 14,101 tons, and the station force was five engineers, four firemen, six station electricians, ten boiler-room men and two repairmen. The fuel cost in toto was $67,000, and the advance in price per ton tended to increase the cost per kilowatt-hour to 0.71 cent. Station wages came to $24,700, or 0.262 cent. per kilowatt-hour, and the total manufacturing cost per kilowatt-hour was 1.06 cents, the amount expended for power production being $100,000. The energy generated by the station was 9,426,000 kilowatt-hours. The other items of production cost were not altered to any considerable extent compared with those of the previous year.

Summing up the history of the station during the period considered, there has been a progressive increase in the cost of coal, which is a serious obstacle to the economical production of power with a fairly stationary equipment. This has been offset to a considerable degree in the plant by careful operation, and particularly by the increasing of the power load each year. At the end of the four years this had increased to 3,760,000 kilowatt-hours, or 2.7 times the power sales of 1905. The steadying effect of such an output is inevitably a great help toward the operation of station apparatus at points nearer their most efficient output. That the cost per kilowatt-hour should have been reduced from 1.3 cents to about 1 cent in this period indicates that the plant has been operated with skill, in the face of high fuel costs and not the most modern equipment.

Two Loose Nuts

By W. H. Wakeman

The engineer of a certain plant reported that his engine pounded badly for a portion of the time, then would run quietly until for some reason the pound returned, and this disagreeable condition of affairs annoyed him for several days. If the pound had been continuous the cause would undoubtedly have been found with little delay and trouble, but the intermittent action constituted a puzzle that baffled his efforts. Another engineer was called in for advice, and he proceeded to give the machine a thorough examination. He found the piston rod screwed into the crosshead in the usual way, but the check nut was loose, and this allowed the rod to



LOOSE CHECKNUT AND PISTON PARTLY UNSCREWED FROM THE CROSSHEAD turn in the crosshead. It would unscrew until the piston struck the cylinder head at every revolution, causing a heavy pound, but for some unaccountable reason nothing was bent or broken.

The rod would then screw into the crosshead until the usual clearance on the head end was restored, consequently the pound disappeared. As the nut was frequently in contact with the crosshead when the engine was shut down, the defect was not discovered by the regular engineer.

In another case the same defect caused trouble, but in this instance much heavier blows were struck on the cylinder head when the crank was about to pass the inside center, as shown in the illustration. The engine was promptly shut down, the defect discovered, and both rod and nut were returned to their proper places, with but little delay in the operation of the machinery.

Shims had been placed between the end of the connecting rod and the corresponding half of the wristpin box, and these were forced together until a more perfect fit was secured for the surfaces in contact, by the great stress brought to bear on them by the toggle-joint action of the crank while in the position illustrated, in connection with the leverage of the flywheel. When the engine was started again there was a slight pound at the wristpin, although this box gave no evidence of lost motion before the accident. It was necessary to readjust the wedge at this point in order to restore normal conditions.

The joint made by joining the frame to the cylinder began to leak steam soon afterward, and when at attempt was made to tighten the nuts at this point, three studs were found broken in two, or pulled apart by the great strain that had been brought to bear on them. Fortunately the remainder proved sufficient to carry the load, thus preventing more serious trouble, but it was a very narrow escape.

This method of fastening a piston rod is preferred by many engineers because it admits of easy and accurate adjustment at all times, and allows the piston to be removed from the cylinder with little trouble. Do not use a pipe wrench on the piston rod to turn it out of the crosshead, as a certain engineer did, but turn the check nut back as far as it will go on the threads, then apply the solid wrench which is supplied by the engine builders for this purpose.

Great care should be taken to fasten the nut securely when the rod is returned to its proper place. It is not sufficient to put a wrench on it, then allow the fireman to sit on its short handle, but several smart blows with a hammer of suitable weight ought to be struck near the end of it, as the shock so produced is equal to, or better than, the operation of a long lever under steady weight or pressure.

Production of Electricity by Peat

By E. [illegible]

Peat exists in large quantities in Europe and America. In some sections of the United States, as in Michigan, for instance, the peat deposits are covered by woods, shrubbery or swamp, and are sometimes 40 feet in depth, rarely more. Wet peat contains from 80 to 90 per cent. of water and is dark brown, nearly black.

In order to prepare peat for fuel it has to be dug, formed into rectangular strips or blocks, of cross-section about the size of a tile, and dried in the open air. These operations may be wholly done by hand or partly by machinery. In the latter case the peat is dug by hand, carried by a conveyer to the press or mixing machine, where its fibrous structure is separated and expelled in the form of strips about 5x5x15 inches in size. These are piled on the ground for some weeks to dry. They are laid crosswise in a pile about 2 feet high, which permits the air to circulate around them, and in this way they become thoroughly dried, when they are ready for use.

Dry peat is dense and hard, like tile, is very inflammable and produces little smoke and ash. Its thermal value is about from 6900 to 7200 B.t.u. (if containing from 15 to 20 per cent. moisture), or practically one-half the thermal value of high-grade coal. The material when free of water is composed of 60 per cent. C, 5 per cent. H and 35 per cent. O.

The use of peat produced in the manner outlined has two marked disadvantages: (1) The drying process is dependent upon the weather. In Europe, for instance, the production period usually only extends over 100 days a year, and the capacity of the plants is very small. In fact, 10,000 tons a year is considered a very high output. (2) Transportation costs are in proportion to the weight, not the thermal value, and this means paying twice as much freight, compared with coal, for the same amount of heat. Therefore, peat is in general more expensive than coal.

Careful investigations have led to the following conclusions: It is better to bring the factory to the peat than the peat to the factory, and save the cost of transportation. Also, it is more profitable to use wet peat for fuel, as this permits the plant to be operated the year round without regard to the weather.

Producing Electricity from Peat

In certain parts of Europe, in producing electricity from peat, either of the following methods is used:

(a) Gas is made in a producer and burned in a gas engine. For the most part dry peat is used, but it is possible to use wet peat, or from 40 to 50 per cent. moisture. The producers and gas engines used with peat [illegible] usually the patents of firms which have been engaged in this line for years. The gas producers are built by Lutter in Braunschweig (Germany), Reed in Mannheim and Körting in Hannover. The thermal value of the gas is from 990 to 1100 B.t.u.

(b) Wet peat is placed in a boiler, where the moisture (80 to 90 per cent.) is evaporated and superheated and employed in driving a steam engine or turbine. The residue is dry peat, which is automatically ejected and burned under the boiler. Thus, while some dry peat is used it only requires about one-eighth as much as though dry peat were used altogether. A wet-peat plant of great horsepower is in course of construction to supply light and power to the towns of [illegible] and [illegible] and fifty other places within a radius of thirty miles. The engine and boiler are to be furnished by the Maschinenbau Gesellschaft, Nürnberg.

These two methods are comparatively new. The difficulty with the first is to produce a gas free of tar. This would not be difficult ordinarily with dry peat (of 20 per cent. moisture), but in the case under discussion the process is expensive and the peat exists in small quantity. The objectionable feature of the second method is the complicated boiler.

Peat Problem in the United States

Under present conditions in the United States the peat problem is not very important. Coal is cheaper and wages higher. When the United States becomes more densely populated the problem will be ripe for discussion and solution. Americans have to get the experience of the old country, as yet, and it would be a waste of time to try new methods. The only chance for improvement is to substitute machinery for hand labor, and perfect the machinery.

The peat problem seems very simple but, in truth, it is quite the reverse. Millions upon millions of dollars have been lost, but it is also a fact that experienced producers made big profits with small investments.

In the inquiry on "Path of Point on Connecting Rod," published in the December 29 number, page 1104, formula (1) and the last formula used in the answer were not printed according to copy. Formula (1) should read

[illegible]

and the substitution of figures made in the formula should read

[illegible]

The answer was given correctly but it would, undoubtedly, be a matter of question how such a result was obtained from the expression as printed.

POWER AND THE ENGINEER

DEVOTED TO THE GENERATION AND TRANSMISSION OF POWER

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Contents

Municipal Ownership

We give place to a letter on "Municipal Ownership," by Arthur Williams, in our correspondence columns, despite the fact that we are not interested in the question, which is a sociological rather than an engineering one. POWER'S subject is engineering and not political economy.

The clipping from the Wisconsin paper, to which the editorial which called out Mr. Williams' letter refers, says that "a city cannot run a lighting plant as cheaply as private companies can supply the light." The subscriber who sent it asked for our opinion upon this question, which, divested of politics, is an engineering one; and after a careful consideration of Mr. Williams' contention we should still answer it as we did before. The boilers, engines and generators do not know nor care who owns them. Put them into the hands of an equally good man, give him a free swing and hold him responsible for results and they will produce current for the people as cheaply as for a corporation. The additional dividends which it is necessary to pay upon watered stock, franchise valuation, corruption funds, etc., may be put against the increased costs due to political graft, etc., of which Mr. Willams protests—but this is getting out of the engineering side of the case.

The business of producing electricity is getting systematized. The cost of plant per kilowatt, the cost of putting current upon the switchboard, the cost of distribution are becoming known and a free exchange of data among such plants and the publication of uniform reports, as is done by water-works engineers, would make a particularly extravagant station stick out like a sore thumb, whether it belonged to the public or to an individual.

Please remember that a continuation of this discussion must be along engineering and not socialistic nor political-economical lines.

The Gas Engine Engineer

Repeatedly the assertion has been made that the average stationary engineer does not develop into as efficient a gas engineer as the ordinary machinist, although why such a view of the matter should be taken is not always definitely stated. The average machinist has the advantage of knowing how to repair or even make a part of a machine in case of breakdown. He has a better knowledge of the use of tools, if he is a man of experience, but it is difficult to see how these accomplishments are such strong points in his favor as to put the steam engineer out of the race. The machinist's one real advantage over the steam engineer is that he does not know how to run a steam engine; this can be considered advantageous because, not knowing anything about the operation of any type of engine, he is more likely to feel receptive toward advice and instruction.

The steam engineer is familiar with the operation of both steam and gas engines, as far as the reciprocating parts are concerned, but in the matter of the action of the power medium he is familiar only with steam. Of the action of gas in an engine cylinder he has much to learn—as much as, if not more than, the machinist, because there is liability of his confusing the manner of regulating the effect of exploding gases with that of steam expansion. In the matter of adjustments the engineer should be at home; in the care of bearings, the same vigilance is required as with steam engines, and no more.

With all the good things that may be said in favor of the steam engineer as a candidate for gas-engine honors, however, he is handicapped in one particular. He is familiar with steam-engine operation and expects to obtain the same results from a gas engine. This is something that cannot be done. It is no uncommon thing to see a steam engineer fret and worry because his engine has developed a pound or some little thing out of the ordinary; such an engineer will not rest contented until that fault is found and remedied. His greatest ambition is so to adjust his engine that it will operate practically without noise, and in some cases this is carried so far as to become almost a mania. There is a good deal of satisfaction in having a smooth-running engine, and the engineer is excusable if he is a trifle "finicky" on this subject. When it comes to running a gas engine, noiseless operation is a snare and a delusion to an operator who has fond dreams that its operation is to be a round of pleasure. He expects almost noiseless operation, and gets rattling and sometimes clanging. He listens for a modest click by the valve gear and hears the whacking of the cams and the muffled thump of the valves as they seat. The smooth-running engine which was expected is not in evidence, and then the steam engineer makes his mistake; he attempts, by adjustments here and there, to make the gas engine operate as quietly as a steam engine. As the functions of the different devices on the gas engine are not at first fully understood, it does not take long for him to get the adjustments so out of place that the engine refuses to work properly, and serious trouble ensues.

Here, then, is the chief difference between the two candidates. The machinist, not expecting any particular sounds from the engine, accepts the noises of operation as he finds them, and consequently does not meddle with the adjustments until he has so familiarized himself with the working of the engine that he knows what he is about. If a steam engineer will not demand of the gas engine that which it cannot give, and will leave all adjustments alone until he understands what the effects of making them will be, he will be able to hold his own against all comers.

Compression

Some months ago there were received from a small town in Oklahoma two sets of indicator diagrams. One set was of the conventional type of Corliss-engine diagram, with the compression curve rising to about two-thirds the initial pressure and with plumb-line induction, showing ample lead of steam valves and full pressure on the piston while the crank was still on the center. The other set from the same engine showed only a little rounded heel of a compression curve and the admission line inclined toward the middle of the diagram, showing plainly that the piston had actually moved a measurable distance before full steam pressure was realized in the cylinder.

These second diagrams were not good-looking, as handsome diagrams are usually considered, and computation showed that the indicated horsepower was considerably less in the case of late steam-valve opening and lack of compression than it was where ample steam lead had obtained and all of the lost motion in pins and journal was taken up by plenty of compression. But the engineer said that the actual load, that is, the useful work that the engine was doing, was the same in both cases, and asked why less steam was used to do the work with the one style of valve setting than with the other. The answer that was given him said in substance that the reduction of pressure on pins and main journal reduced the friction of the engine and thus decreased the load to be carried and consequently reduced the quantity of steam used per brake horsepower per hour.

Attempts were made to get one or two mechanical-engineering professors interested in the matter, to the extent of experimenting on an engine with a fixed load with different valve settings, with rather discouraging results. It was said the steam in expanding gives up to the piston all of the energy expended in the compression and it makes little or no difference as far as economy is concerned whether an engine is operated with or without compression.

These ex-cathedra statements have a tendency to create a feeling of antagonism in the mind of the average operating engineer toward all technically educated men. Some engineers know from experience that there is a slight loss if compression is carried above the terminal pressure, while others feel that there is really a gain made by carrying the compression line to about one-half or two-thirds of the boiler pressure.

Most of the mechanical-engineering laboratories of the universities of the country are equipped with engines fitted to decide this question by scientific investigation. It could be shown whether an engine with a constant brake load, such as could be readily measured, would use more or less steam with one form of valve adjustment than with another. Pounds of steam per indicated horsepower-hour, pounds of steam per brake horsepower-hour and the indicated horsepower necessary under different valve setting to carry a certain brake horsepower are questions that are of vital interest to the designing as well as to the operating engineer. And only in the laboratories of the technical colleges of the country is the apparatus suitable for making an exhaustive test to be found. Can the men at the heads of these experiment stations determine these things?

Some years ago some experiments along this line were made in Belgium and although they were incomplete, owing to the fact that the engine used "did not lend itself readily to compression," the conclusion reached was that compression of exhaust steam in the clearance space resulted in a direct loss.

At many of the universities are engines which will readily lend themselves to compression. Can one or more of these engines be pressed into the service of settling for the operating engineer, who has no opportunities for satisfactory experiment, the question of whether compression leads toward economy or away from it?

The Engineer and the Central Power Station

Successful steam-engine operation means a great deal beyond the running of a steam plant at its highest efficiency. Not alone should the engineer seek to keep his plant in the best of operating condition, but he should also see to it that nothing that may be of advantage to himself or the plant escapes his attention.

In its search for business the central power station is competing with the isolated plant and through its solicitors attempting to show the small-plant owner that business wisdom indicates that it is better and cheaper to buy power than to attempt to make it. Whether this is true can be better determined by the engineer of the small plant than by anyone else in the world.

In a manufacturing town a new engineer of a large building found several of the tenants buying both power and light from the central station and the proposal was good for some business for the central plant. After thoroughly familiarizing himself with all of the facts of the situation he went to the proprietor and said:

"You have an engine furnishing power and lights to some of your tenants. The proper thing to do is to furnish all the power and all the light to all of your tenants. You have an engine running at sixty revolutions a minute and it is lightly loaded. The speed should be increased to one hundred revolutions, and it can be with perfect safety. This will give you an increase of forty per cent. in power, which will enable you to take over all of the load that is being carried by motors with current from the central company. I know how many lamps are being used and the size of dynamo needed to light them. Buy and install this and change the speed of the engine, then I will say to your tenants: 'You are paying thirteen cents per kilowatt-hour for current to light your rooms. I am prepared to furnish this light to you for eight cents.'

"Since I will have a full load for the engine without costing you any [illegible] for extra coal. For seven months of the year you have to heat the buildings, so it will cost you practically nothing to run the engine and the revenue from the lighting will pay a big rate of interest on the outlay."

The proprietor was skeptical, but finally consented to the change. At the beginning of each month the engineer laid his reports before the owner. As time went on the revenue from the lights, which had been applied directly to the liquidation of the coal bill, began to show a surplus. One day when the reports were being examined the engineer said:

"You see that the coal bill last month was six hundred and some odd dollars, while the amount collected for lighting amounted to more than seven hundred dollars. From these figures you can readily see that you do not need to worry any over my salary. The Central Lighting and Power Company is paying that [illegible]."

And being asked to explain, he said:

"Before I took this place you were burning very nearly as much coal as you are today. You were heating the different buildings with [illegible] through the engine, lots of steam direct from the boilers was used.

"The engine has been speeded up and more load put on and the exhaust used for heating. The extra load came from the lights and power that were taken from the Central Company. The money that your tenants paid that company is now paid to you and it is all profit, a small interest and depreciation [illegible]. [illegible] formerly went to the Central, it costs you practically nothing. [illegible] for you. I have shown you that I am a source of revenue to you. I want a part of it because I am worth it, and because I [illegible] Central Company."

The Weighton Air Gage

In steam-engine practice the losses resulting from air leakage in the condenser system have been guessed rather than calculated. In order that the engineer may determine at a glance the amount of air being discharged an air pump may be

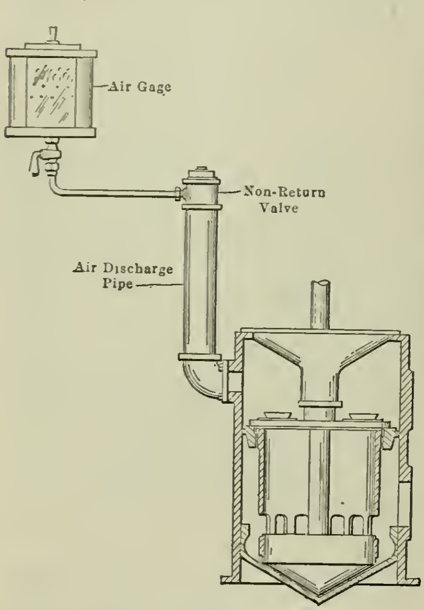

FIG. 1

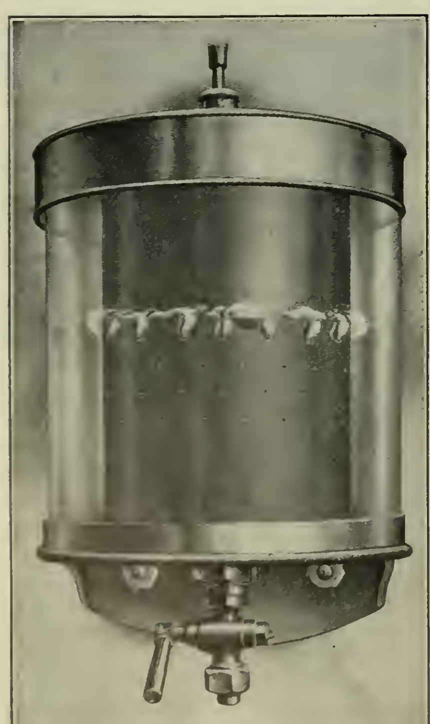

FIG. 2

fitted with a Weighton air gage. It is a glass cylinder, closed at the bottom and containing a stationary bell, the interior of which is in communication with the air-discharge pipe of the air pump. See Fig. 1. Around the surface of the bell are several rows of holes, as shown in

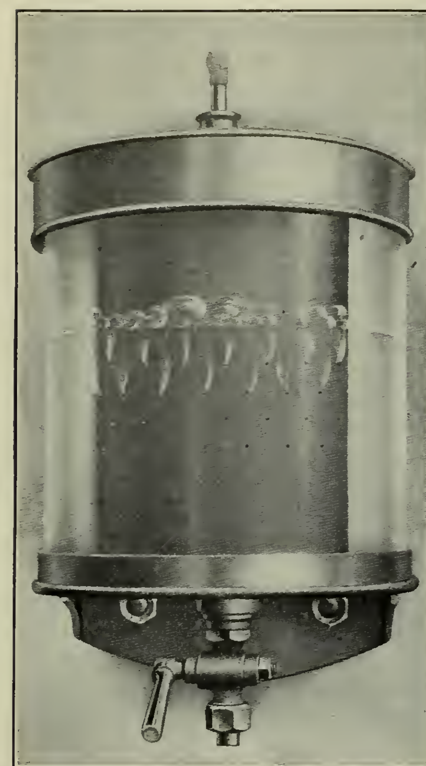

FIG. 3

Fig. 2. The outer cylinder is filled with water to a point where it will just cover the highest row of holes. When air is admitted, even under very slight pressure, the water level is depressed below the top row of holes and air escapes through them. As more air is admitted to the bell the water is correspondingly depressed and additional holes are exposed. As original calibrations have been made, the number of cubic feet of air being discharged under any given condition is easily ascertained, while the relative amount of air being handled by the air pump is shown by the condition of the air gage (Figs. 3 and 4). The device is the invention of R. L. Weighton, professor of electrical engineering at Durham College of Science, Newcastle-upon-Tyne, England. It will be introduced in this country by the Elwold Company, North American building, Philadelphia, Penn., which also represents the Contraflo Condenser Company, Ltd., of London.

FIG. 4

Museum of Safety and Sanitation

Announcement has just been made of the acceptance of the treasurership of the Museum of Safety and Sanitation by Frank A. Vanderlip. An executive office for the administrative and promotive work of the museum has been opened at the United Engineering Societies' building, 29 West Thirty-ninth street. New York City.

A committee on plan and scope includes Prof. F. R. Hutton, chairman; Dr. Thomas Darlington, commissioner of the health department of the City of New York; P. T. Dodge, president of the Engineers' Club; William J. Moran, attorney-at-law and Henry D. Whitfield, architect.

Plans are being pushed forward along practicable lines to prevent the enormous loss of life and limb to American life and labor, through the Museum of Safety and Sanitation, where safety devices for dangerous machines and preventable methods of combating dread diseases may be demonstrated. Charles Kirchhoff, editor of *The Iron Age*, is the chairman of the committees of direction; T. C. Martin, editor of *The Electrical World*, vice-chairman, and Dr. William H. Tolman, director.

Street and Electric Railway Power Plants

In a preliminary report on street and electric railways in the United States, exclusive of Alaska, Hawaii, Philippine islands and Porto Rico, the Department of Commerce and Labor shows that for the year ending December 31, 1907, there were 827 power houses, 2,384,518 horsepower of steam and gas engines, including turbines, or 2552 units in all, and 228 water wheels, aggregating 91,961 horsepower, employed in the street-railway business. These figures represent 2.7, 83.4, 8.5 and 42.5 per cent. of increase, respectively, over the year ending June 30, 1902.

GROUP OF OFFICERS AT NATIONAL MARINE ENGINEERS' BENEFICIAL ASSOCIATION CONVENTION AT WASHINGTON, D. C., JANUARY, 1909

DELEGATES AT NATIONAL MARINE ENGINEERS' BENEFICIAL ASSOCIATION CONVENTION AT WASHINGTON, D. C., JANUARY, 1909

NEW YORK DELEGATION TO NATIONAL MARINE ENGINEERS' BENEFICIAL ASSOCIATION CONVENTION AT WASHINGTON, D. C., JANUARY, 1909

Bulletin No. 26, "High Steam Pressures in Locomotive Service," has just been issued by the University of Illinois Engineering Experiment Station. It summarizes the results of one hundred locomotive tests conducted by Dr. W. F. M. Goss under the patronage of the Carnegie Institution in coöperation with the authorities of Purdue University. The general question is discussed as to whether a possible increase in the weight of a boiler should be utilized by making the boiler stronger that it may carry a heavier pressure, or by making it bigger that it may have more heating surface. The conclusion is to the effect that single-expansion locomotives using saturated steam are most efficient when operated under a boiler pressure of 180 pounds; that when this limit of pressure has been reached, any farther increase in weight which may be possible should be utilized in securing increased boiler capacity rather than higher boiler pressures. Copies of this bulletin may be obtained gratis upon application to the director of the Engineering Experiment Station, Urbana, Ill.

The American Anti-Accident Association, with headquarters at Sharpsville, Penn., will hold open meetings, afternoon and evening of Thursday, February 11, in the Y. M. C. A. hall, 215 West Twenty-third street, New York City, for the delivery of addresses and considering of ways and means to prevent accidents. In order that all classes may have a hearing the society extends a general invitation to Government and municipal officials, professional men and women, commercial travelers, manufacturers, managers and superintendents, merchants, labor leaders, mechanics, etc., factory inspectors, fire and life insurance officers, teachers and all other citizens who may be interested in this work, to attend both sessions of these public meetings.

NATIONAL MARINE ENGINEERS SUPPLYMEN'S ASSOCIATION AT THE CONVENTION AT WASHINGTON, D. C., JANUARY, 1909

Inquiries

Questions are not answered unless they are of general interest and are accompanied by the name and address of the inquirer

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Using a Motor as a Dynamo

Can I use a 500-volt direct-current motor as a 110-volt dynamo? If so, what changes are necessary?

R. M.

No; not without completely rewinding the field magnet and armature. You can use the machine as a 500-volt dynamo by discarding the starting box, putting a rheostat in the field-winding circuit and driving the armature at a speed about 10 per cent. higher than that at which it runs as a motor.

Reversing a Compound-wound Dynamo

What changes are necessary in order to permit driving a compound-wound direct-current dynamo in the reverse direction of rotation?

G. W. McF.

Transpose the cables leading from the brush holders to the terminal block, making the change at the brush-holder ends in order to avoid accidental disturbance of some other connection. Then reverse the brush holders so that they extend from the studs in the opposite direction from the original one. That is, if they now "trail" with respect to the travel of the commutator, they should be turned around so that they will "trail" when the rotation is reversed. Carefully avoid making any changes in the connections of the field-magnet windings.

Power Value of Different Gases

What is the effect of the kind of gas used in an engine upon the power of the engine? That is, will rich gas give more power than poor gas?

J. T. M.

The maximum ability of an engine of given piston displacement is somewhat higher with rich gas than with poor, but not in proportion to the heat value. It is the heat value of the mixture that really determines the performance, and rich gases require so much more air than poor gases that the mixture is not as much richer as you would think. A good mixture of natural gas and air has only about 50 per cent. more heat value than a good mixture of producer gas and air, although natural gas has about seven or eight times the heat value of producer gas.

Ratio of Expansion

Will you please tell me what is ratio of expansion and how is it found?

M. H.

Ratio of expansion is the proportion the total volume of the steam in the cylinder at the end of the stroke bears to the volume at cutoff. To find the ratio of expansion divide the stroke in inches by the number of inches of the stroke completed when cutoff takes place. To be exact in calculating the ratio of expansion the clearance must be known and taken into consideration. If, for instance, the effect of the clearance is such that it adds 1 inch in length to the volume of the cylinder at each end, then this must be added to the stroke of the piston and to the distance the piston moves before cutoff. Suppose the stroke of the engine to be 30 inches and the cutoff to take place after the piston has traveled 6 inches; nominally the cutoff would be at 1/5 stroke and the ratio of expansion would be 5, but actually the cutoff would be 7/31 of the stroke and the ratio of expansion would be 4.428.

Effect on Cutoff, etc., of Shifting the Eccentric Center

What is the effect, on the cutoff, compression and lead, of shifting the eccentric center toward the shaft center when the point of suspension of the eccentric is located on the center line of the crank and the shaft on the same side of the shaft as the crank pin?

M. C. B.

Lead being understood as the distance which the valve has opened when the crank reaches the dead center, it would be affected by shifting the eccentric center toward the shaft center as follows: First, with the eccentric pin preceding the crank in the direction of rotation, the lead would be increased if the movement of the eccentric rod was reversed through a rocker arm, as is the case with some engines, and had an inside steam valve, that is, a valve which admits steam by the inner edge. Second, under the same conditions the lead would also be increased if the motion of the eccentric rod was transmitted direct to the valve through the ordinary carrier arm, and an outside valve was used, that is, one taking steam by the outer edge like an ordinary slide valve. Third, if the eccentric followed the crank in the direction of rotation, the lead would be decreased if the motion of the eccentric rod was reversed through a rocker arm and an outside steam valve was used. Fourth, with the eccentric following the crank the lead would be again decreased if the eccentric motion was transmitted direct through a carrier arm and an inside steam valve was used. The cutoff and compression would take place earlier under each and all of the above arrangements.

Amount of Injection Water Required to Condense Steam

Will you give me a rule or formula that will enable me to determine the amount of injection water needed to condense the steam from an engine?

T. W. L.

The quantity of water necessary to condense the steam from an engine depends upon the volume and total heat of the steam and the temperature of the condensing water. Let

H = Total heat in 1 pound of steam at terminal pressure.

h = Heat in a pound of water at the temperature of the condensed steam.

t = Temperature of condensing water entering the condenser,

T = Temperature of water leaving the condenser.

Then, the amount of water needed would be determined by the equation

$$\text{Quantity of water} = \frac{H - h}{T - t},$$

because the number of heat units absorbed by each pound of water will be represented by $T - t$ and the number of heat units taken out of each pound of steam will be represented by $H - h$.

From the formula the rule is deduced:

RULE—*From the total heat of 1 pound of steam at the given pressure, subtract the heat in 1 pound of water at the temperature it leaves the condenser. Divide this remainder by the rise in the temperature of the condensing water. The quotient will be the pounds of water needed to condense 1 pound of steam. That multiplied by the number of pounds of steam used by the engine will give the total condensing water required.*

In a general way, it may be stated that with condensing water at or near 70 degrees temperature and with a 26-inch vacuum, from twenty to thirty times the weight of water fed to the boilers will be required to condense the steam.

Changing Generator Frequency

I have an old-style Thomson-Houston 1100-volt 125-cycle generator and I should like to know if this or any other 125-cycle generator may be changed to 60-cycle by reducing the speed one-half. I take it that the capacity would also be reduced one-half, but by keeping the voltage of the former amount would not the machine do as good work at a lower frequency but with the same voltage? Of course, there are other things to be considered.

D. A. S.

The frequency can be changed to 60 cycles by reducing the speed to 48 per cent. of the rated speed. This, however, will reduce the voltage to 48 per cent. of the normal, or 528 volts. In order to avoid this the armature would need to be rewound with wire coils containing 2.08 times the present number of turns of wire. This wire would be less than half the size of the present wire and the full-load current would be correspondingly reduced.

La Technique Moderne is the name of a new monthly journal of applied science and published by Messrs. Dunod & Pinat, at Paris. Editorial direction is under M. Boutroux, inspector of technical instruction in the Ministry of Commerce and Industry. The committee of advice comprises some well known professional and university specialists, and the first number, that of December, 1908, presents a promising and creditable appearance.

Business Items

George T. Ladd has established offices at 1620 Farmers' Bank building, Pittsburg, Penn., as representative of the Bass Foundry and Machine Company, of Fort Wayne, Ind.

The York Manufacturing Company, York, Penn., manufacturer of ice-making and refrigerating machinery, has received 26 recent orders aggregating 992 tons of refrigeration. One of these plants is for Yokahoma, Japan, Japan, and one for Smyrna, Turkey.

J. G. Aldrich, who was formerly with the Power and Mining Machinery Company, of Cudahy, Wis., has accepted the position of chief engineer of the Industrial Gas Power Company, of Milwaukee. Mr. Aldrich will continue to make a specialty of gas-engine and producer work, in which branch of endeavor he has been active for the past eight years.

The Larson Lumber Company, of Bellingham, Wash., has ordered from the Minneapolis Steel and Machinery Company, a 22x42 Twin-City Corliss engine. This engine will develop about 500-horsepower. It will have a flywheel 14 feet in diameter, grooved for twenty-four 1½-inch ropes. The machinery for the main drive has also been ordered from the same company.

The Rockwell Furnace Company has been awarded the contract covering the complete furnace equipment for the new locomotive shops of the Delaware, Lackawana & Western Railroad at Scranton, Penn. The furnace equipment consists of 35 of the latest-type furnaces operated with 300-B.t.u. water gas, which is made in Loomis-Pettibone producers. These shops will be capable of turning out complete locomotives, and are to be in operation in three months.

In order to take care of the increased business the L. J. Wing Manufacturing Company has increased its capital from $25,000 to $100,000 and has secured offices at its present address, the West street building, 90 West street, New York, twice the size of those at present occupied by them, and into which they expect to be removed by the 15th of February. While the ventilating business of the company has greatly increased, the principal increase is in the sales of the Wing "Typhoon" turbine blower made by this company.

The Buckeye Boiler Skimmer Company, South End, Toledo, Ohio, maker of the Buckeye boiler skimmer, has received a letter from the Harris Toy Company, Toledo, Ohio, in which they say: "We have had in use for about a year one of your boiler skimmers, attached to our McNull water-tube boiler, and have found it a very profitable investment. Before putting on this device, we were obliged to clean out our water tubes every two or three weeks in order to keep up a satisfactory amount of steam. After installing your Buckeye boiler skimmer, we found it only necessary to clean our boiler once in three months and in opening up the tubes we find but very little mud and scale."

An attractive brochure is printed by the Keystone Lubricating Company, Philadelphia, bearing the title, "Grease versus Oil," and containing instructive comparisons of the efficiency of the two great types of lubricant that are used to grease the wheels of industry. Some of the inner reasons for the extensive use of the liquid lubricant, oil, at the present day, to do the work that should properly be done by grease, are interestingly explained. A feature of the argument for Keystone grease as an ideal lubricant, at minimum first cost and operating cost, is an account of exhaustive tests made by the head chemist of William Cramp & Sons, the Philadelphia ship-builders, on the chemical constitution and mechanical and anti-friction qualities of the product. This booklet, of which many thousands have been printed and distributed, may be obtained gratis on application to the home office of the company, Philadelphia, or to any of its agencies.

New Equipment

The Rogersville (Tenn.) Ice Company has been incorporated. Capital, $10,000.

The Empire Electric Power and Supply Company, Carthage, Mo., will enlarge plant.

The Spreckles Sugar Refining Company, Philadelphia, Penn., will erect a power house.

The question of a municipal electric light plant at Union, Ore., is under consideration.

The Concully (Wash.) Copper Mining Company is planning to install an electric plant.

The Holton Power Company is erecting a new power plant near the present one in Holtville, Cal.

The Alton (Ill.) Water Company is said to have decided to expend about $70,000 in improvements.

The City Council, Dodgeville, Wis., has under consideration the question of installing a municipal electric-light plant.

The Valley Power Company, Cashmere, Wash., proposes to increase its output. It is said about $125,000 will be expended.

Fred. C. Schaub, Cody, Wyo., has been granted a franchise to construct an electric-light and power plant in Meeteese, Wyo.

The Oelwein (Iowa) Light, Heat and Power Company is planning improvements to plant which will cost about $25,000.

C. D. McCarthy has been granted franchise by the City Council, Stevensville, Mont., to construct an electric-light plant.

The city of Bellevue, Iowa, proposes to rebuild the municipal electric light plant at a cost of about $7000 W. J. Fay, city clerk.

The Marengo Electric Light and Power Company, Marengo, Iowa, is in the market for a fire tube boiler 125 to 140 pounds pressure.

The citizens of Samson, Ala., voted to issue $25,000 bonds for construction of electric-light plant and water-works. W. J. Gresham, mayor.

The municipal electric-light plant at Oconomowoc, Wis., is to be enlarged, for which purpose an appropriation of $11,000 has been made.

The Crystal Coal & Coke Company, Godfrey, W. Va., is in the market for a second-hand power plant. About 400 k.w. in two units will be needed.

The Washington Power Company, Spokane, Wash., will soon begin the construction of a new $750,000 power plant at Little Falls on the Spokane River.

It is reported that the Laclede Gas Light Company, St. Louis, Mo., contemplates making extensive improvements at an expenditure of about $10,000,000.

The City Council, Plano, Tex., is making arrangements to establish a municipal electric-light plant. J. C. Skinner can give further information.

The Asheville (N. C.) Electric Company has under consideration plans for improvements and extensions including construction of new power plant.

The Yukon (Okla.) Mill and Grain Company will receive bids until Feburary 15 for water-tube boilers, pumps, Corliss engine, etc., as per specifications.

The Citizens' Electric Light and Power Company, East St. Louis, Ill., has been granted a franchise to construct and operate an electric-light plant.

The North Yakima & East Selah Irrigation Company, North Yakima, Wash., contemplates the installation of a pumping plant of about 3000 horsepower.

R. B. Flesch & Co., is said to have been granted a franchise by the town council of Fowler, Kan., for an electric-light plant, water works and ice plant.

New Catalogs

The Deming Company, Salem, Ohio. Catalog. Spray pumps and appliances. Illustrated, 32 pages, 5x8½ inches.

The Burt Mfg. Company, Akron, Ohio. Catalog. Oil filters, exhaust heads, ventilators. Illustrated, 96 pages, 6x9 inches.

National Meter Company, 84 Chambers street, New York. Catalog. Nash gas engines. Illustrated, 36 pages, 6x9 inches.

Leavitt Machine Company, Orange, Mass. Catalog No. 15. Dexter valve reseating machine. Illustrated, 22 pages, 7x8½ inches.

Industrial Instrument Company, Foxboro, Mass. Bulletin No. 11. Self-winding clock systems. Illustrated, 40 pages, 8x11 inches.

National Steam Pump Company, Upper Sandusky, Ohio. Catalog No. 29. Pumping machinery and air compressors. Illustrated.

The Casey-Hedges Company, Chattanooga, Tenn. Catalog. Water-tube marine and standard boilers. Illustrated, 80 pages, 7x10 inches.

H. W. Johns-Manville Company, 100 William street, New York. Catalog No. 100. Pipe and boiler insulation. Illustrated, 70 pages, 4½x7 inches.

Westinghouse Electric and Manufacturing Company, Pittsburg, Penn. Circular No. 1157. Type S distributing transformers. Illustrated, 16 pages, 7x10 inches.

The Bristol Company, Waterbury, Conn. Bulletin No. 100. Combination indicating and recording unit of Bristol electric pyrometers. Illustrated, 8 pages, 8x10½ inches.

The Yale & Towne Manufacturing Company, 9 Murray street, New York. Catalog. Chain blocks, electric hoists, trolleys and cranes. Illustrated, 70 pages, 6x9 inches.

Oil Well Supply Company, Boiler Works Department, Oswego, N. Y. Catalog. Water tube boilers. Illustrated, 30 pages, 6x9 inches. Circular. Horizontal tubular boilers. Illustrated, 12 pages, 8x11 inches. Circular. Locomotive type portable boilers. Illustrated, 8 pages, 8x11 inches.

A New Lighting Station for Brockton

A Modern Alternating-current Turbine Plant Supplying 2200-volt A. C. Service and Direct-current Lighting through Rotary Converters

BY E. T. REED

To take care of increasing business and obtain a location where coal and water supply would be more convenient, the Edison Electric Illuminating Company, of Brockton, built a new power station in East Bridgewater to supplement an old plant in the heart of the city of Brockton. It was necessary in the old plant to run engines noncondensing. Coal and ashes had to be carted and city water used in the boilers. In the new plant the Matfield river supplies water for condensing and boiler feed, and coal is landed in the yard from a spur track from the New York, New Haven & Hartford Railroad.

The new plant was put in operation about a year ago. The building is of brick and concrete construction. The stack is self-supporting and made of steel

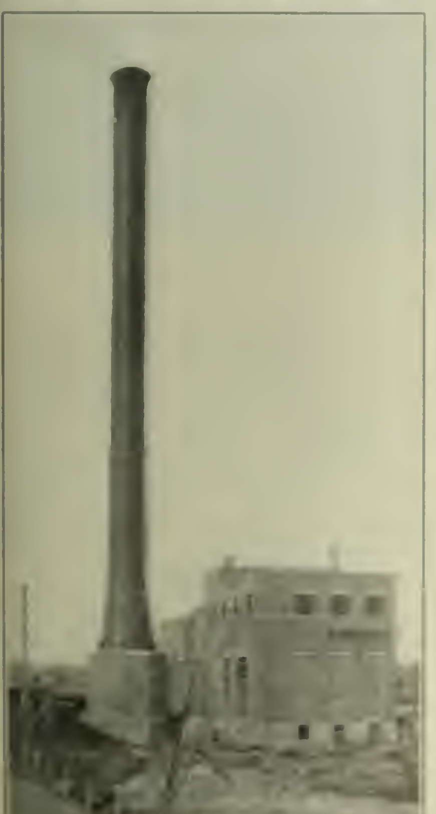


FIG. 1. POWER STATION AT EAST BRIDGEWATER

plate lined with brick. It is [illegible] feet in diameter and 235 feet high. The turbines and boilers are set in parallel rows, allowing for extensions in the future.

BOILER-ROOM EQUIPMENT

At present the boiler room is equipped with three 525-horsepower Stirling boilers with Babcock & Wilcox [illegible] superheaters furnishing steam at 200 pounds pressure and 150 degrees superheat. Provision is made for two rows of boilers with a firing aisle between, and coal is [illegible]

[illegible]

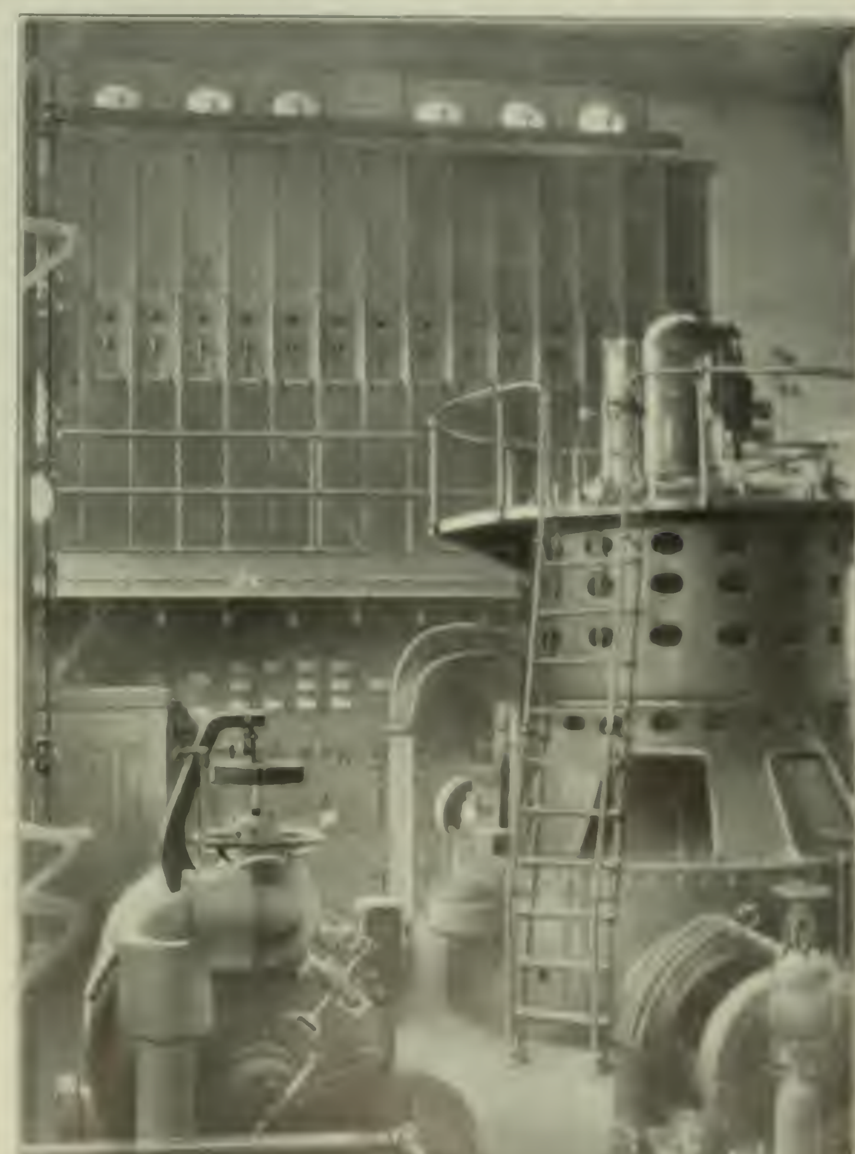


FIG. 2. [illegible]

[illegible]

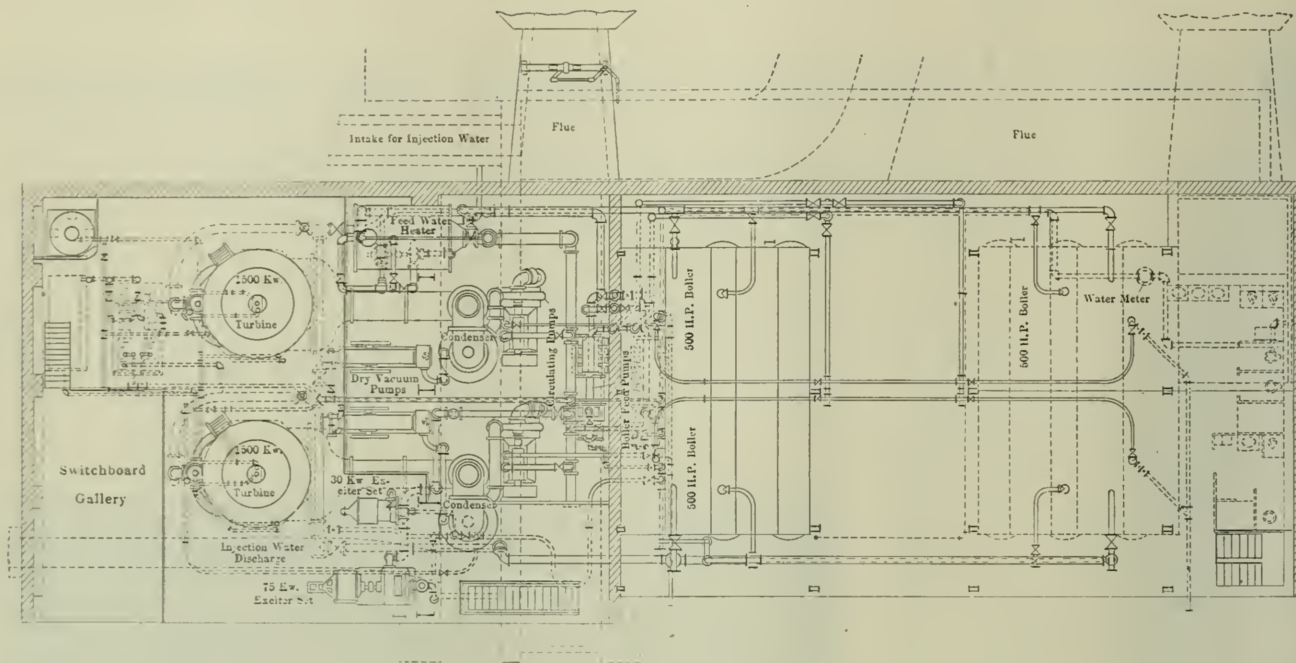


FIG. 3. PLAN OF POWER PLANT AT EAST BRIDGEWATER

8-inch branch, while the third boiler is connected to a 10-inch branch which is intended to care for four boilers. The superheated-steam main is 10 inches in diameter and is situated underneath the turbine-room floor. The saturated-steam main is also in the basement, and it is connected in the same way to the drums of the boilers. There is a connection between the superheated- and saturated-steam mains whereby superheated steam can be used on auxiliaries if necessary. The exciter turbines use superheated steam, but can be run on saturated steam if desired. All superheated-steam piping is of cast steel with welded flanges and is covered 3 inches thick with H. W. Johns-Manville 85 per cent. magnesia.

Two Blake duplex compound outside-packed plunger pumps, with cylinders 9x14x8x12-inch, take water from a Cochrane open feed-water heater and supply the boilers through two 5-inch brass mains, two 1½-inch branches extending to each boiler. The feed pumps can draw water from either the cold or hot wells in case the heater is cut out, and are equipped with regulators which keep the pressure on the feed mains the same at all times.

All auxiliaries exhaust through a 12-inch main to the heater which raises the temperature of the water to 210 degrees Fahrenheit. The feed-control valves on the boilers have valve stems extending to within easy reach of the floor, and there

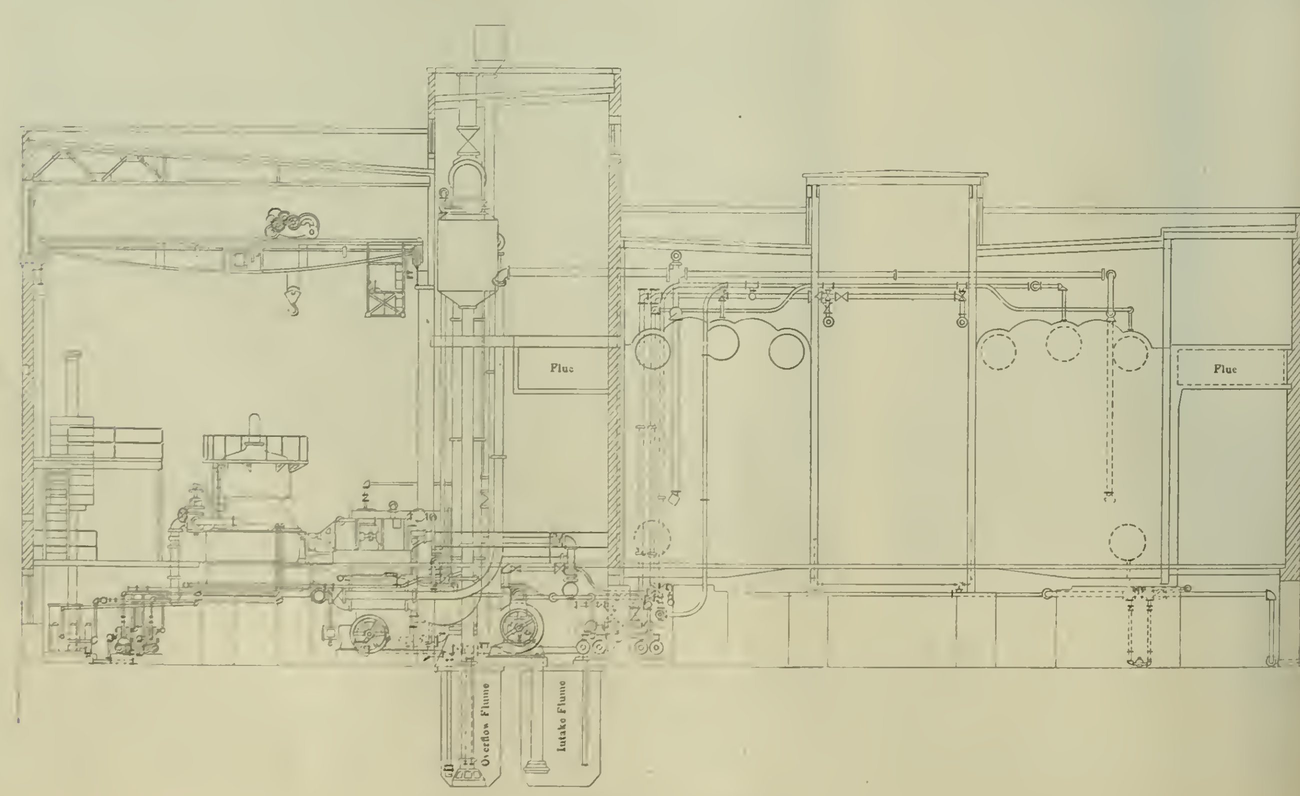


FIG. 4. SECTIONAL ELEVATION THROUGH PLANT

FIG. 5. SWITCHBOARD IN POWER STATION

is a stop valve and check between the regulating valve and the boiler.

A 5¼x4¾x5-inch duplex Blake service pump and tank furnish water from the cold well for all purposes about the plant, except the wash basins and shower baths in the toilet room. A 4-inch city water main is connected to all water connections and is used in cases of emergency. The hot and cold wells run parallel with the turbines and are under the basement floor, the condenser auxiliaries being grouped about them. A 4-horsepower three-phase motor, direct connected to a Worthington volute pump, elevates the water from the hot well to the feed-water heater, a low-water alarm giving notice when the water supply to the heater fails.

Thermometers are installed in the superheated and saturated steam pipes, turbine exhaust, boiler flue, supply and discharge pipes of the condensers and in the feed water at the pumps and at the boilers. Readings are taken every two hours. A Venturi meter measures the amount of water fed to the boilers, and by means of a weir at the end of the discharge pipe from the condensers, the amount of water escaping can also be measured. Ellison gages show the draft pressure at the boilers. A Bristol recording steam gage is connected to the steam main and a recording thermometer of the same make keeps a record of the steam temperatures at the turbines. A Stewart City boundary is now being installed. All high-pressure drips are returned to the boilers by a Holly steam loop.

THE TURBINES

There are two turbines installed and these are General Electric 1500-kilowatt four-stage condensing units running at 900 revolutions per minute. They are equipped with mechanical valve gear, and each unit exhausts through a 48-inch exhaust pipe and atmospheric to a Hender barometric condenser. Each condenser is supplied with circulating water by a 14-inch centrifugal pump driven by an 8x15x9-inch Westinghouse compound engine. The noncondensable gases are removed from the condensers by Hender 9x20x12-inch single stage dry vacuum pumps. The circulating pumps are controlled by a regulator in the steam pipe, which increases the speed of the pumps if the vacuum falls. At the river the intake is protected with a 2-inch screen and at the entrance with a 1-inch and ½-inch screens. All auxiliary pumps and engines are equipped with Richardson sight-feed oil pumps.

Oil is used in the step bearings of the turbines, and a Turner oil filter and two 6x2¼x10-inch Worthington outside-packed plunger pumps are installed in the basement to furnish an oil pressure of 800 pounds, which is reduced through baffles to 400 pounds at the bearings. An accumulator with a 10-inch plunger and 14-foot drop is connected with the oil-piping system, and will maintain the pressure on one turbine for ten minutes, in case of the failure of the pump. The oil piping is of extra-heavy brass with extra-heavy brass Chapman gate valves and cast-steel fittings. The accumulator is connected through a system of rods and levers to ... valves on the steam supply to the pumps and these keep the accumulator at a fixed height at all times. If the accumulator should start to descend, an

FIG. 6. ROTARY CONVERTERS IN SUBSTATION

electric alarm notifies the operator, and this alarm is tested every day when the pumps are changed.

There are two exciter turbines rated at 75 and 35 kilowatts, respectively, and these run noncondensing, the former at 2400 revolutions per minute and the latter at 3600 revolutions. A 9½x9½x10-inch Westinghouse air pump supplies compressed air for blowing out the electrical machinery, and to handle the large apparatus it contains, the station is equipped with a 20-ton Whitney electric crane.

communicate with the two generators through disconnecting switches and with three feeder oil switches which are mechanically controlled from the board. Each pole of the oil switches is in a separate compartment, and all potential and current transformers are also separated.

The switchboard consists of ten slate panels. One Tirrell regulator, two exciter, three feeder, one station and one local panel. Two of the feeder panels control two 13,200-volt, three-phase lines

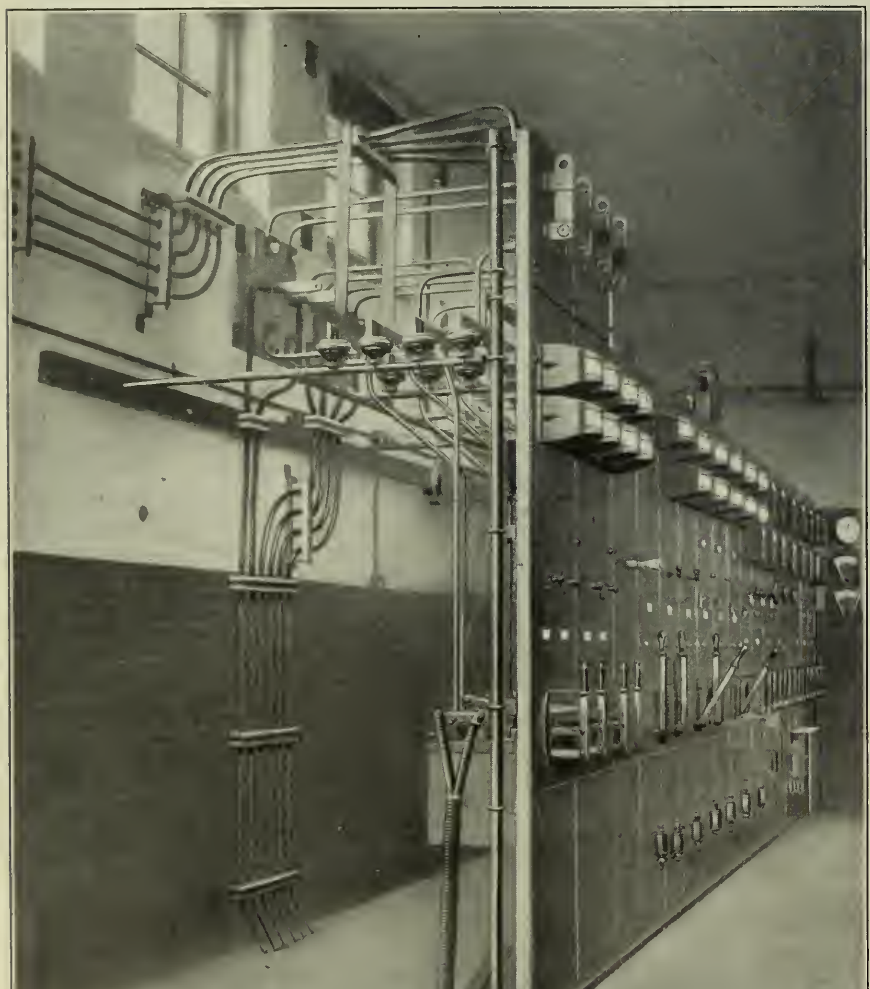


FIG. 7. SUBSTATION SWITCHBOARD

Electrical Equipment

The generators are General Electric, three-phase, revolving-field, 60-cycle, alternating-current machines with star connections and grounded neutral. The voltage is 13,200. The exciters are compound with interpole windings, and the voltage is 125 at all loads. The generator leads are run through brass conduits to the floor and then through fiber conduits to the oil switches installed in a high-tension brick structure over the switchboard. The busbars are 2x¼-inch flat copper, each bar being in a separate compartment. They

to a substation in Brockton, and the third feeder panel supplies current at 13,200 volts to transformers for the station and East Bridgewater.

Two 20-kilowatt 13,200-200-110-volt station transformers are connected to the auxiliary feeder through an oil switch and supply current for lighting the station and also to motors for the pumps and the coal hoist. East Bridgewater is supplied with current at 2200 volts, three-phase, by two 75-kilowatt 13,200-2200 transformers connected through disconnecting switches to the auxiliary feeder, and a 30-kilowatt tub transformer furnishes street lights for East Bridgewater.

On the regulator panel is mounted the Tirrell regulator with switches for use on either exciter, each exciter having two relays. Swung from this panel is a small panel carrying the synchronizer and two kilovolt meters; one is connected to the busbars and the other can be connected to any phase on either machine by means of plugs. The potential transformer for the Tirrell regulator is connected to the busbars without fuses.

Each exciter panel has an ammeter and voltmeter. One voltmeter is connected to the buses, and the other can be used on either machine. Exciter rheostats are mounted on the back of the panels and field rheostats are underneath the floor.

The generator panels have three ammeters, one indicating wattmeter, a power-factor indicator, a field ammeter and on each panel there is a switch for operating the synchronizing motor on the turbine governor. A polyphase-recording wattmeter is mounted on the back of each generator panel.

The feeder panels have one ammeter and can be connected with any phase by a jack switch. The station panel has one voltmeter and one ammeter. The voltage is 114, and the three-wire system is in use. Lighting for the plant is distributed through three panel boxes of eight circuits each. One is placed in the boiler room, one in the turbine room and one in the basement. There is one circuit for arc lamps in the yard and one for flaming-arc lamps on the ceiling. There is a double-throw, three-pole switch on this panel, whereby lighting can be thrown on the exciter in case of failure of the transformers. Another three-pole switch furnishes 220 volts, three-phase, for auxiliary motors.

The 2200-volt panel for East Bridgewater has two circuits; one 2200-volt three-phase, and the other for street lights. All feeders have automatic oil switches with time-limit relays which are tripped with current from the exciter busbars. All switchboard apparatus was furnished by the General Electric Company.

At the end of the switchboard on similar panels are the gages and speed indicators for the turbines. Each machine has a speed indicator, steam gage on the first stage, also vacuum and step pressure gages. A Holman & Maurer mercury vacuum gage is mounted on these panels and can be used on either turbine.

Brockton Substation

This is located in the business center of the city and is connected with the main station at East Bridgewater by two 88-ampere, 13,200-volt transmission lines. The lines are seven miles in length and are made up of No. 2 copper wire carried on Locke insulators. The lines run overhead from the East Bridgewater station to a lightning-arrester house, which is situated about one-half mile from the substation, and from here are brought underground to the basement of the substation and connected to oil switches located in masonry cells remote from the switchboard panels.

At present the substation equipment comprises nine 75-kilowatt, 13,200-volt, 60-cycle, oil-cooled transformers, with one-third and two-thirds voltage starting taps for rotary converters; three 375-kilowatt, 13,200 to 2200-volt, 60-cycle, three-phase, two-phase, oil-cooled transformers, supplying the 2200-volt, two-phase service; three 220-kilowatt, 250-200-volt, direct-current, 60-cycle, six-phase, shunt-wound converters, supplying the three-wire direct-current system; a 44,000-volt testing transformer and a 12-cell Westinghouse storage battery and motor-generator charging set furnishes current to operate the trip coils on the high-tension oil switches. Located in the basement is a 2-horsepower air compressor connected by pipe line to the main floor, where the air is used for cleaning purposes.

The switchboard is constructed of the best quality of Monson slate and consists of the following panels: Two three-phase, high-tension transformer panels, one of which is spare; two three-phase incoming-line panels, three alternating-current rotary-converter panels, three direct-current rotary-converter panels and five direct-current feeder panels. Opposite each converter is located a six-phase starting panel and a Type I, right-hand, 20-kilowatt voltage regulator.

All panels are made with a [illegible] bevel, and the front and edges are treated with a coating of lacquer, giving a smooth dull black marine finish. All instrument cap nuts and handles are finished with a dull black oxide. All high-tension feeder panels are supplied with indicator lamps, red and green. The red lamps burn when conditions are normal, and green when the switch is opened by overload or short circuit, attention being immediately called to the open circuit by the ringing of a gong.

In the basement of the substation are located oil switches for controlling all high-tension lines, and these are mounted in masonry cells below the main switchboard. The entire installation, with the exception of the storage-battery equipment, was furnished by the General Electric Company.

The substation controls the current supply for Brockton, Whitman and Stoughton. Stoughton at present is fed by a 2200-volt line to a transformer house at Montello, a suburb of Brockton, where the voltage is stepped up to 6600, and at Stoughton stepped down to 2200 volts for distribution. In the near future Stoughton will be fed by a 13,200-volt high-tension line now under construction.

The Electric Light & Power Company of Abington and Rockland, which lights Rockland, Abington and Hanover, is soon to be supplied from the East Bridgewater station, the high-tension line and transforming apparatus now being installed. The Stoughton, Abington and Rockland lines will tap the main feeders in a new [illegible] house. They will be connected to the feeders by oil switches controlled from the substation. The maximum load is now about [illegible] kilowatts but will soon be considerably increased.

Adjoining the substation is the old plant, which is held in readiness in case of emergency. Part of the feeder panels in the old station are still in use, supplied from feeders in the substation. In the old station is also located the street-lighting service, comprising a nine-panel, two-phase plug board and nine tub transformers.

Petroleum Industry of the United States

As apparent in the accompanying table, the production of crude petroleum in the United States during 1908 showed a large increase over that of 1907.

PRODUCTION OF CRUDE PETROLEUM IN THE UNITED STATES

(In Barrels of 42 Gal.)

Field	1907	1908
California	[illegible]	[illegible]
Colorado	[illegible]	(a) [illegible]
Gulf { Texas	[illegible]	[illegible]
Gulf { Louisiana	[illegible]	[illegible]
Illinois	[illegible]	[illegible]
Lima { Indiana } { Ohio }	[illegible]	[illegible]
Mid-continental (b)	[illegible]	[illegible]
Kentucky-Tennessee	[illegible]	(a) [illegible]
Appalachian (c)	[illegible]	[illegible]
Wyoming	[illegible]	(a) [illegible]
Others	[illegible]	(a) [illegible]
Total	[illegible]	[illegible]

(a) Estimated to be same as in 1907.
(b) Kansas and Oklahoma.
(c) Pennsylvania, New York, West Virginia and eastern Ohio.

California is now producing about [illegible] barrels of oil per year, that being the estimated output for 1908. In 1907 the yield was [illegible] barrels, valued at [illegible], or about [illegible] cents per barrel. In 1906 the average price was [illegible] cents per barrel. In 1908 the average price at the wells to the producers was about [illegible] cents per barrel and at the end of the year it was perhaps higher than [illegible] cents per barrel. All the old contracts have been worked up and the new ones being made vary from [illegible] cents per barrel. [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Gate Valves in Steam-Pipe Lines

Practical Suggestions for Locating and Using Them in These Days of Saturated Steam at High Pressure and Superheated Steam

BY W. H. WAKEMAN

The use of saturated steam at high pressure, and superheated steam at any pressure, has rendered obsolete some of the globe valves that formerly did good service in our main steam lines, therefore others must be substituted. However, the fact that certain hard-rubber, or composition, disks are quickly destroyed by steam at high temperature does not necessarily condemn all kinds of globe valve, even for severe conditions, while for ordinary plants the composition disk is as good now as it was twenty years ago. In view of these facts the use of gate valves in steam-pipe lines is uncalled for, and furthermore it is not an intelligent application of knowledge along this line, because a gate valve is always more difficult to operate and more expensive to repair than a globe valve. There are gate valves that contain composition disks, so may easily be replaced when worn out, making the valve as good as new, provided the seat is not injured; but if the seat requires repairs it is a hard and expensive job to scrape the surface until it becomes perfectly true.

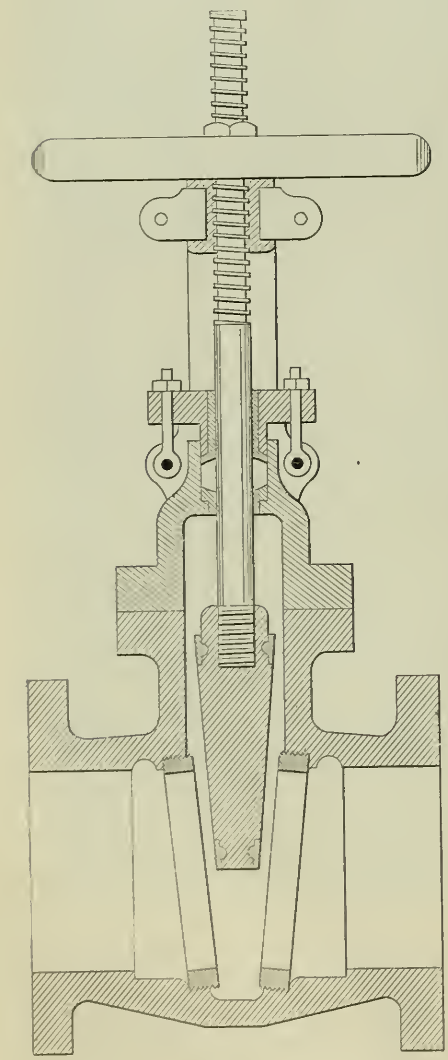


FIG. 1

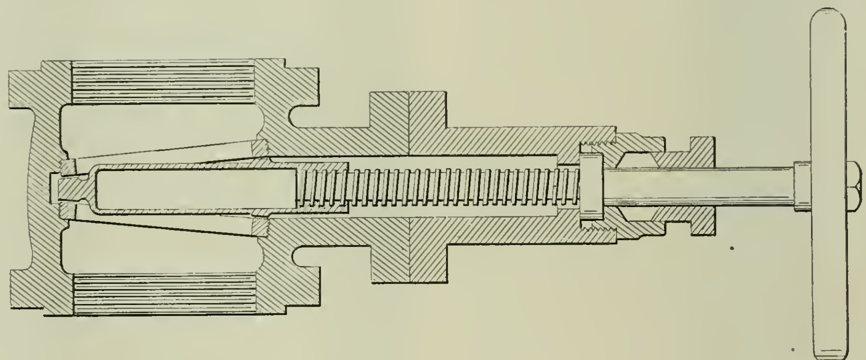


FIG. 2

There is more than one way to locate and use a gate valve, and as they are not all made alike, suggestions along this line should prove valuable.

If a valve of this kind is located with the stem in a vertical position, as shown in Fig. 1, friction is reduced to a minimum, because the heavy gate is suspended on the stem, the surfaces in contact being small in consequence. The only objection to this arrangement, as far as the valve itself is concerned, is that a pocket which is formed at the bottom between the two inclined seats is located just right to catch sediment and scale, and thus prevent the gate from going down to its proper place, but fortunately there is little danger of an excessive amount of sediment collecting in a steam-pipe line.

This valve is fitted with what is technically known as a rising stem, because the wheel stays in the same place (except that it revolves) when the valve is operated, while the stem travels with the gate. This point must be taken into consideration when locating a large valve in close quarters. A left-hand thread must be cut on the stem in order to cause the wheel to operate in the correct way, which is to turn with the hands of a watch to close the valve, and in the opposite direction to open it.

Fig. 2 is fitted with a nonrising stem, consequently the space occupied by the valve is a fixed quantity at all times. This must also be a left-hand thread. It is concealed in the bonnet and the gate, and cannot be lubricated properly, which causes it to wear much more rapidly than if it were exposed and well oiled. The collar shown on the stem soon wears enough to give objectionable lost motion, as it cannot be oiled.

A valve of this kind is located in an 8-inch horizontal branch steam line in my plant, and the stem is in a horizontal position. The consequence is that when this valve is opened and closed, the gate must slide on its edge, traveling on a rough guide, and the resulting friction causes grunts and groans that are very disagreeable because they denote inferior design and imperfect workmanship, although the name of one of the best known construction companies in New England is cast on the bonnet.

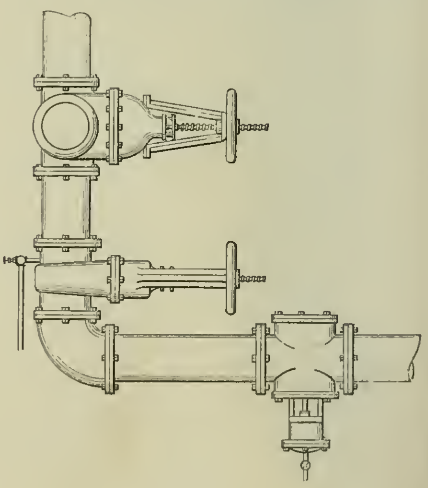


FIG. 3

This branch line was designed to supply steam for two engines, only one of which is in use at present during a part of the time; and after that engine is shut down it seems proper to close the gate valve mentioned, as it is located near the header, which extends across five boilers, and much heat would otherwise be lost. The ordinary plan for doing this is to close the throttle valve and, after the engine has stopped, to shut the gate valve, then allow steam in the pipe to condense, as a good trap removes all water resulting from the cooling process. If this plan is followed here the gate valve leaks badly and heat is wasted the same as if it was left open. This is due to the fact that when the gate chatters over the rough guide mentioned it is in equilibrium; consequently it is not held against the seat. The threaded stem is a very loose fit in the gate; therefore, when the latter is forced as far as it will go, it does not rest squarely on the seat, and it leaks.

This action is proved by the following result. If the gate valve is closed while the engine is running full speed, the gate is not in equilibrium, as pressure is reduced on the engine side; therefore, the gate is pressed firmly against the seat and when the valve is closed it is perfectly tight. After the engine has stopped the throttle valve is closed.

The upper valve in Fig. 3 (which represents a section of piping in our engine room) is represented as being located in a horizontal line coming directly toward the reader. It is fitted with a rising stem, or outside thread and yoke. The valve below it is quite differently located, for although its stem is in a horizontal position, the body is in a vertical pipe. In this case the gate always rests on the seat, giving smooth action in opening and closing, and a tight valve when shut. Both sides of the gate are intended to be steam-tight.

One advantage of a gate valve in this service is that if the wheel is turned with ordinary speed, which is always slow in good practice when the valve is to be opened, the opening for the admission of steam will be very small at first and will increase slowly, thus giving time for pressure to rise gradually, and avoiding the shocks and jars caused by turning too much steam into a comparatively cool pipe. It is difficult, but not impossible to secure the same result with a globe valve, because a similar movement of the wheel gives so much greater opening for the passage of steam. This type of valve has several advantages, but this is not one of them.

It follows as a natural consequence that it takes a comparatively long time to open a gate valve, which is an annoying feature when haste is necessary. I have noticed, however, that some engineers lose more time than is necessary under conditions shown in Fig. 3. The small valve connected above the gate is first opened to draw off the water of condensation, then the larger one is slowly opened, admitting steam to the reducing valve in the horizontal pipe below it. Soon a light pressure accumulates and brings the reducing valve into action. As soon as this is evident, the large valve may be opened quickly. It is not necessary to continue the slow process until the long stem is run out to its full length.

Globe Valve Substituted for a Gate Valve

Fig. 5 illustrates a section of piping where a globe valve was substituted for a gate valve to my great satisfaction. Formerly it was necessary to exert a considerable force to start the gate (as there was no bypass provided), then it required nearly two revolutions of the wheel to open the valve slightly, and when the reducing valve began to operate the gate moved easily because the pressure was balanced, but it took about six revolutions more to secure a full opening. With the globe valve in use, the instant that the wheel is moved, steam begins to pass through, and after the reducing valve begins to control the pressure in the system, requiring but a few seconds for the operation, about two revolutions of the wheel opens the valve to its full capacity. When steam is to be shut off there is practically no friction to be overcome because the disk is in equilibrium until it rests on the seat. The contrast between this and operating the gate valve which was used in this place for twelve years is very great.

Fig. 7 illustrates a connection between one of six boilers and the header which receives steam from all of them. A gate valve is used here with its stem in a horizontal position. When this boiler is to be "cut out" the valve is shut in the usual way, but the disk is always balanced, or in equilibrium and this condition is never changed, because pressure cannot be reduced on one side of it. The result is that when the boiler is cooled off and the main stop valve loosened, steam may leak in [illegible] according to the position [illegible] the gate was [illegible]

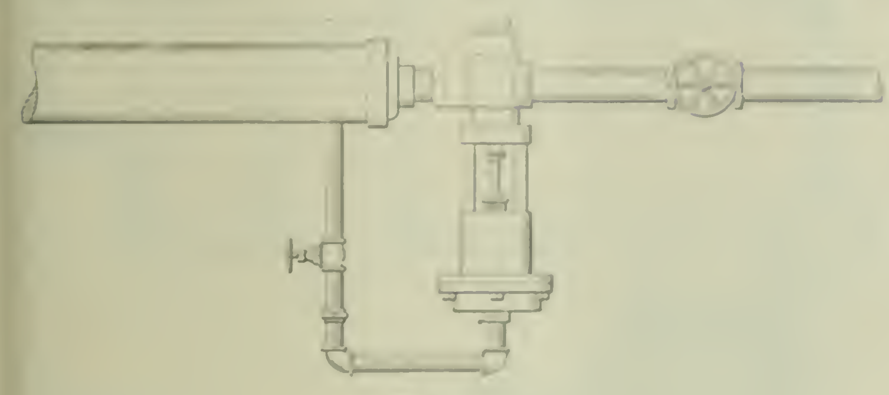


FIG. 4

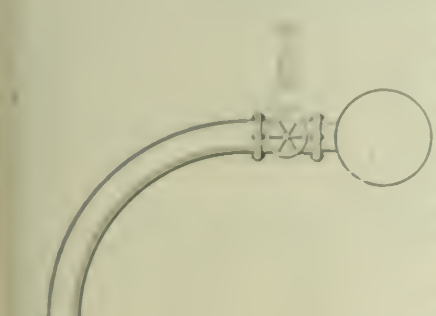


FIG. 5

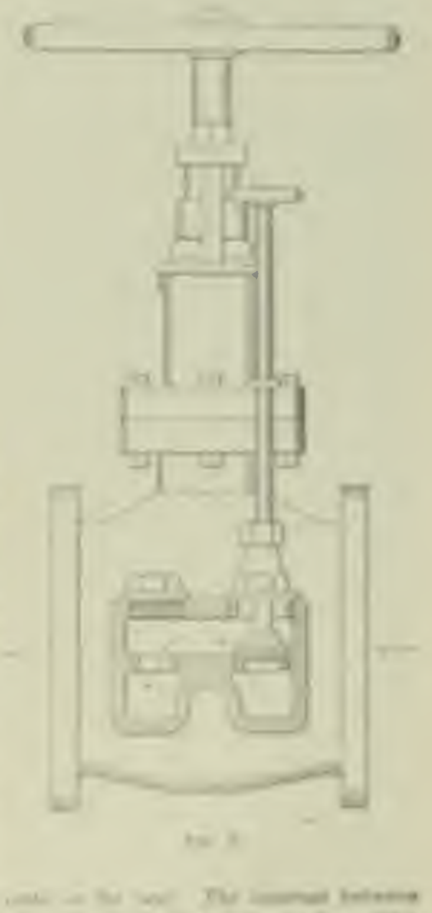


FIG. 6

limit of its travel. If it was practicable to lower the pressure on one side of it, the result would be more satisfactory, as explained in connection with Fig. 2. If the stem of this valve was located in a vertical position, as represented by the dotted lines, it would undoubtedly give better results. However, there is not head room enough for this purpose, especially for a rising stem. A globe valve with a pin, projecting from the lower side of the disk, that travels in a guide provided for this purpose would be much better.

Fig. 6 is a gate valve fitted with a bypass, the operation of which is apparently not as well understood by firemen and engine runners as it ought to be. Steam enters as indicated by the arrow and, acting on one side of the closed gate, presses it to its seat with great force; therefore, it is necessary to overcome excessive friction before the valve can be opened, especially with steam at very high pressure. To overcome this objection the bypass is provided. By opening the small globe valve which is cast with the body of the large valve, steam is admitted from the right-hand side of the gate around it to the left-hand side, as shown by the arrows. This fills the space at this point and raises the pressure until the gate is balanced and nearly all friction removed; consequently, the valve can easily be opened, after which the bypass is shut. When a man closes the bypass before he opens the main valve, thus reducing the pressure on the outlet side, it is good evidence that he does not understand the value of a bypass. If this device is wanted in a case where it was not included in the original valve, it can be provided by tapping a small pipe into the main line on each side of the large valve and putting a small valve in it.

As a general rule a gate valve is designed so that it is not convenient to get bolts into the flange on the bonnet, as the space allowed for this purpose is too small, making it necessary to drop some of the nuts down behind the flange and screw the bolts into them. Bolts that are carried in stock by supply houses have heads that are supposed to be artistic in design, but when a wrench is applied to them it is sure to slip off, to the disgust of the workman who wishes to do a good job. To overcome this objection I have found it a good plan to take round norway iron and cut it into suitable lengths to go through the flanges and two nuts, then by cutting a thread on each end and tapping nuts to match, it is possible to make studs to be used as bolts that can be applied to good advantage, and a proper wrench will not slip off, especially if square nuts are adopted. There are a few places in a steam plant where square nuts cannot be turned, but they are much fewer than is generally admitted, judging by the large proportion of hexagon nuts used, which soon become almost round if a wrench is applied to them a few times; consequently, they are not screwed down tight enough to prevent packing from blowing out under pressure. This applies to the quality of nuts usually found on the bonnets of gate valves and ordinary flange joints.

The James Watt Memorial Building

By W. H. Booth

Greenock is a small town down the Clyde a few miles below the city of Glasgow. Its occupation is chiefly shipbuilding, and its title to fame historically rests on the fact that James Watt was born there in the year 1736 on the nineteenth day of January. James Watt, by his invention of the air pump and separate condenser, laid the foundation of modern practice in steam engineering. It was the first stage in the compound working of the steam engine and marked the abolition of the practice of doing two operations in one vessel, for in the Newcomen engine the cylinder was alternately a jet condenser and a working steam cylinder. We deplore today the initial condensation which takes place in a cylinder that has been merely momentarily exposed to the condenser pressure and temperature, but what must it have been when the cylinder was drenched with cold water?

FIG. I. JAMES WATT MEMORIAL BUILDING

The story goes that Watt, who was mathematical-instrument maker to the Glasgow university, had intrusted to him a model of a Newcomen engine to repair. Being a man of scientific bent of mind and specially trained in a trade that would cultivate his thinking faculties, he naturally would begin to think about the steam engine. He came of a family of some local standing in Greenock, for his father was a maker of ship blocks and was a member of the local council and a magistrate; his grandfather was a teacher of surveying and navigation, and his uncle was a surveyor and civil engineer at Ayr. The story of his youth about the tea kettle appears to have been invented as a bit of telling biography. If he had really thought so early about the steam engine, he would have done something with it earlier than he did.

Watt was delicate in health and had little scholastic training. At the age of eighteen he was sent to London to learn the trade of instrument maker. There he stayed only a year on account of bad health. Returning to Greenock he set up in business in Glasgow as a mathematical-instrument maker, and the university authorities, perhaps through influence, gave him a helping hand and appointed him instrument maker to the university, with rooms in the building. He did not make very much at his trade and eked out his small income by mending and even making fiddles.

This would bring us to about the year 1756. Watt apparently spent some ten years at the university, and in 1767 was employed to make a survey and estimate for a canal to unite the Clyde with the estuary of the Forth. After this he obtained more civil engineering work and was engaged in work in connection with the deepening of the Clyde and other rivers, with harbor work and canals.

It was in 1759, however, that Watt began to study steam, and for some years he made experiments on that critical and elusive fluid. He would then be about 23 years of age. It was about 1763-4 that the Newcomen model fell into his hands for repair, and in 1769, when 33 years of age, he took out his patent in which he says:

"My method of lessening the consumption of steam, and consequently fuel, in fire engines, consists of the following principles:

"First—That vessel on which the powers of steam are to be employed to work the engine, which is called the cylinder in common fire engines, and which I call the steam vessel, must, during the whole time the engine is at work, be kept as hot as the steam that enters it; first, by inclosing it in a case of wood; secondly, by surrounding it with steam or other heated bodies and, thirdly, by suffering neither water nor any other substance colder than the steam to enter or touch it during that time.

"Secondly—In engines that are to be worked wholly or partially by condensation of steam, the steam is to be condensed in vessels distinct from the steam vessels or cylinders, although occasionally communicating with them; these vessels I call condensers; and while the engines are working, these condensers ought at least to be kept as cold as the air in the neighborhood of the engines, by application of water or other cold bodies.

"Thirdly—Whatever air or other elastic vapor is not condensed by the cold of the condenser, and may impede the working of the engine, is to be drawn out of the steam vessels or condensers by means of pumps, wrought by the engines themselves or otherwise.

"Fourthly—I intend in many cases to employ the expansive force of steam to press on the pistons, or whatever may be used instead of them, in the same manner in which the pressure of the atmosphere is now employed in common fire engines. In cases where cold water cannot be had in plenty, the engines may be wrought by this force of steam only, by discharging the steam into the air after it has done its office.

"Lastly—Instead of using water to render the pistons and other parts of the engines air- and steam-tight, I employ oils, wax, resinous bodies, fat of animals, quicksilver and other metals in their fluid state."

Here is [illegible] art of steam engineering a [illegible] one might say, half forgotten [illegible] to read some of the denial [illegible] well known effect of cylinders [illegible] the steam, or much of [illegible] them, one might almost [illegible] the separate condenser was [illegible]

Dr. Roebuck was the first to extend [illegible] Watt. He was the original [illegible] of the Carron Iron Works, where carronades were first cast, and [illegible] productions of the Carron [illegible] be seen today on the ramparts of Quebec, bearing on their trunnion ends the words Carron and the dates 1905, 1906, 1907.

Presumably Dr. Roebuck tired of the expense or did not appreciate the value of the invention or perhaps he found the cost greater than he could afford, for we next find Watt being liberally helped by Matthew Boulton, a Birmingham man. To Boulton, of Birmingham, the world owes it that Watt's great invention was put into successful operation. Watt's patent was much contested, but Boulton found the necessary fighting funds which enabled Watt to establish the validity of his patents. Watt invented a cutoff in 1769 and described it in a letter to Dr. Small. He used the cutoff in 1776, but did not patent it until 1782, when he patented it and the double-acting engine with the rod parallel motion in place of the link chain and quadrant-ended beam, as seen in the old engines at South Kensington Museum. As someone else had patented the crank, Watt had to invent the sun-and-planet gear to take its place. It is claimed that Watt had invented the application of the crank before 1778, but that some other man had patented it. Practically Watt left the steam engine as it is today. Nothing has yet gone beyond his essential principles.

His native town of Greenock has long wished to have some memorial of Watt, but so far as Scotland is concerned Watt's monument has been like Wren's "Circumspice" for the river Clyde as it now is is the direct result of the great vessels which are built on its banks and driven by Watt engines. The Watt Memorial House is, therefore, about one-tenth general public and nine-tenths Dr. Carnegie, for only about $5000 was generally subscribed until Andrew Carnegie subscribed $50,000 in two installments, and later a subscription, limited to 25 cents, raised a further sum of something between $1500 and $2000 under the care of an engineer, John Rankin, of Greenock. The scheme, as carried out, is by no means as ambitious as originally intended, owing to the small response that the public made. Ultimately it took the form of a small technical institution costing something over $35,000, the remainder of the fund, about $20,000 serving as an endowment and for furnishing, so that not more than $15,000 has been really available by way of endowment.

The memorial building stands at the corner of William and Dalrymple streets, on the site of the house in which Watt was born. It is only two stories high and at the corner about 20 feet from the ground the building is constructed with a reentrant square corner, leaving a square platform at that hight of about 10 feet, on which stands a pedestal surmounted by a statue of Watt, 8 feet 6 inches high and cast in bronze from the modeling of Henry C. Fehr, of London, and a replica of a similar statue already at Leeds. The base of the house is rough-faced granite to a hight of about 7 feet, above which the walls are of dressed stone. Within are two class rooms, attractive, for the teaching of navigation and marine engineering. It is hoped these will be found of service to officers desirous of passing their examinations when in port. The roof is flat, so as to serve as a deck whereon to take solar observations, for even at Greenock the sun is sometimes very much in evidence.

In the engineering class room are drawing benches with lockers and models, some of which have been given to the institution, and there are some 200 volumes in the little library on engineering and navigation. The room is oak-paneled to a hight of 8 feet. A fireplace of Gibsonian stone is in the Scottish baronial style. This room is on the ground floor. On the first floor is the navigation room similarly equipped, oak lined, and with a panel ornamental ceiling. The building was opened on Monday, June 1, 1908, and Watt's statue was unveiled by Dr. Carnegie. The inscription on the marble plate reads:

James Watt

Born 19th January 1736

This Memorial Building is Erected

on the Site of His Birthplace

The street floor, upper on Dalrymple

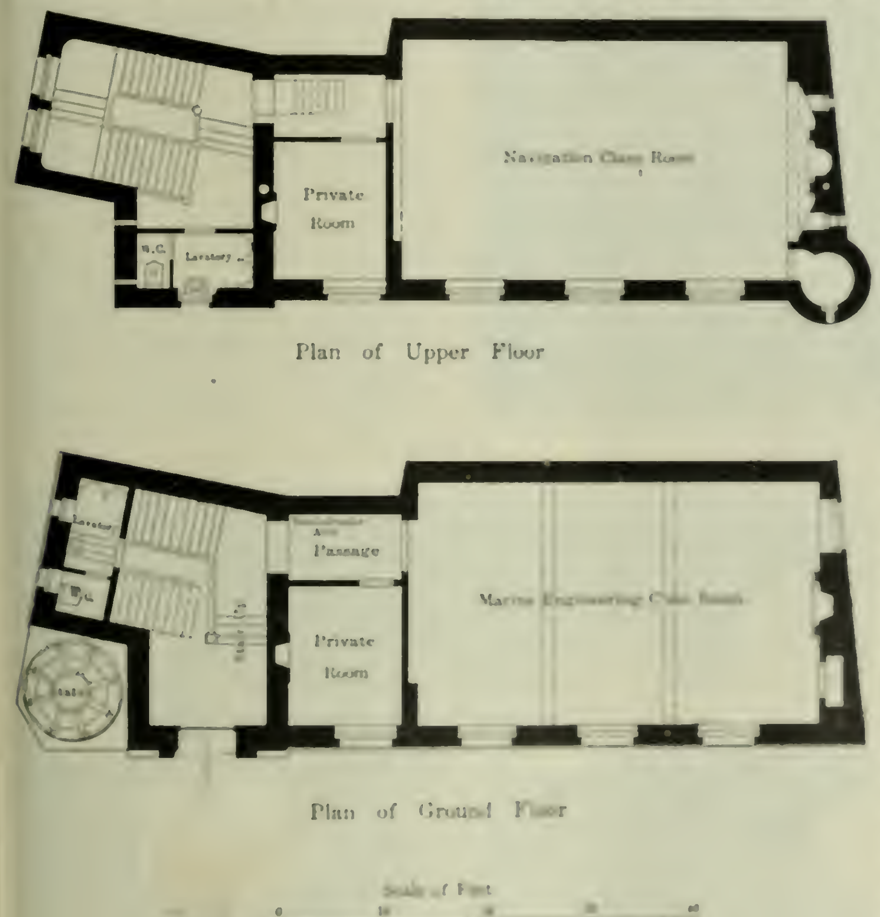


FIG. 2. FLOOR PLANS OF BUILDING

street and is made of teak. Above the door is the Greenock coat of arms with the inscription:

Sigillum Burgi de Greenock.

The electric-light fittings are of hand-wrought iron with armorplate finish, and there is provision for special lighting for demonstration purposes. The supply comes from the corporation mains, the switchboard being in the entrance hall.

The architect to whom the work was intrusted was David Barclay, of 245 St. Vincent street, Glasgow, and to him we are indebted for the plans of the building. Since the building was to represent a house that formerly stood on the site, though not intended to be a copy of the old house, it was decided that to some extent it should represent a style of Scottish architecture.

The primary object of the building was to mark the site of the house in which James Watt was born, and the memorial house is itself small since it is confined to the site of the original house which it memorializes. The locality is near to the harbor, for one old tenement house alone intervenes. This it is generally desired should some day be removed should there be funds available for the purpose. If so, the view of the memorial house would be opened up to the river. As in all industrial and growing towns some localities become reduced in character, so has this. It has suffered very considerable decadence since the Watts lived on the site and a general demolition of some of the neighboring properties would be a worthy public improvement if the finances of the town would permit or the public generally would interest themselves in the matter and step in to finish the work inaugurated by Dr. Carnegie.

The architects prepared, we are given to understand, several designs for a memorial, and of these one at least was purely memorial, but Dr. Carnegie expressed a desire that there should be some building that should serve a useful purpose as well as being an ornament, and therefore the final choice fell on the design as carried out. Since the building was to be so small, too much was not attempted, and the teaching to be given within it was narrowed down to the subjects named, marine engineering and navigation, each of which is allotted one of the large rooms.

FIG. 3. ENGINEERING CLASS ROOM

In accordance with the object of the building, the finishing of the rooms is perhaps more elaborate than usual with class rooms, the walls being paneled in timber and the mantelpieces being of carved stone, but the wall paneling is so designed as to serve for blackboard purposes and the exhibition of diagrams. The upper floor ceiling is vaulted and decorated with Cymric ornaments, while the small rooms of the staircase tower will serve for museum purposes. The stone carving records ancient and modern engineering and shipbuilding. The statue itself is in the dress of 100 years ago, and Watt appears to be reading a steam gage. The pedestal is supported by flying buttresses of antique design carved with some elaboration with emblems of engineering tools.

Seeing that the site was so small, the house appears to have been designed to fill a useful purpose about as well as could be, and the purpose it will fill is closely connected with the trade and industry of the town. It might be pointed out that the Clyde, down which have been launched some of the largest ships ever built, was once a mere shallow creek, and but for the steam engine and all that the steam engine has rendered possible, it would have remained so. Watt's invention set the steam engine along the road of improvement and started the struggle for coal economy which has today culminated at or near the long-sought one pound per horsepower per hour. But today, though we possess the turbine and the surface condenser and accurate machine tools, we are still striving after Watt's axiom, the keeping of the cylin-

FIG. 4. NAVIGATION CLASS ROOM

Modern British High-Speed Steam Engines

Design of the Type of Governor in Most General Use; System of Forced Lubrication; Some Makes of High-speed Engines

BY JOHN DAVIDSON

Governors

As previously stated, in all cases the engines are governed by means of a centrifugal governor attached to the crankshaft, which controls the speed of the engine by acting directly upon a throttle valve of a balanced type. Where the load of the engine is nearly uniform this system of governing leaves nothing to be desired, either in speed regulation or economy. The type of governor used by almost all firms is practically the same, and the general design is illustrated in Fig. 10.

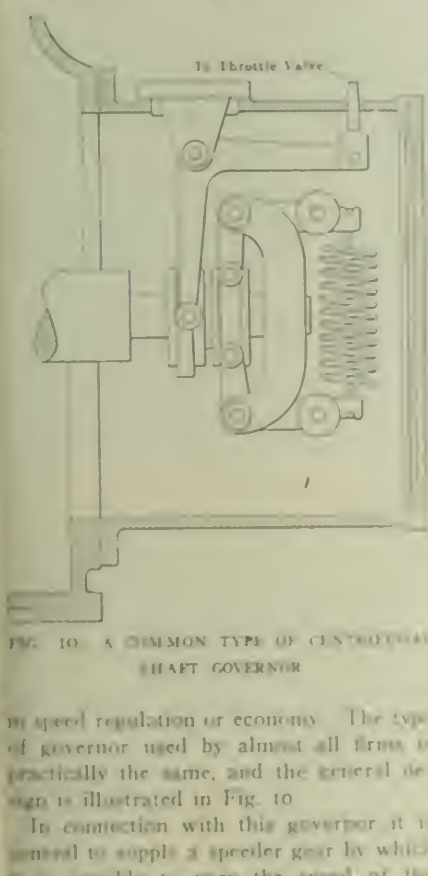


FIG. 10. A COMMON TYPE OF CENTRIFUGAL SHAFT GOVERNOR

In connection with this governor it is general to supply a speeder gear by which it is possible to vary the speed of the engine at least 5 per cent. above or below normal, while the engine is running. This is generally effected by means of an additional spring attached to the spindle end or bell-crank lever of the governor, in such a way that it may act with the main governor spring, so that if the tension of this spring is varied the speed of the engine will be varied accordingly.

Recently the governor gear has been put under forced lubrication, so that no part of the engine requires attention, all being lubricated from the main oil pump. The throttle consists of a single double-beat Cornish valve designed in such a way that it is not affected by difference in temperature. In Fig. 11 is shown a section of this valve.

FIG. 11. DOUBLE-BEAT CORNISH THROTTLE VALVE

The throttle-valve spindle is made steam-tight where it leaves the valve box by simply being passed through a long bushing, inside of which are turned several water grooves. This method of packing the spindle has been found much more satisfactory than fitting stuffing boxes of the ordinary type, as it is most essential to guard against friction in any part of the governor gear, and where stuffing boxes are introduced it is easy for the attendant to upset the governor and cause hunting by simply screwing up the gland.

During the last two or three years, governing by means of varying the expansion has again been taken up, but this time has only been combined with throttle governing. Great trouble was previously experi-

FIG. 13. ECONOMY OF VARIABLE EXPANSION

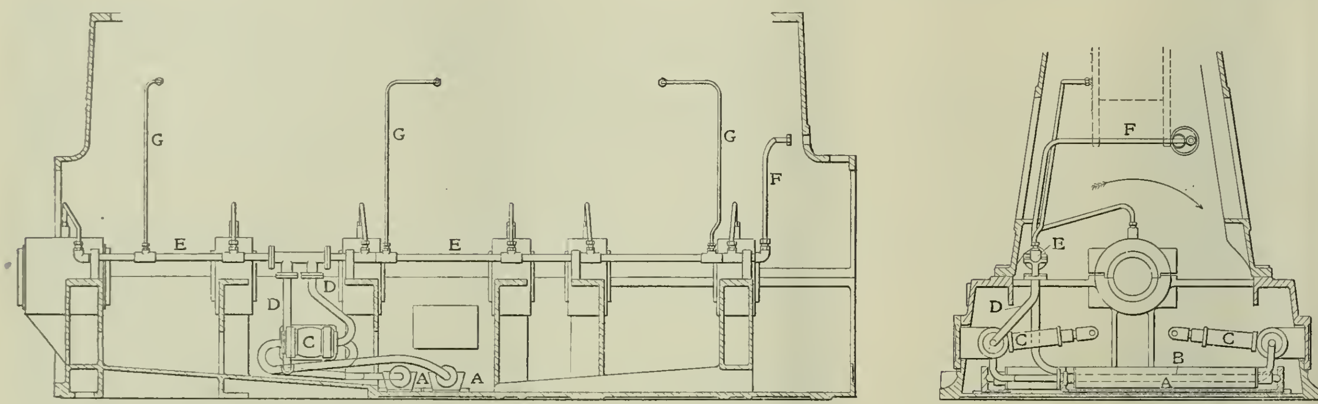
enced from centrifugal governors acting directly upon the eccentric driving the valve. In the later type of expansion gear the degree of expansion is varied without varying the travel of the valve, and simply by rotating the [illegible] on its spindle through a small angle. This valve may easily be adjusted in this manner by the governor as the inertia of the valve gear has not to be overcome. In Fig. 12 is shown one method of effecting this arrangement. The centrifugal governor acts on the throttle valve in the usual way. From no load up to 75 per cent. load the engine is entirely under control and governed only by the throttle valve. At this load [illegible] the throttle-valve spindle is moved further by the governor, but in doing this by means of [illegible] and an upright shaft, the main piston valve is caused to rotate through a small amount by means of [illegible] which [illegible] as shown on the [illegible] of the piston valve. The [illegible]

FIG. 12. METHOD OF VARYING [illegible]

at *A*, and the ports in the liner are made in triangular shape, as shown at *B*.

In the drawing at the right is shown to a large scale one of the ports and the edge of the valve, and the corresponding edge of the valve when at the earliest cutoff position. The lead of the valve in this position is represented by *C*. If, however, the valve is rotated through a small amount, as shown by the dotted lines, it will be noted that the lead has increased to the amount shown by *D*, and consequently the cutoff made later. By this means it is possible to obtain a range of cutoff sufficient to carry a load varying between 75 per cent. of full load and 25 per cent. overload at the expense of the lead, and at the same time obtain better economy at all loads between these two positions than if the engine was controlled entirely at the throttle valve.

For electrical purposes standard practice is to make all engines capable of developing 25 per cent. overload, condensing, and capable of developing full load noncondensing when required. If an engine is controlled entirely by throttle governing, it is necessary that full boiler pressure should only be used at the maximum overload, or when running noncondensing, and when running under what should be the most economical load, viz., full load, the engine is using steam very considerably throttled. The diagram in Fig. 13 shows this point clearly, and it will be seen that when the engine is only controlled by the throttle valve throughout its range, the steam consumption per brake horsepower at full load is 16.4 pounds, whereas if the engine is fitted with an expansion gear and arranged so that the throttle governor only controls the engine between no load and 75 per cent. of full load, there is a saving of 0.8 pound per brake horsepower per hour, or 5 per cent. The steam consumption is also slightly better at 75 per cent. load, and if the average load on the engine ranges between 75 per cent. load and 25 per cent. overload, it will be seen that the saving in coal per annum is no small item.



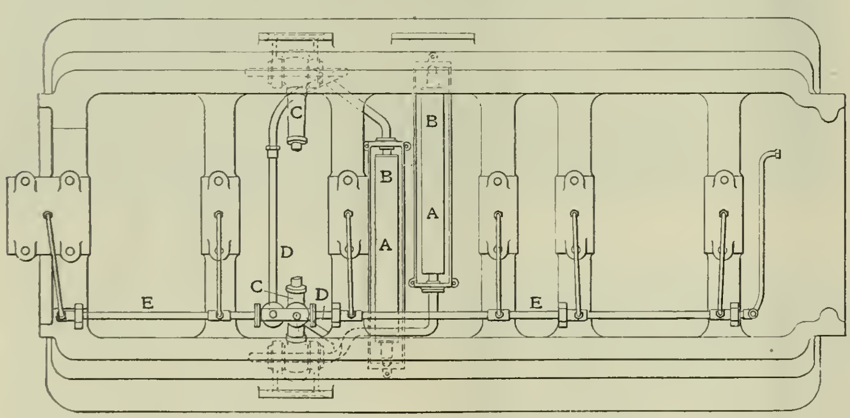


FIG. 14. SYSTEM OF FORCED LUBRICATION

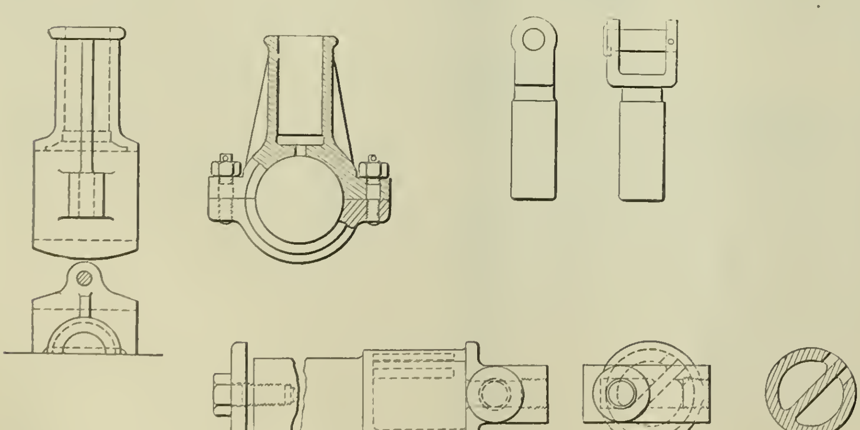


FIG. 15. OIL PUMP DETAILS

For instance, suppose an engine of 500 brake horsepower is working 12 hours per day and 6 days per week at an average load of between 75 per cent. load and 25 per cent. overload, the amount of coal required per annum will be 2000 tons, and taking coal at $2.50 per ton and an average saving of 5 per cent., as above, the amount saved will be $250 per annum.

Forced Lubrication

The system of lubrication may at first sight appear to be elaborate, but when considered in detail it will be found to be a simple arrangement. In Fig. 14 is illustrated the arrangement of forced lubrication as fitted to a three-crank triple-expansion engine. In the lowest part of the base are fitted two troughs *A A* into which are fitted strainers *B B*, which consist of perforated tubes around which is wrapped fine copper gauze. The object of the troughs is to prevent any dirt or sediment of any kind, which may be collected by the oil or get into the crank case, being drawn into the pump and so delivered into the main oil pipes. A certain amount of water also drips from the glands of the cylinders, and although additional glands are fitted at the top of the frame where the piston and valve rods pass through, leakage cannot entirely be prevented. If this water, however, does collect at the bottom of the base, it cannot be drawn into the pumps unless it is allowed to collect to such an extent that the level reaches to the top of the troughs. It is not likely therefore to cause any damage unless the engine attendant is careless, because the oil floating at the top of the

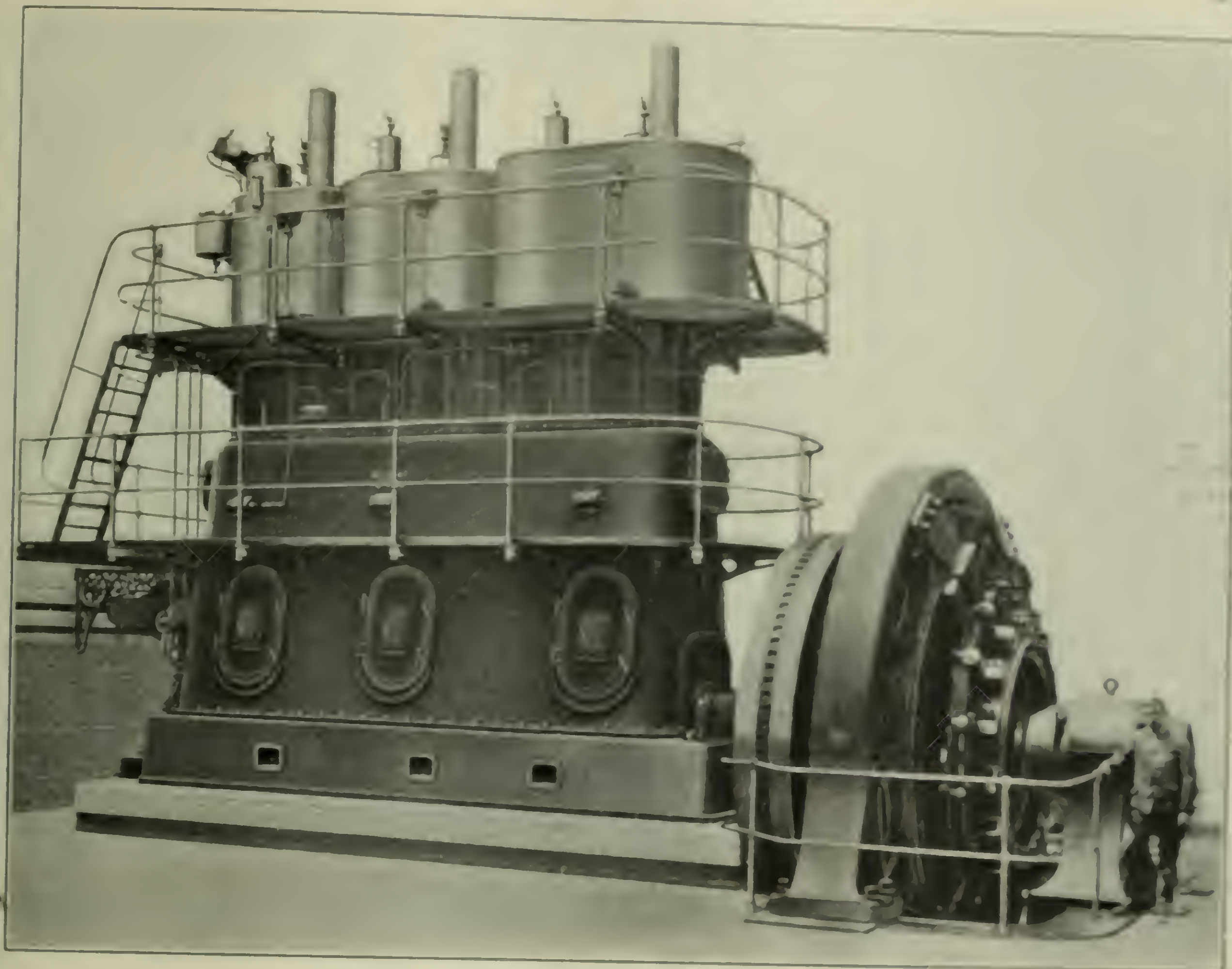


FIG. 16. BELLISS-[illegible] GENERATING SET

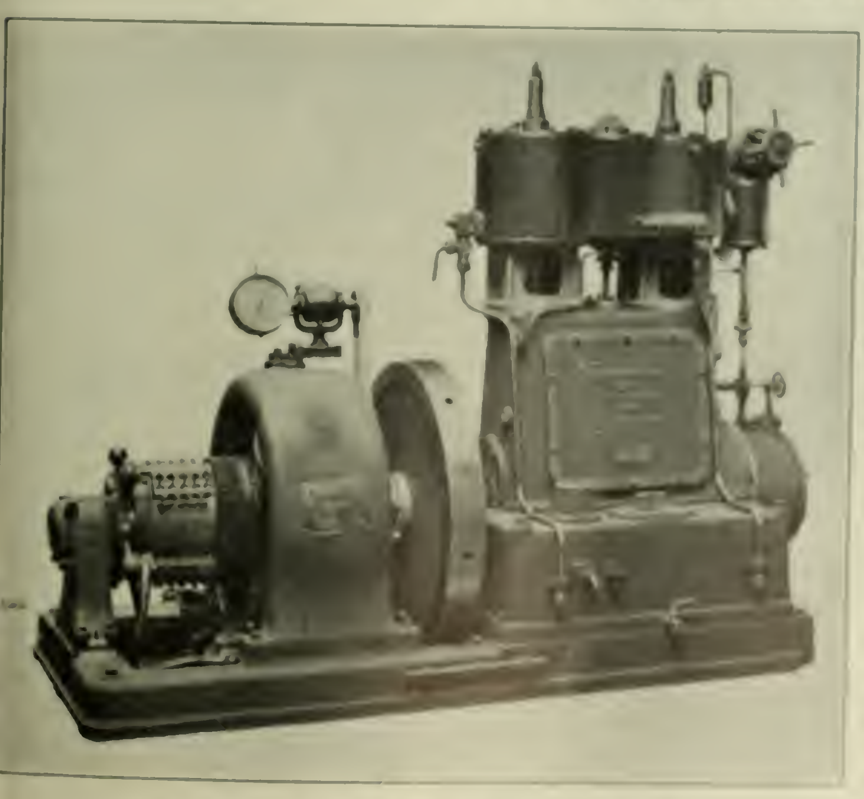


FIG. 17. SMALL TWO-CRANK [illegible] ENGINE

water overflows into the trough and is so delivered into the mains.

In the case of large engines similar to the one illustrated, it is usual to fit two oil pumps, each being of sufficient capacity to maintain the full oil pressure. These pumps are generally worked from one eccentric driving the valve gear and are of simple construction, viz., the valveless type. The oil pumps are shown at C C and details of similar pumps are illustrated in Fig. 15. The drawing is self explanatory. The oil is delivered from the pumps through pipes D D, in Fig. 14, to the main oil pipe E, and from this main branches are taken, as shown, to each of the main bearings and crosshead slides. One end of the main pipe is coupled to a pressure gage by means of the pipe F, and a bypass valve is also fitted to this main so that the pressure may be regulated as required, the usual pressure being [illegible] lb. or [illegible] per square inch.

The crankpins receive their supply of oil by means of a hole drilled through the crankshaft from the journal of the main bearings to the crankpin. One end of this hole is always in connection with a groove turned in the main bearings. In the crosshead journals a similar groove is formed, and the oil is led through this groove by means of a pipe attached to the side of the connecting rod up to the crosshead pin. In the case of small engines an additional groove is cut in the crosshead brasses and oil is conducted from this to the slides, but for large engines it is advisable to use a separate supply pipe direct from the main, as shown at *G* in Fig. 14. The eccentric and eccentric-rod crosshead pins, together with the crosshead slides, receive their supply of oil in a similar way, so that all of the working parts of the engine are automatically lubricated by means of the two pumps *C C*. The oil leaking from the various parts drips down into the crank case, but before being drawn into the pump again, it has to pass through the strainers already referred to. Where two pumps are fitted, a valve is generally attached to one end of the trough, so that when the strainer is withdrawn it automatically shuts off the supply of oil to that pump, and thus prevents the possibility of any grit being drawn in. It is thus possible to remove and clean a strainer while the engine is running.

Standard Makes of High-speed Engine

Belliss & Morcom. The largest firm of high-speed engine builders in England is Messrs. Belliss & Morcom, Ltd., of Birmingham. This firm alone has manufactured over 3000 engines. The largest engines built are suitable for driving generators of 1500 kilowatts capacity, and in Fig. 16 is shown a photograph of one of the Belliss-Dick, Kerr sets installed in the new Summer Lane electricity-supply station of the Birmingham Corporation.

Eight of these sets are installed and each is capable of developing as a continuous output 1500 kilowatts and 25 per cent. overload for short periods of time. They run at 166½ revolutions per minute and are supplied with steam at a pressure of 180 pounds per square inch. The normal output in brake horsepower is 2140, the maximum being 2680.

Of each set the high-pressure cylinder is 25 inches in diameter, the intermediate 36½ inches, and the low-pressure 55 inches, the stroke being 33 inches. Piston valves are fitted to all cylinders, these being driven direct from the crankshaft by a single eccentric. Messrs. Belliss' patent automatic-expansion gear, which is very similar to that previously described, is fitted to the high-pressure cylinder, the position of the valve being determined by a special relay cylinder which is operated from the governor controlling the throttle valve. With this arrangement the engine is governed by automatic expansion at the high loads and by the throttle at light loads.

In Fig. 17 is illustrated a small two-crank compound engine built by Messrs. Belliss & Morcom for the Peninsular and Oriental steamship "Mooltan. This engine is shown coupled to a Siemens dynamo capable of developing 40 kilowatts, the engine being capable of developing 58 brake horsepower when running at a speed of 450 revolutions per minute. The

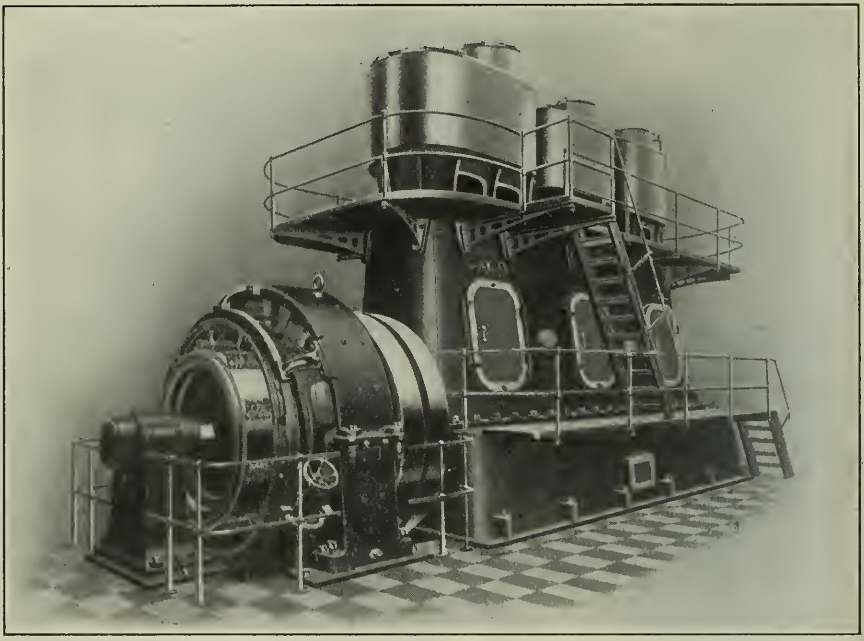


FIG. 19. EXTERIOR OF BROWETT-LINDLEY ENGINE

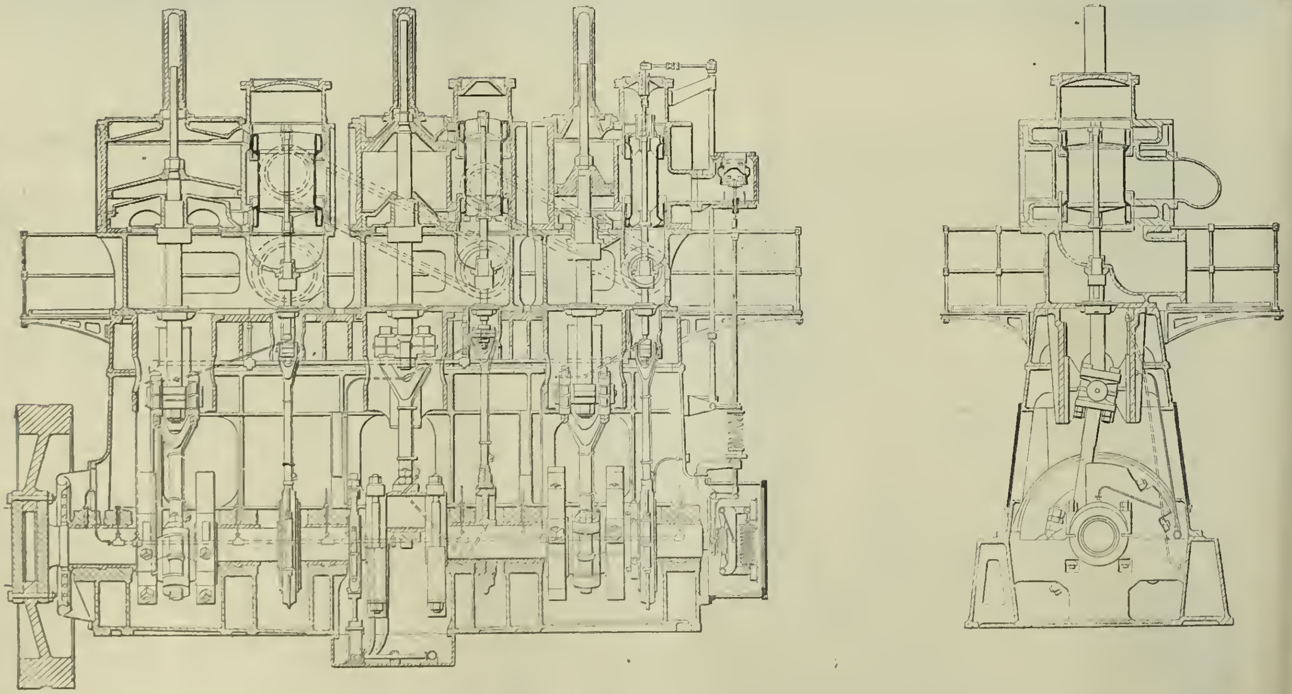


FIG. 18. TRIPLE-EXPANSION BROWETT-LINDLEY 2400-HORSEPOWER ENGINE

sets, of which there are five installed supply current for 1400 incandescent lamps of 16 candlepower each, four hundred 12-inch electric fans, six forced-draft fans, four large ventilating fans, a searchlight of 8000 candlepower, six coaling lamps of 20,000 candlepower, electric headlight and sidelights and two Brockie-Bell lamps of 40,000 candlepower each.

Browett, Lindley. Another large firm which manufactures engines of all powers from 20 to 3000 horsepower are Messrs. Browett, Lindley & Co., Ltd., of Patricroft, Manchester. This firm manufactures engines in the usual varieties, viz., single-crank simple and compound engines, two- and three-crank compound engines and three-crank triple-expansion engines. Their standard design of two-crank compound engine has already been illustrated in Fig. 3, and this drawing shows generally the arrangement of cylinders and motion work of the engine.

Engines of the type illustrated in Fig. 3 are manufactured in powers ranging from 300 to 1000 horsepower. The productions of this firm are undoubtedly of substantial design and material is not in any way stinted throughout the engine. All parts are accessible and at the same time the frame work of the engine is unusually rigid.

In Fig. 18 is shown in full section one of the largest-sized engines manufactured. This engine is capable of developing 2400 indicated horsepower as a normal load and 3000 as a maximum for periods of about two hours. It is of the triple expansion type and has cylinders 25x39x60 inches in diameter and a 27-inch stroke. It will develop the power stated when running at a speed of 200 revolutions per minute if supplied with steam at a pressure of 150 pounds per square inch and exhausting into a condenser. Piston valves are used throughout, and the cut-off of the high-pressure valve is under control of the governor, so that when working at the higher loads the engine is governed by variable expansion. At lighter loads throttling takes place in combination with the alteration to the cutoff.

The crank-shaft for this engine is forged in one piece, and the flywheel bolted to a large coupling formed at one end. The bolts in this coupling pass right through the crank-shaft, flywheel and dynamo coupling, so that no energy has to be transmitted through the crankshaft due to any shocks which may be received from the generator end. The economy of the high-speed engine compares most favorably with the best engine on the market, and this size of engine requires only 11.8 to 12.1 pounds of steam per brake horsepower when supplied with steam at a pressure of 150 pounds, superheated 150 degrees Fahrenheit, and working condensing at 26 inches of vacuum. The figures quoted are not results obtained from one particular engine, but represent what is obtained in every-day practice from a large number of engines. An exterior view of the engine illustrated is given in Fig. 19.

The Problem of Furnace Design for Water-tube Boilers

By Harold V. Coes

The water-tube boiler, while possessing many advantages for large power units, has one distinct inherent disadvantage in the difficulty of obtaining perfect combustion in the furnace as now designed. Until very recently and even now, with a few exceptions, it has been the practice to place the relatively cold heating surface in direct contact with the flames, thus defying at the very outset one of the laws governing complete and perfect combustion.

Messrs. Booth and Kershaw, in their work entitled "Smoke Prevention and Fuel Economy," lay down the following requisites for perfect combustion:

1. A draft velocity of not less than 30 feet per second, over the fire to draw in air above the fire bed for combustion with the gases distilled from the freshly charged fuel.

2. A thorough mixing of this air with the fuel gas, which can usually be done by allowing the air and gas to flow together over the length of the furnace. The air must be admitted in numerous fine jets, as through a perforated plate in the door.

3. A sufficient temperature to insure ignition at the bridge end of the furnace.

4. Space in which the combustion can complete itself undisturbed.

Consider the water-tube boiler and see how many of these requisites are violated or observed, and why, and how to remedy the shortcomings.

Unless horizontal baffles or arches are used, the air entering the doors short-circuits and passes directly up the tubes. It is true that the tubes mix the gases and air, but this is after the temperature has been reduced, so that if they do unite it will be at some point beyond the tubes, where the heat derived cannot be effective. Consequently the gas and air pass up the tubes unmixed instead of being thoroughly mixed and passing over the fire. Since each component of the fuel requires a definite amount of air to oxidize it, and since the gas and the air have to be thoroughly mixed to attain this result, if the tubes are put close to the grate, as in the water-tube boiler (thus chilling the flames), the highest temperature is not reached. Some of the hydrocarbons cannot be burned or oxidized except at high temperature, and as we both lower the temperature and do not mix the gases and air we violate the third requisite.

By placing the tubes close to the grate, we violate the fourth essential of good combustion, as one of the most important considerations in the design of a furnace is the combustion chamber.

Character of Fuel the First Thing to be Considered

The first thing to be considered in the design of the combustion chamber is the character of the fuel to be burned. The ignoring of this fact is responsible for a great many failures to attain perfect combustion. Trying to burn high volatile bituminous coals under a water-tube boiler with an anthracite setting causes still more failures and dissatisfaction. The greater the volatile content of the coal the more difficult becomes the problem. In burning the fine grades of anthracite, such as that from the mines of eastern Pennsylvania, the heating surfaces can be set relatively close to the grate, as there are practically no volatile hydrocarbons distilled from such coals, and as the flame length is proportional to the volatile matter in the fuel.

In such cases the tubes near the bridge-wall may be only a few feet from the grate and give good results, but the moment high volatile coal is burned under this setting trouble begins, as it is absolutely impossible to operate a boiler under these conditions without objectionable smoke and a correspondingly low furnace efficiency. The reason for this is that the high volatile fuel burns with long flames, and if the tubes or heating surfaces are not sufficiently removed to prevent the flames from impinging on it, and before the flames can be properly mixed with the requisite amount of air, they are chilled to a point below the combustion temperature. This causes the carbon to be precipitated either in the form of soot or smoke and, as smoke, to pass off up the stack with the rest of the products of combustion in a dense black cloud, which is sure evidence of poor heat transference and poor combustion.

The fact that this takes place in most water-tube boilers using soft coal on the grates is due primarily to the fact that in many instances water-tube boilers equipped with anthracite grates and settings were used in soft-coal districts, with the consequent results of poor combustion and low efficiency.

It is thus clearly seen, and this is the main point for consideration, that the furnace should be designed for and adapted to the fuel to be used in it.

How the Furnace Should be Designed

The combustion chamber should be of such size that combustion may be complete and undisturbed and permit the flames to burn out before coming in contact with the heating surface. As previously stated, the length of a flame is in almost direct proportion to the volatile content of the fuel, depending somewhat on the [illegible] this volatile matter. The short-circuiting of the air and gases and the prevention of the flames from reaching the heating surfaces can be accomplished simultaneously by the use of firebrick arches, tile roofs or dutch ovens; although the dutch oven is seldom used except with some form of automatic stoker.

One of the most effective ways of increasing the volume of the combustion chamber and of keeping the volatile gases from contact with the tubes in a water-tube boiler, is to build a tile roof across the furnace, covering up the lower portion of the first and second passes and reversing the circulation of the gases, the products of combustion now passing first over the bridgewall, up through the third pass, down to the second and up the first pass to the flue. This constitutes a dutch oven to all intents and purposes in the boiler itself.

The length of this tile roof or flat arch depends upon the flame length, for the flames should be extinguished or burnt out before going up the pass. And as stated before, the flame length depends upon the volatile content. The longer this arch is made the longer is the travel of the hydrocarbons in contact with it, and consequently the longer is the time interval for perfect combustion to take place. With the lower volatile Eastern coals, this arch need not be over 4 feet in length in order to obtain complete combustion. As the percentage of volatile matter increases the length of the arch or roof increases in almost direct ratio. It is also affected by the rate of combustion, so that with a knowledge of these two elements a furnace setting can be designed which will be absolutely smokeless under all operating conditions.

One type of arch which has given satisfaction, especially when used with fine anthracite, is that used in the Webster furnace. This consists of several arches strung across the grate in such a manner as to prevent the cooling of the fire when the charging doors are open. These arches are particularly effective when induced draft is used, as the difference in static pressure may in this case amount to several tenths of an inch of water, causing an inrush of cold air as soon as the doors are open and the consequent chilling of the tubes and lowering of the furnace temperature, unless the foregoing means are used to prevent it.

Hight of Boiler Tubes Important

A very important consideration irrespective of the type of furnace is the hight of the boiler tubes above the floor, or, what amounts to the same thing, above the grate. This again, of course, depends upon whether a tile roof is used or not. Formerly it was customary to install the Babcock & Wilcox boiler with the bottom of its header from 7 to 7½ feet above the floor line. This distance has gradually been increased for burning high volatile bituminous coals to 9 feet, and in some recent installations has been placed 10 feet above the floor line. And even this figure will probably be increased under some new gravity underfeed stokers.

The tile roof, furthermore, has a reverberatory action which keeps the furnace temperature at maximum, thus insuring the ignition temperature of the hydrocarbons and a heating of the air passing over the fire, with a thorough mixing of these two elements and the resulting good combustion. If the air for combustion can be preheated by any of the advantageous methods at disposal, the better will be the combustion.

The use of steam jets and that type of apparatus should not be tolerated, for they do little if any good, and that at the expense of good combustion. Operating engineers believe that they prevent clinkers. The only reason that a steam jet stops clinkers is because it lowers the furnace temperature below the fusing point of the clinker, which is a good reason for not using it, since any agent that tends to lower the temperature of combustion is a poor one.

There is a method, however, for small installations which merits consideration, and that is a combination turbine-driven disk fan, which uses a very small percentage of exhaust steam, but which materially aids in distributing the air for combustion. Of course for large installations some one of the mechanical-draft installations would be used. But then, again, large installations generally have an engineering staff capable of properly designing and specifying the kind of furnace to be used.

Amount of Coal Burned

The amount of coal that can be burned per square foot of grate surface per hour varies over a wide range for various installations and various conditions. The problem depends upon the load to be carried, kind and amount of draft, type of boiler and the character of the fuel. In some of the large central stations using the finer grades of anthracite this amounts to from 25 to 30 pounds. During the peak load, by increasing the draft, this figure may be increased to 50 pounds per square foot.

With soft coal, except where stoker-fired, it is not generally good practice to burn more than about 20 pounds per square foot on a flat grate, on account of the difficulty of good air distribution. When soft coal is fired with an automatic stoker, as is done in large stations, from 65 to 70 pounds of coal per square foot of grate per hour may be burned. This has recently been done by a new type of gravity underfeed stoker.

The type of grate to be used is a matter of choice, there being many good types on the market. Whether a dumping or a shaking grate will be used depends upon the amount of ash and clinker in the fuel. If this is rather small the shaking grate will give good results; if high, then the former should be used.

The one thing to bear in mind is the fact that the burning of coal is governed by just as accurate physical laws as is the generation of steam. Just as much care, thought and time should be spent upon the design and selection of a furnace as upon any other part of the boiler. For after all, this is the heart of the boiler, and any saving that is made in the furnace is a direct saving, for no processes of manufacture have taken place until the coal is fired; consequently, the saving in raw material represents hard cash.

The Function of Compression

By R. T. Strohm

Judging by what one reads and hears, the question of compression or no compression seems to be causing no little mental agitation. There are those who have come out broadly for the elimination of the compression heel from the indicator diagram, on the ground that compression in steam engines is not necessary, and that most engines would run better, both mechanically and economically, if it should be dispensed with.

Such statements, to say the least, are combatable. To begin with, it is rather absurd to think that steam engineers have been making the egregious blunder, for many decades, of clinging to compression and thereby wasting steam. It is scarcely believable that if eliminating compression increases economy, the fact would not ere this have been discovered and put to practical use. Engine builders who have guaranteed certain definite results as to economical performance have designed and manufactured engines in which compression figures largely. Is it possible that they have thus long been ignorant of the suggested means of lowering steam consumption?

Argument of this character, alone, does not nullify the statement that compression is unnecessary. That much is admitted. But there are other ways of attacking the problem. Compression in steam engines is not only desirable, to a greater or less extent, but is a necessity. There are two good reasons for this condition. One is that silent and smooth running is thereby secured. The other, and just as important reason, is that the economy of the engine is improved thereby. It will be observed that these statements are diametrically opposed to those referred to in the opening paragraph. It now remains to adduce something in the way of support and proof.

The reciprocating parts of an engine do

not move with a uniform velocity. Instead, the velocity increases from zero at the beginning of the stroke to a maximum at the middle of the stroke, and then decreases to zero at the end of the stroke. During the period of acceleration, the pressure of the expanding steam is the force causing the acceleration. But during the period of retardation, the retarding force may be either a cushion of steam, a reaction from the crank pin, or a combination of the two. If compression is used, the increasing pressure of the steam trapped in the compression space will furnish the resistance necessary to overcome the inertia of the reciprocating parts, and it is evident that, by adjusting the amount of compression, the reciprocating parts may be brought to rest without subjecting the crank pin or wrist-pin to any great pressure.

In Fig. 1 is shown a curve of inertia pressures in a reciprocating steam engine, *a b* representing the stroke, and vertical distances from *a b* to *d e* representing inertia pressures. It will be seen that at the

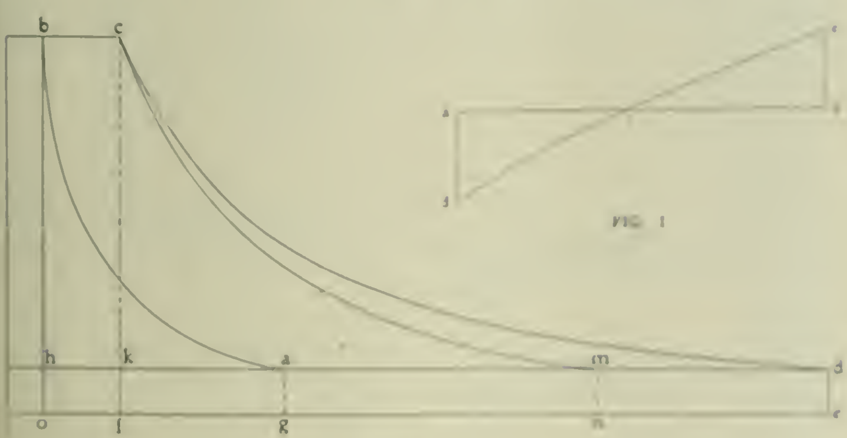


FIG. 1

FIG. 2

beginning of the stroke, the inertia pressure is negative, and of a value *a d*. As the parts become accelerated, the inertia pressure grows smaller, until, at the point of maximum velocity *c* the inertia pressure is zero, since at that point the crank pin and crosshead are moving with the same linear velocity. From *c* to *b* the crosshead motion decreases in velocity, and at *b* the inertia pressure *b e* is again large, but this time positive in value. The increase of velocity of the reciprocating parts during the portion of the stroke represented by *a c* is due to the expenditure of a portion of the energy of the expanding steam. The decrease of velocity from *c* to *b* is due to the fact that the reciprocating parts are giving up the energy received during the earlier portion of the stroke.

If the reciprocating parts are brought to rest by means of a cushion of compressed steam, the resisting force increases from zero to a maximum, just as the inertia pressure changes in similar fashion; and furthermore, the resistance is introduced against the piston, which forms a large proportion of the weight of the reciprocating parts, and this point of application of the resistance is therefore the most direct and the most rational. If no compression is used, the inertia thrust of the rapidly moving parts will be transmitted to the crank pin with ever increasing intensity.

Now, is it not manifestly better to bring the reciprocating parts to rest by a cushion of steam than by the influence of the crank pin? By means of the steam cushion, the pressure is transmitted directly to the cylinder head, which in turn is attached to the most rigid portion of the engine frame. As a result, the inertia of the reciprocating parts is absorbed, and they are brought to rest with the least unbalancing or vibrating effect. On the other hand, if the reaction at the crank pin is relied upon to accomplish the desired end, the pressure is applied through intervening links in the connections of which some slack exists, and the tendency is to produce pounding. The balancing of an engine to overcome the disturbing effects of the rotating and reciprocating parts is a very pretty problem, indeed, and while there are a few engines in which a practically perfect balance has been secured, there are many that are far less accurately balanced, and the elimination of compression from such engines would be followed by running conditions that no sane engineer would regard as desirable or safe.

Large Flywheel Energy Not Wasted

It has been argued that it is a wasteful proceeding to use part of the energy stored in the flywheel to compress the steam contained in the clearance space. This idea is based on a misconception, surely. It is not necessary to take any considerable energy out of the flywheel to accomplish compression. If the point of compression is so chosen that the amount of energy required for compression is just equal to that given up by the reciprocating parts in coming to rest, it will be unnecessary to take additional energy from the flywheel. This would be the ideal condition, so far as smooth running is concerned.

But there is another side to the question of compression. Compression is of practical value in neutralizing the evil effects of clearance on the steam consumption. There will be few engineers to combat the statement that clearance is a mechanical necessity. As long as bearings and pins are subject to wear, just so long will it be necessary to allow a greater or less amount of clearance between the piston and the cylinder head at the extreme ends of the stroke. Now, the effect of clearance is to increase the steam consumption per unit of work done, and the greater the clearance, the greater is the loss. This can be very readily shown by illustrative examples.

Take a case in which 1 cubic foot of steam at 105 pounds per square inch, absolute, is expanded to a pressure of 15 pounds absolute, there being no clearance and no compression. Under these conditions, the ratio of expansion is 7. The work during expansion or compression according to the law $PV = a$ constant is found by the formula

$$W = 2.3026\, P_1 V_1 \log \frac{V_2}{V_1}$$

where

W = Work in foot-pounds,

P_1 = Initial absolute pressure, in pounds per square inch,

V_1 = Initial volume, in cubic feet,

V_2 = Final volume, in cubic feet.

Since the expansion of saturated steam follows most closely the equilateral hyperbola, $PV = a$ constant, the above formula will be used in calculating the work areas under the curves in Fig. 2. Also, where rectangular areas are concerned, the work may be found by the formula

$$W = P_1 (V_2 - V_1)$$

in which the several terms have the same significance as before.

In Fig. 2, let $b c$ represent 1 cubic foot of steam at a pressure of 105 pounds per square inch absolute, the pressure being represented by the height $b f$. First, assume neither clearance nor compression, and let the steam expand to the pressure of the atmosphere. Then, the expansion curve is $c m$, and the work represented by the column areas is found by the foregoing formulas as

[illegible] foot-pounds.

[illegible] foot-pounds.

[illegible] foot-pounds.

[illegible] foot-pounds.

Therefore, [illegible] foot-pounds, the [illegible] work done by 1 cubic foot of steam with no clearance nor compression.

Now, add 0.5 cubic foot for clearance, as indicated by *o l*. Then, in reducing to 15 pounds pressure, as before, the piston will sweep through 10 cubic feet, and the final volume of the steam will be 10.5 cubic feet. As the initial volume was 1.5 cubic feet, as represented by *f l*, the ratio of expansion remains unchanged. Then,

$$c\,d\,e\,f = 2.3026 \times 105 \times 144 \times 1.5 \log 7 = 44{,}133 \text{ foot-pounds.}$$

$$b\,c\,f\,o = 105 \times 144 \times 1 = 15{,}120 \text{ foot-pounds.}$$

$$o\,b\,c\,d\,e = 44{,}133 + 15{,}120 = 59{,}253 \text{ foot-pounds.}$$

$$h\,d\,e\,o = 15 \times 144 \times 10 = 21{,}600 \text{ foot-pounds.}$$

Therefore, $b\,c\,d\,h = 59{,}253 - 21{,}600 = 37{,}653$ foot-pounds. This amount of work was accomplished by 1.5 cubic feet of steam, so that the work per cubic foot was $37{,}653 \div 1.5 = 25{,}102$ foot-pounds, as compared with 29,422 foot-pounds without clearance. This shows the manner in which adding clearance decreases the work done per unit of steam used.

Now assume compression to commence at *a*, so that when the piston reaches the end of its stroke there will be 0.5 cubic foot of steam at 105 pounds absolute pressure in the clearance space. Under these conditions the clearance space is filled with steam at the initial pressure, so that the amount admitted up to cutoff is merely that represented by *b c*, or 1 cubic foot. The work of compression is represented by the area *o b a g*, and as before it is found that

$$o\,b\,a\,g = 2.3026 \times 105 \times 144 \times 0.5 \log 7 = 14{,}711 \text{ foot-pounds.}$$

Also,

$$g\,a\,d\,e = 15 \times 144 \times 7 = 15{,}120 \text{ foot-pounds.}$$

The area *a b c d* representing the net work performed is equal to

$$o\,b\,c\,d\,e - o\,b\,a\,g - g\,a\,d\,e = 59{,}253 - 14{,}711 - 15{,}120 = 29{,}422 \text{ foot-pounds.}$$

The total work done with a clearance of 0.5 cubic foot and no compression was 44,133 foot-pounds, and the total work with neither clearance nor compression was 29,422 foot-pounds. The difference between these is 14,711 foot-pounds, which must be represented by the area *c d m*. But, the area *o b a g* also represents 14,711 foot-pounds. In other words, the gain due to increased expansion after adding clearance is exactly offset by carrying compression up to the initial pressure, and the net work, represented by the area *a b c d*, accomplished by 1 cubic foot of steam is equal to the work obtained from the same amount of steam expanded without clearance or compression, since in each case the work amounts to 29,422 foot-pounds.

This proves conclusively that when compression is carried up to the initial pressure, so that the clearance space at the beginning of the stroke is filled with steam at the admission pressure, the wasteful effect of clearance is nullified, and the steam economy is the same as though there was no clearance nor compression.

It is possible that someone may argue that in ordinary cases the compression is not carried up to the initial pressure, and that during compression there is a definite loss due to radiation and condensation of the entrapped steam. These facts are freely admitted. But such an admission does not destroy the truth of the statement that compression is economical. It has been shown that the evil effect of clearance is wholly offset by compressing to the initial pressure. If the compression is less than this, the saving is correspondingly decreased, but in any case it is better than dispensing with compression altogether, and filling the clearance space with live steam at the beginning of each stroke. For this steam does no work on the piston until after the valve closes, and then, by its expansion, it adds somewhat to the diagram, as indicated by the area *c m d*, Fig. 2.

Finally, the necessity of having compression grows less as the speed of the reciprocating parts or the percentage of clearance decrease. In high-speed automatic engines the clearance is usually large, and it will be found that, almost without exception, diagrams from this class of engine show compression curves running from two-thirds to three-fourths the hight of the diagrams. In Corliss engines the percentage of clearance is much less and the piston speed is lower, and in many such engines it is possible to reduce the compression to such a degree that the heel of the diagram is almost square, without affecting the smoothness of operation or steam economy of the engine. But though this may be done in the case of slow-speed engines having small clearance volumes, and has been successfully demonstrated in such cases, it ought not to be formulated into a general statement and heralded as being applicable to all types and classes of engine. For most assuredly it is not.

Central Electric Light and Power Stations in the U. S.

In the accompanying table are shown the data of a preliminary report, by the Department of Commerce and Labor, on central light and power stations in the United States, exclusive of Alaska, Hawaii, Philippine islands and Porto Rico.

PRELIMINARY REPORT ON CENTRAL ELECTRIC LIGHT AND POWER STATIONS.

	1907.	1902.	Per Cent. of Increase.
Number of establishments	4,714	3,620	30.2
Commercial	3,462	2,805	23.4
Municipal	1,252	815	53.6
Total cost of plants	$996,613,622	$504,740,352	97.5
Total income (1)	$175,642,338	$ 85,700,605	104.9
Lighting service	$125,755,114	$ 70,138,147	79.3
All other electrical service	$ 43,859,577	$ 14,048,458	212.2
All other sources	$ 6,027,647	$ 1,514,000	298.1
Total expenses	$134,196,911	$ 68,081,375	97.1
Salaried employees:			
Number	12,990	6,996	85.7
Salaries	$ 11,733,787	$ 5,663,580	107.2
Wage-earners:			
Average number	34,642	23,330	48.5
Wages	$ 23,686,537	$ 14,983,112	58.1
Supplies, materials and fuel	$ 44,458,568	$ 22,915,932	94.0
All other expenses (including interest on bonds)	$ 54,318,019	$ 24,518,751	121.5
Steam and gas engines (including turbines):			
Number	7,674	6,095	25.9
Horsepower	2,684,228	1,392,122	92.8
Water wheels:			
Number	2,474	1,390	78.0
Horsepower	1,347,487	438,472	207.3
Total kilowatt capacity of dynamos	2,642,403	1,218,735	116.8
Output of stations, total kilowatt-hours	5,858,121,860	2,507,051,115	133.7
Estimated number of lamps wired for service:			
Arc lamps	(2) 555,921	385,698	44.1
Incandescent lamps	(2) 41,807,944	18,194,044	129.8
Stationary motors served:			
Total horsepower capacity	1,649,026	438,005	276 5

(1) Exclusive of income for current used for light and power that was furnished by railway companies, and which is included in the report for street and electric railways.

(2) Exclusive of lamps used by the establishments reporting to light their own properties.

The final report will contain an analysis of the above totals and present detail statistics by States and for other phases of the industry.

The statistics relate to the years ending December 31, 1907, and June 30, 1902. The totals include central stations only. They do not include isolated plants, or plants that were idle or in course of construction, and in but few instances plants operated by electric-railway companies.

It is interesting to note that in connection with the conservation of water power a recent advance in transmission voltage, by the placing in service of a 110,000-volt line in Michigan, is a clear indication of the rapid elimination of distance as an obstacle to electric-current service.

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

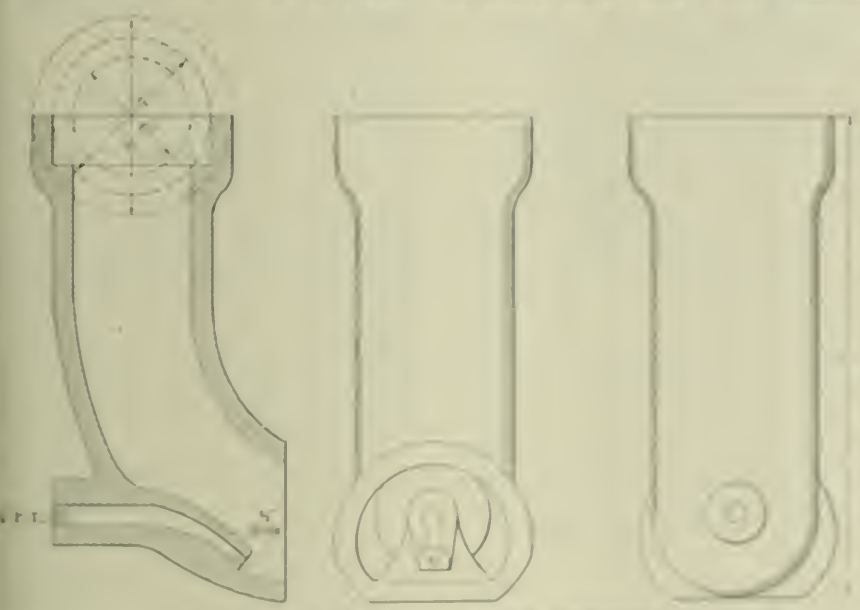
Independent Steam Gage Movements

I was much surprised to see a description of a steam gage movement which is mounted upon the base of the spring, so as to be independent of the case, appear in a recent issue of POWER as a new thing. I am sure that it has been upon the market for seven or eight years, and it is not at all original with the company to whom it is credited in the description. The description mentions among the advantages of this construction that "jar and vibration do not affect its accuracy nor sensitiveness." I think that experience has shown that jar and vibration have more effect on a gage of this type than they do on a gage where the movement is fastened to the back of the case, although there is not a great difference, and what is true of one is as true of the other.

It has never been proved that the air space at the back of the case was beneficial in any way, due to the fact that when the necessary amount of heat reaches the case to cause it to expand, as well as the movement, to such an extent that the reading of the gage would be affected, this amount of heat would, before the reading would be affected due to expansion, damage the tube to such an extent that the gage would be useless, anyway.

H. E. TRAVERS.

Pittsburg, Penn.



[illegible]

Solution on Indicator Cards

Can any reader inform me what solution is used on prepared indicator cards and how it is applied?

D. O. [illegible]

Freeport, Ill.

A Sawdust Stoker

In a large sawmill boiler room were 11 boilers, two of which were fitted with dutch-oven furnaces and hand-fired. The remaining nine boilers were divided into two batteries of two boilers each, and one battery of five. There was no dividing wall between the boilers of each battery, the boilers being hung from I-beams. The sawdust was carried in [illegible] from conveyors and dropped through openings between the boilers.

Combustion under these conditions was very unsatisfactory, as a large cone of sawdust was formed under each opening and between each cone was a large [illegible] of bare grate. A plan which worked well was to arrange things so that the sawdust falls into the curved pipe [illegible] to the [illegible], and is then blown into the furnace by a jet of steam or compressed air. The jet strikes the edge of the [illegible] in such a manner that the sawdust spreads out like a fan, covering the entire grate surface.

[illegible]

[illegible]

Compound versus Simple Engines

In a recent number were published a letter and indicator diagrams, by George W. Harding. The diagrams were intended to prove that a compound engine develops twice the horsepower that a simple engine does.

The data furnished with Mr. Harding's diagrams show that the [illegible] pressure was from 13 to 15 pounds, gage, and the vacuum was from 21 to 22.5 inches. Now if this had been a simple engine it would have been exhausting into 21 or 22 inches of vacuum instead of 13 to 15 pounds gage pressure. Mr. Harding's diagrams only show that the work was nearly equally divided between the high- and low-pressure cylinders, nothing more.

He wishes to know why engines are compounded if not to develop more work by again using the steam that has done work in the high-pressure cylinder. Engines are not compounded to develop more power, but to save fuel. It is cheaper to build a 200-horsepower simple engine than a 150-horsepower compound engine. It would seem that the compound engine is not as generally understood as it should be by many engineers.

Let us see what advantage the compound engine really has over the simple engine. For example, take two engines of [illegible] horsepower each, one a compound, the other a simple engine. The steam pressure will be [illegible] pounds gage for each engine. [illegible]

[illegible]

in the compound engine than in the simple engine; therefore, there is a greater economy in favor of the compound engine.

C. E. Bascom.

West Halifax, Vt.

Finding Engine Clearance from Indicator Diagrams

In a recent number a writer presented two methods for finding engine clearance from the indicator diagram, which were incorrect in one important and essential point, as he used the atmosphere line as a base line, while as a matter of fact the atmosphere line has nothing to do with the determination of clearance.

The correct method of obtaining the clearance from the diagrams is as follows: Select the best diagrams that can be obtained from the engine, having smooth expansion and compression curves. Lay off the absolute zero-pressure line parallel to the atmosphere line and at a distance below it to represent 14.5 pounds on the scale of spring used for the diagram. Draw the line *A B C D,* Fig. 1, cutting the smoothest portion of the expansion or compression curve at the points *B* and *C*. Then locate the point *D* so that the distance *C D* equals *A B*; the perpendicular line *D E* will then represent the point of zero volume, and the per cent. of clearance may be obtained by dividing the length *E F,* in inches, by the length of the diagrams *F G,* in inches, and multiplying by 100.

The explanation for this construction is that the expansion curve and compression curve for saturated steam, and for air when the compressor is running very slowly, are nearly enough in form to an equilateral hyperbola, whose axes are the zero-volume line (clearance line) and the absolute zero-pressure line, that they may be assumed to be so. On such a curve, if a line such as *A B C D* be drawn intersecting the curve in two points and touching the two axes, then it is true that the two portions *A B C D* are equal.

If the second method should be used the line which is an extension of the diagonal of the constructed rectangle should be continued to the absolute zero-pressure line. This method should not be recommended, as there are too many chances for error in construction, and it is more difficult to get right.

If the engine is an old high-speed machine, there is a chance that leaks in the valve or error in the indicator will show on the expansion line, and in this case it is better to use the compression curve, Fig. 1.

On many Corliss engines, and others of slow speed, the compression may be so short as to give a very small curve, and then the construction must be on the expansion line, Fig. 2. In any determination of this kind the greatest care must be exercised to obtain accurate results; a fine-pointed hard pencil must be used and the distances *A B* and *C D* should be measured with dividers.

W. T. Heck.

Lafayette, Ind.

A Peculiar Lighting Condition

Concerning the answer to my letter, "A Peculiar Lighting Condition," by Walter G. Mullen, page 70, January 5 number, I will say that he gave the correct *cause* of the trouble, but his reason for the opening of the circuit-breaker is not exactly right.

He says: "If now the switch *A* is opened all of the circuit *C* must pass through the circuit-breaker; this momentary rush of current may be sufficient to trip the same in the manner spoken of." Now, it takes much more than the current of circuit *C* to trip the breaker, as it was installed to carry this current continuously. What really happened is this: Consider the two circuits, *B* and *C,* to be

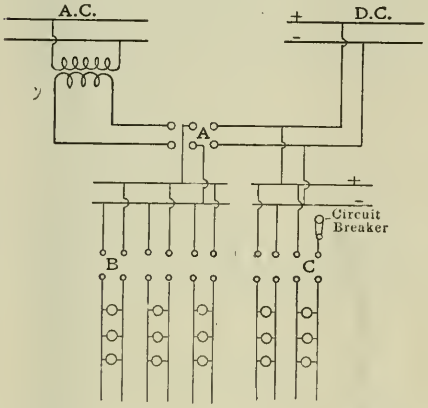


DIAGRAM OF WIRING FOR LIGHTING SYSTEM (REPRODUCED)

each grounded on the negative side, the whole considered as a direct-current system. This gives two negative paths for the current of all the circuits on switch *A,* and not alone that of circuit *B*.

One path is the normal one through the negative pole of switch *A* to the negative bus of the exciter, and the other is through the ground on *B* to the negative side of *C,* through the circuit-breaker to the negative bus.

At the instant switch *A* is opened, a resistance is introduced into the circuit at the negative break, which as the length of the break increases becomes high enough to shunt all of the return current of all of the circuits on switch *A,* through the grounded path, through the circuit-breaker, causing it to open. Since there are a hundred or more lamps on switch *A* the resultant overload on the circuit-breaker is at once apparent.

Of course, this rush of current was of short duration, lasting only while the positive pole of switch *A* was breaking the circuit, yet it was sufficient to trip the circuit-breaker.

Mr. Mullen's explanation of why the lamps of circuit *C* would burn with the circuit-breaker open was entirely correct.

C. L. Greer.

Handley, Tex.

A Motor Trouble

In reply to Mr. Sheehan's puzzle, I would say that if the generators were bought as generators and one used as a motor, it would operate as a differential motor, which was the reason it stalled; and the man had to shift his clutch in order to allow the motor to produce torque.

The reason, of course, for the motor reversing was the series field overcoming the shunt field and reversing the polarity, causing the armature to reverse its direction of rotation. The weak field at the instant of reversal and the heavy armature current would cause the violent sparking; as would the lead of the brushes. If the shunt field had become open for some reason the motor would have acted in the way stated.

L. E. Brown.

Ensley, Ala.

Probable Cause of Air Compressor Explosions

In the issue of January 12, I note a letter from F. W. Holman, with the above title, in which he suggests leaky discharge valves as the "most plausible" explanation of the cause of certain destructive compressed-air pipe explosions. As far as my knowledge extends, the letter does not suggest even a possible cause of such explosions.

The letter says: "Air which had been compressed evidently leaked back into the cylinder, where it became recompressed. This recompression will make it hotter and hotter until it either reaches a point where radiation will take the heat faster than the temperature can rise, or the temperature will rise until the oil catches fire."

In the case under consideration the air was compressed to 17 pounds gage and, with an initial temperature of 60 degrees Fahrenheit, the temperature after compression would be 190 degrees. If the air at this temperature could be recompressed, the final temperature would then be much higher, and if this operation could be repeated many times, the theoretical temperature attained might go as high as the most unbridled imagination could carry it; but no such result could come from leaky discharge valves.

The discharge valves would have to be in very bad condition to leak back 5 per cent. of the air compressed per stroke, and this return leakage into the compressor cylinder would occur during the intake stroke, continuing perhaps, if the leakage was very bad, during a small portion of the compression stroke; not far, because with adiabatic compression, full pressure would be reached when the piston reached the middle. When the piston starts for the intake stroke the air in the clearance space, heated by compression, must first re-expand down to atmospheric pressure and, coincidently with its re-expansion, its temperature will fall entirely back to what it was before the compression began. The air leaking back through the discharge valves also re-expands and its temperature falls correspondingly and, mingling with the incoming air at atmospheric pressure and temperature, the temperature of the whole cannot be raised appreciably by the leakage. This air which has leaked back becomes an inseparable part of the cylinderful and when the mass is compressed and discharged it is carried along together and no portion of it can be isolated and worked back and forth, as assumed, to have its temperature cumulatively augmented.

These attempts to solve the mysteries which still seem to be connected with some of the explosions that occur in connection with compressed air are certainly not to be discouraged. It would seem that the oil rather than the air is the thing to be studied. It is a noticeable thing that the initial explosions seem to occur more frequently in the pipes after the air has left the compressor rather than in the compressor cylinder head, where the temperature may be assumed to be the highest.

Compressed air alone, no matter how hot it may be, cannot possibly explode. The explosion is, of course, due to the ignition of a mixture of air and a volatile constituent of the lubricating oil. This volatile ingredient being present in sufficient quantity, there must still be provided time and opportunity for the mixing to be completed. This operation goes on rapidly, so that the conditions may be ripe for the catastrophe very close to the compressor. With the mixture ready for the explosion, ignition may occur spontaneously if the temperature is sufficient or a spark may be produced by friction and cause the explosion at a lower temperature.

Oil often burns bodily in the compressor cylinder heads and in the receiver without any explosion, receivers and contiguous piping sometimes becoming red hot. This might be going on in some case and provide the means of firing the explosive mixture which might be formed farther along in the pipes.

The obvious deduction is that we should use oils from which the more readily volatile constituents have been distilled, that we should use as little as possible of even the best oil and that, wherever there is a possibility of the used oil accumulating, provision should be made, and availed of, for frequent draining.

FRANK RICHARDS.

New York City.

The Barrus Universal Calorimeter

In the December [illegible] number there appeared an article entitled, "Barrus Universal Calorimeter," by Charles N. Cross, parts of which I beg to take exception to. Mr. Cross says the steam passes from the sampling pipe directly to the heat gage and thence through the separator to the atmosphere. The correct arrangement of this instrument is just the reverse, the steam first passing through the separator, where the major portion of the moisture is removed, and then through the heat gage to the atmosphere.

[illegible]

On the other hand, by placing the separator before the heat gage, the steam drops all but about [illegible] per cent. of its moisture in the separator, and is then in a proper condition for the expansion through the heat gage.

CHARLES B. [illegible], JR.

Philadelphia, Penn.

Trouble on Arc Circuit

The transformer in the accompanying illustration evidently had its primary winding connected across a single phase when operating on [illegible] volts. The change of line voltage to [illegible] volts necessitated the changing to [illegible] transformers, with the connections as in the diagram, the secondaries being connected in parallel and the primaries in [illegible]

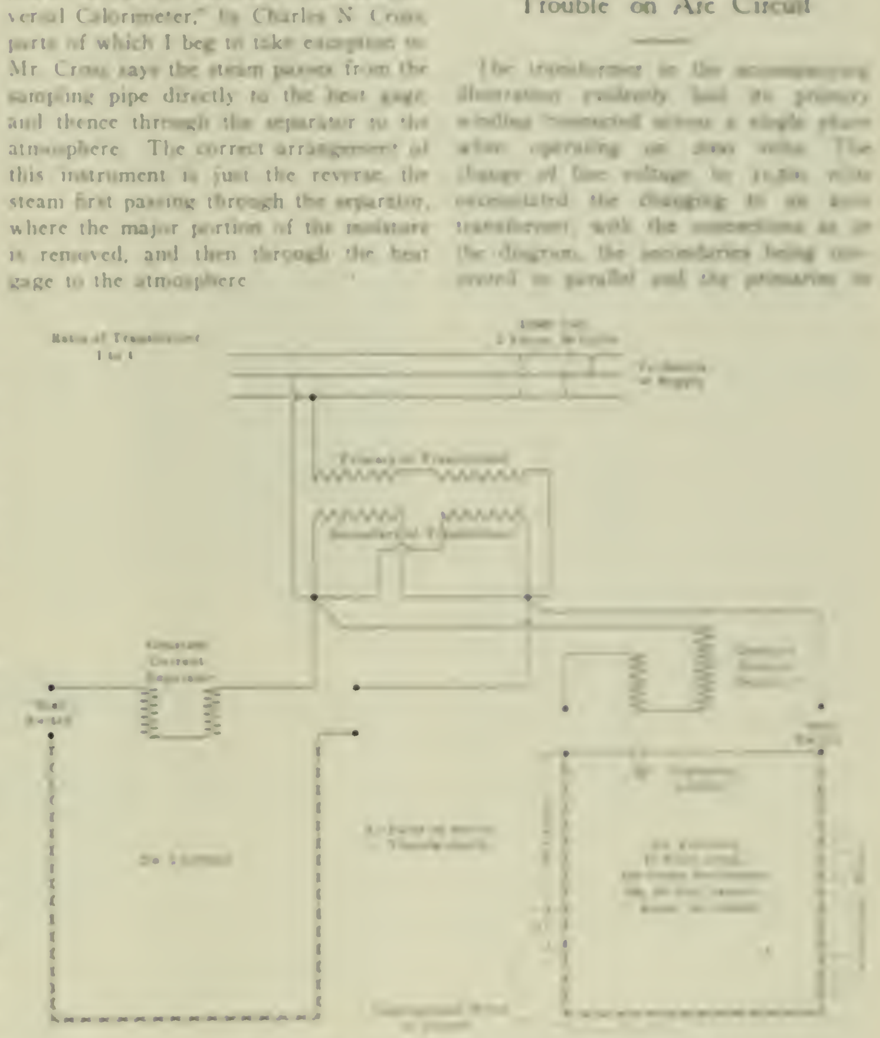


FIG. 1. TRANSFORMER AND CIRCUIT CONNECTIONS

[illegible]

[illegible]

ning arrester to ground, also that the aërial line of 40 lamps would burn all right and the ammeter show 7 amperes, but that upon sending the circuit underground trouble started, the rest of the circuit being fed from underground cable having only 4 amperes flowing through it. The regulator acted as if the line was short-circuited.

The trouble should have suggested itself at once. If there was a discharge through the lightning arrester and also trouble was found where the circuit entered the ground, evidently the trouble had to be between the arrester and the underground circuit, showing that the cable had been punctured by the high voltage. The ground wire of the arrester and the other side of the arrester itself had this high potential across it also, causing it to discharge across the gap. There might also have been a possibility of the

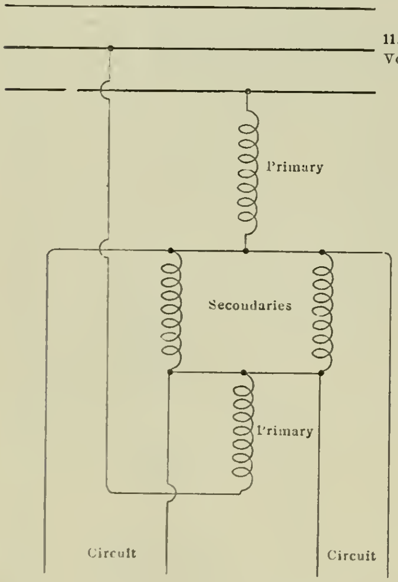


FIG. 2. SECONDARIES IN PARALLEL BETWEEN PRIMARIES

cable being broken down all along in the underground conduit.

The fact of making an insulation test using from 10 to 100 volts and finding one megohm resistance would not guarantee the cable from breaking down when 11,500 volts were sent through it. Finding 500 megohms resistance by such a test would not insure safety from breakdown with this high potential. The correct way would be to test a sample piece of cable directly on 11,500 volts from the conductor to the lead sheath.

The lightning arrester evidently was not built for a circuit of 11,500 volts, the discharge gap being too small to prevent this high-pressure current discharging to ground. In dry air, 11,500 volts will jump an air gap nearly 0.6 inch long and 10,000 volts will readily jump across a ½-inch gap.

The reason for 4 amperes flowing through the rest of the circuit and 7 amperes being indicated by the ammeter was that 3 amperes were escaping to ground, showing again that the underground cable had been punctured. The lamps fed from underground evidently would flicker on account of receiving only about one-half their normal current, which was too small to give enough excitation to the series coils in the lamps that attract the armature holding the upper carbon in suspension. This condition in the lamps would cause them to pick up and drop at short intervals.

The earth return circuit from the underground cable through the lightning arrester would cause the regulator to act as if the line were short-circuited, as it was only regulating 40 lamps, the other 70 lamps having no regulation at all. The trouble would probably disappear if the lightning arrester were removed, thus destroying the return circuit through the earth to the ground wire. When operating on 11,500 volts or even 8000 to 9000 volts, the best and only sure way is to get an equipment of electrical apparatus designed for high voltage, for example a transformer whose primary will stand 12,000 volts across the phase.

In Fig. 2 is given a method by which the insulation strain will be reduced about 1200 volts. In this diagram the secondaries are connected in parallel between the primaries.

EDWARD J MCGANN.

Chicago, Ill.

Necessity of Good Pipe Work

The editorial on the necessity of good work in suction piping is very much to the point. If one end of a pipe is under water and the other end attached to a pump in which there are no leaks, and the pump continually loses its water, it is only reasonable to suppose that air leaks in, as the following case will show:

There had been a 12-inch bell-and-spigot joint pipe line, 1400 feet long, laid down a river to a pump located at an elevation of 16 feet above the average level of the water. The pipe joints were supposed to have been properly made, but the pump worked miserably and often had to be stopped and primed after losing its water. The contractor finally agreed to dig up the pipe and ascertain where the trouble was. It became my duty to test every joint as exposed. There was a foot valve at the rims and I adopted the method of stopping the pump and opening a bypass from the delivery to the suction pipe, letting about 30 pounds onto the latter. We left this pressure on for ten minutes, keeping a pan under the joint so as to catch and determine the amount of water that leaked out. In this way we discovered 21 leaks of from 1 to 14 ounces in the ten-minute test, the total of all being 7½ pounds, or 314 pounds per minute. When they were all made tight the pump worked all right.

Most of the leaks were at the bottom of the joint where the lead meets, and was partially cooled, after flowing down the sides of the joint, and possibly due to the fact that the joint does not always get as good calking there as on the more accessible top and sides.

The difference between good and poor work is shown in the fact that we have in daily use a 6-inch galvanized wrought-iron pipe, 700 feet long, with a lift of 24 feet, which is perfectly tight and has been for thirty-one years.

PETER H. BULLOCK.

Concord Junction, Mass.

Firing Stationary Boilers

The remarks on firing stationary boilers, by J. F. Bradley, in the January 5 number, in which he quotes Mr. Wadleigh as saying: "The fireman should know that the place to shut off or regulate draft is at the stack damper and not by the ashpit doors, the latter being for the purpose of *regulating the air supply*," arouses my curiosity as to how Mr. Wadleigh differentiates between regulating the draft and regulating the air supply.

Mr. Bradley's theory that smoky coal will clog the tubes quicker with the damper partly closed than with the ashpit doors partly closed is true. The fact that it took him a long time to figure out the why and wherefore thereof is no indication that he is slow at "figuring," but that the question of properly operating a steam boiler is one that bothers a whole lot of people.

Regulating draft is primarily a question of fuel economy; secondarily, a question of load variation. I assume that we are dealing with hand-fired boilers, in which case the fuel is fed intermittently, which fact necessitates the intermittent admission of air to the fire.

In my judgment, the ashpit doors should be left wide open while the boiler is in service, and *after* each fresh firing, the stack damper should be opened wide until the gases have been consumed, when the damper should be partially closed the correct amount to take care of whatever load happens to be on the boiler.

After the volatile gases in the coal have been consumed, the passage of excessive air through the furnace results in loss of heat by carrying it up the chimney.

The ideal draft regulation provides for full draft after every fresh charge of fuel, a gradual diminution, according to the load on the boiler, and finally cutting down the draft to the last degree permissible. Such regulation will not increase the deposit of soot in the tubes for the reason that combustion will be more complete and less soot will be made.

E. G. TILDEN.

Downers Grove, Ill.

Filtering Oil

When I had charge of a producer-gas plant and gas engines it at first seemed impossible to get rid of the carbon in the oil that drained from the engine bearings. However, I finally took three cast-off filters of different sizes, took out the filtering arrangements and connected them as shown in the sketch. I put a ½-inch brass coil in can *A* and connected it to the exhaust pipe of the water pump. This gave me just about steam enough to keep the oil warm. I also connected a live-steam pipe to it, so I could shut off the exhaust steam and turn on the live steam, raising the temperature of the oil to 140 degrees. I did this to determine the proper temperature and get the best results. Can *B* was made as shown by putting a perforated plate in the top, the full diameter, which rested on lugs made fast to the sides of the can. The bottom side of this plate was covered with two thicknesses of cheesecloth. Lower are two perforated plates, the space between them being filled with excelsior, and still lower is a similar section, the space being filled with pine chips.

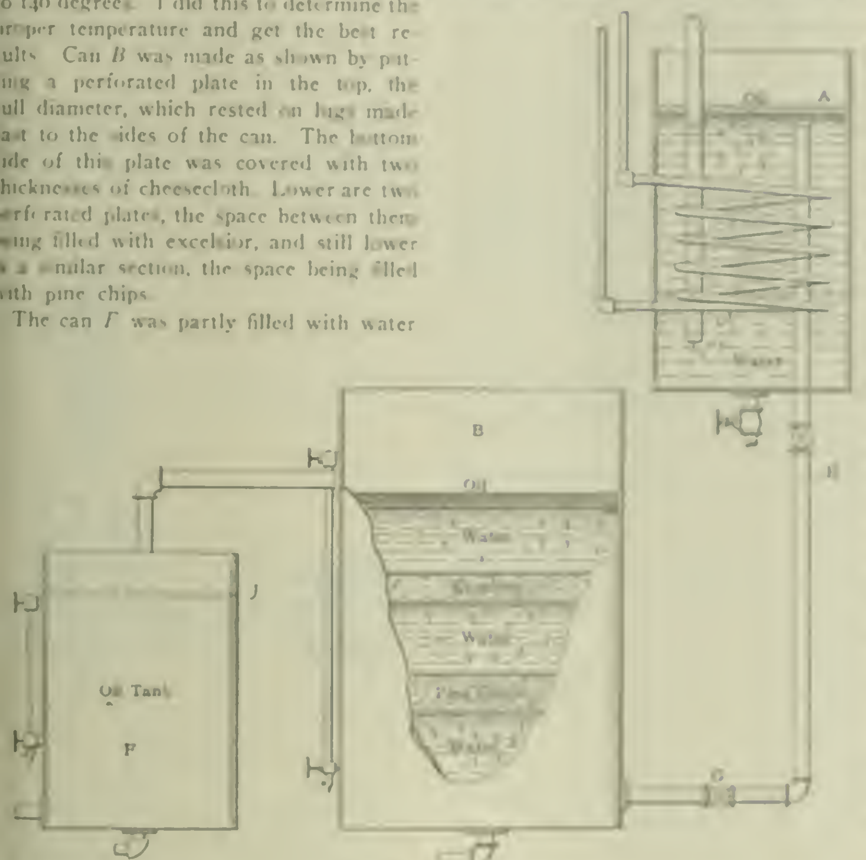
The can *F* was partly filled with water before putting oil in it. I found I got the best results by passing the oil through the pipe *G* and up through all the different parts of the filter.

The operation of the filter is as follows: The oil descends from the engine bearings through the pipe, passing down to within 8 inches of the bottom of the can *A*, rising up around the heated coil to the end of the pipe *H*, and flowing down to the base of can *B*, up through the water, pine chips, excelsior and cheesecloth and out through the overflow to the can *F*. It then passes down through cheesecloth at *J* and is pumped back to the elevated tank. This did the trick with a temperature of 90 degrees Fahrenheit.

Blow-down pipes are placed in the bottom of each can, and all the dirt that collects can be blown off. The pine chips are renewed once a week and the steam hose played on them to cleanse of dirt, etc.

W. A. Dow.

Cambridge, Mass.



HOMEMADE OIL SEPARATOR

Hygrometry

On page 63 of the January 5 number, W. V. Treeby attempts to criticize a statement made by J. H. Hart in an article on "Hygrometry," which appeared in a recent issue. It would appear that Mr. Treeby has an entirely wrong idea as to the meaning of the word saturated as applied to steam. If he will brush the cobwebs off of his physics and consult some handbook on steam, he will find that saturated water vapor or steam does not mean that the vapor or steam is "saturated with heat units."

When steam and water are present in the same vessel, and there is no tendency for the water to change into steam, or the steam into water, except as heat is added or taken away, the water and steam are then said to be in thermal equilibrium. When steam is thus in equilibrium in contact with water, it is said to be saturated. When there is no moisture of water in the liquid condition suspended in or mixed with the vapor, but it is still in the saturated condition as determined by its pressure, temperature and volume, it is called dry and saturated. When there is moisture or water suspended in or mixed with the vapor, the steam is said to be "moist" or "wet." In such cases the steam or vapor part of the mixture must itself be in the saturated condition as defined above, so that wet steam is simply a mixture of saturated water vapor and liquid water.

John French.

Brooklyn, N. Y.

Boiler Setting

The boiler setting illustrated on page 71 of the January 5 number has so many bad features, without any good ones that I have been able to see, that I doubt very much if any set of conditions would warrant its use.

If such a setting could be maintained in good order, which is obviously impossible, we are still confronted with the fact that the soot-blower door is between the fire and the boiler, and cold air would leak through the cracks around the soot doors and mix with the furnace gases before they pass into the boiler tubes.

Aside from this, the soot door produces a source of air leakage in the brickwork and removes a section of brickwork right where a refractory material is most needed for the purpose of raising the temperature of the gases to the igniting point before passing into the tubes. Add to this the loss due to radiation through the thin cast-iron soot door, and it is very easy to account for the loss of a very respectable part of the fuel at this one point.

Turning to the dividing wall midway of the boiler, in practice it would be found impossible to maintain a tight joint between the top of this wall and the shell of the boiler so that instead of the gases following the path that the designer expected, some would "short-circuit" over the top of the wall directly to the chimney without having passed through the boiler at all.

The worst feature of this setting is the absence of a roomy space between the fire and the boiler, where the gases, when distilled from fresh fuel, will have a chance not only to expand and mix with the oxygen of the air coming through from the ashpit, but must flow by or through a mass of incandescent firebrick, thereby raising the temperature of the gases to the igniting point before entering the tubes.

If we are dealing with a working gage pressure of [illegible] lb., [illegible] possible the temperature of the water in the boiler will be [illegible] degrees Fahrenheit, while with the ordinary setting the brick furnace and combustion-chamber lining can be kept at [illegible] degrees Fahrenheit to promote combustion. [illegible]

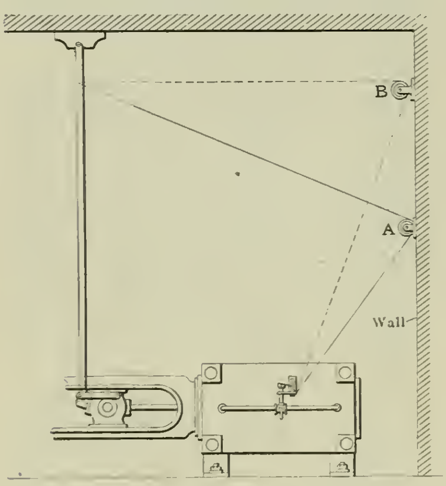
This setting provides a "water space" at the [illegible] but the furnace gases must pass through the comparatively cold boiler tubes before reaching it, which necessarily lowers the temperature to such an extent that any unburnt portion of the gases must be lost.

E. G. Tilden.

Downers Grove, Ill.

Faulty Indicator Reducing Motion

When I was the master mechanic of a certain company in a small town, the manager and chief engineer of the town lighting plant brought several indicator cards to my office and asked me if I could see anything wrong with them. After studying them, I told him that they were very good, and, in fact, I would consider the valve adjustment all right. The cards were taken from a small Corliss engine that they had just installed to drive an alternator. The engine was second-hand, but seemed all right except that the belt flopped badly. The next day I went to the plant and immediately discovered the



REDUCING-MOTION RIG

engineer's error. He had made a reducing motion out of a piece of 1x4-inch pine stick, pivoted to a block fastened to the ceiling, the other end linked to a pin screwed into the crosshead.

The pendulum hung vertically when the crosshead was in the center of its travel. The link was so connected to the pin in the lower end of the pendulum that it swung an equal distance above and below the center line of travel of the pin in the crosshead. In locating his carrying pulley he had placed it as high as he could reach by standing on the cylinder, which brought it to about the position as shown at *A*, in the illustration, which caused a very misleading diagram to be produced.

We raised the carrying pulley to the position shown at *B*, so that the cord (see dotted line) would lead from the pendulum at a right angle when the pendulum was in the center of its travel. When the valves had been readjusted the belt ran without flopping.

V. R. Hughes.

Denver, Colo.

Steam Condensing Plant

G. A. Orrok, in his letter in the December 22 number, on surface condensers, mentions that careful experimenters are reported to have obtained rates of condensation in steam surface condensers as high as 40 or 50 pounds per square foot. It may be interesting to readers to know that in the experiments at the Hartlepool engine works on a small contraflo condenser, designed for use as a winch condenser on board ship, I obtained rates of condensation up to 80 pounds per square foot, and have no reason to believe that I reached the limiting rate of condensation. This condenser had 100 square feet of cooling surface, and the steam was condensed at atmospheric pressure, the air blowing off through a relief valve and no air pump employed. In the tests in which 80 pounds of steam were condensed per square foot of surface, the circulating water entered at 39 degrees Fahrenheit and made its exit at 195 degrees Fahrenheit. The tubes were 5/8 inch external diameter and the velocity of the water through them was 4.6 feet per second.

I believe that with a higher velocity of water a greater rate of steam condensation could have been obtained. It should be noted, however, that the steam was at atmospheric pressure. Steam under a high vacuum is much less dense and, therefore, in a much less favorable condition for a high condensation rate.

With reference to the statement that the heat transmission in surface condensers is proportional to the cube root of the velocity of the circulating water through the tubes, I believe that the heat transmission varies sometimes as the cube root, sometimes as the square root, and sometimes almost directly as the velocity of the water. In fact, the law connecting the transmission of heat with the velocity of the water is of a somewhat complicated nature, but the subject is too big to enter upon on the present occasion.

In Charles L. Hubbard's article on condensers, in the same number, he refers to the relative quantities of condensing water required by a parallel-flow jet condenser, such as that illustrated in his Fig. 5 (reproduced here) and by a surface condenser, and states that the water required by the former is less than that required by the latter. I think that this statement is somewhat misleading.

Assume that the vacuum is 27 inches of mercury (with barometer at 30 inches) and that the condensing water is received at 65 degrees Fahrenheit. The temperature of saturated steam at 27 inches vacuum is 115 degrees Fahrenheit, but as air is always (under practical working conditions) present in the steam the discharge temperature of condensing water and water of condensation in a condenser such as that shown in his Fig. 5 must be considerably below 115 degrees—say 105 degrees. The latent heat of steam at 27 inches of vacuum is 1034 B.t.u., so that the heat withdrawn from the steam is 1044 B.t.u.

Let

W = Pounds of steam per hour,

Q = Pounds of condensing water per hour,

t = Temperature of discharge of condensed steam and condensing water.

Then, as the heat gained by the water must equal the heat lost by the steam,

$$Q \times (105 - 65) = 1044\, W$$

and therefore

$$Q = \frac{1044\, W}{105 - 65} = 26$$

pounds of condensing water.

Surface condensers are variously constructed and worked, and the results obtained with them vary accordingly. The best results as regards consumption of

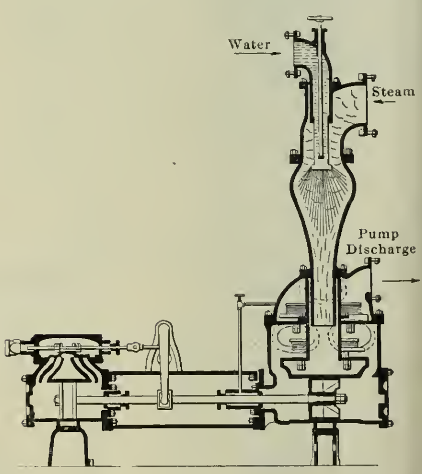


FIG. 5. A COMMON FORM OF JET CONDENSER (REPRODUCED)

condensing water are obtained with surface condensers of the countercurrent type, that is, in condensers in which the general direction of flow of the circulating water is opposite to that of the steam. The exit temperature of the circulating water in such condensers may be anything between its inlet temperature and the inlet temperature of the steam, depending on the design of the condenser and the quantity of water employed.

Professor Weighton in tests on an experimental contraflo condenser at Armstrong College, Newcastle-on-Tyne, England, obtained exit-circulating water temperatures practically the same as the inlet temperatures of the steam and, in fact slightly in excess of the temperatures corresponding to the vacuum maintained It is all a question of design and proportions.

Hence with a 27-inch vacuum and circulating water at 65 degrees Fahrenheit i would be quite possible (although it migh not pay in practice) to have an exit-circulating water temperature of 112 degrees Fahrenheit.

The heat withdrawn from the steam would then be 1037, and we would have

$$Q = \frac{1037\ 11}{112 - 65} = 22$$

pounds of condensing water, considerably less water therefore being required than in the case of the jet condenser.

As aforesaid, a design of surface condenser to give this result might not pay; but, in steam-turbine installations, where the temperature of the circulating water is in the neighborhood of 80 to 85 degrees Fahrenheit, as is common when cooling towers are employed, it usually pays to arrange the surface condensers to use less water than would be possible with a jet condenser of the nature of that shown in Fig. 5 of Mr. Hubbard's article.

Mr. Hubbard referred to cooling towers and mentioned that with the best forms it was claimed that the water could be reduced in temperature 40 or 50 degrees. With the wooden natural-draft towers, which may be said to represent standard practice in turbine power stations in Great Britain, the water is usually cooled to about 80 to 85 degrees Fahrenheit, the inlet temperature of the water to the tower affecting its exit temperature to a comparatively small degree.

R. M. Neilson.

Glasgow, Scotland.

Valve Problem

The answers to the valve problem on page 59 of the January 5 number, are interesting but very conflicting. For instance, G. A. Glick and B. A. Snow both claim that 358 pounds per square inch would be necessary to raise the valve against 100 pounds pressure per square inch on top, whereas J. C. Hawkins says that 100.9 pounds pressure per square inch will be sufficient. I agree with him, as under practical working conditions it is only necessary to consider the area that actually covers the openings, and not the total area of the valve disk.

I know of large pumping engines having valves similar to the one I illustrated on page 970 of the December 8, 1908, number, only much larger, and I should judge that the actual valve passages were not more than half the area of the valve disk, yet I am certain that the pressures in the pumps were never more than a few pounds above that in the lines, whereas according to Mr. Snow and Mr. Glick they ought to be about double.

Under practical conditions I do not believe that any valve seats so closely as actually to touch surface to surface all over, which it would have to in order to fulfil the conditions assumed by Messrs. Glick and Snow. The surfaces only touch in a few places, the remainder being separated by a film of liquid or gas—whichever may be used—in this: that the adhesion and surface friction is enough to resist the actual flow, but as the difference in pressure on each side of the valve becomes less and less, the elasticity of the material where the surfaces actually touch is compressed, thus slightly increasing the thickness of the film and allowing the pressure of the liquid, or gas, to be transmitted over a greater area until, as the pressures become equal, and the under side of the valve is receiving the full pressure, a slight increase will lift the valve. I believe it is possible to surface a valve and its seat so accurately that the pressures will have to be proportional to the top and bottom areas before the valve will start.

George P. Pearce.

Exeter, N. H.

A Homemade Condenser

In the December 29 number, M. D. Caspar asks for advice for making a condenser for the returns from an exhaust steam heating system.

The only device that he needs, as far as I can see, is an ordinary low-pressure pump connected direct to the return main and large enough to handle the volume of water that may accumulate. This pump may discharge into a heater or hotwell, etc., as conditions warrant. A pump will handle the water as it collects, provided the pump is placed at a lower level than the system, so that the water will flow to it by gravity.

Charles A. [illegible]

[illegible], Penn.

Coal Consumption

I was much interested in the article on coal consumption per kilowatt-hour by Mr. [illegible], in the December 29 number, on page [illegible], in which he notes the difference between two plants, one containing engines fitted with a long-range cutoff and the other with engines having only one eccentric. His figure of [illegible] pounds per kilowatt-hour is the lowest I have ever heard of. I fail to see where the type of valve gear would make the difference noted. The only advantage I see in the long-range cutoff is the ability to handle sudden overloads. If the engines were running at their most economical load, which they must be doing to make a kilowatt-hour on the given quantity of coal, the single-eccentric engine would cut off just the same as the double-eccentric engine, and the only difference indicator diagrams might show would be in the compression curves, and they would probably be the same. I am inclined to believe the difference in the coal consumption can be traced back to some other feature of the plant.

[illegible] H. Lane.

Kansas City, Mo.

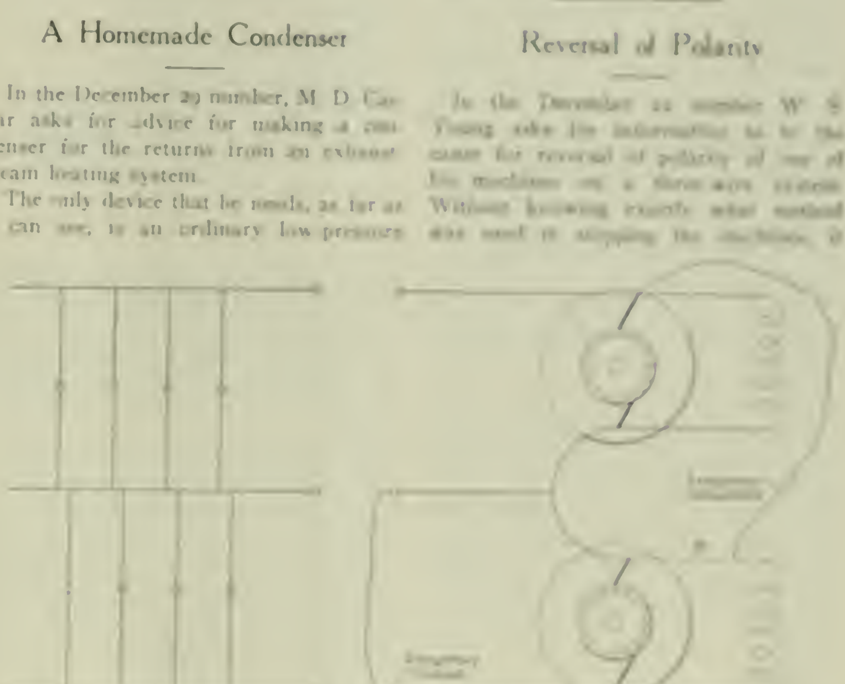
Reversal of Polarity

In the December 22 number W. S. Young asks for information as to the cause for reversal of polarity of one of his machines on a three-wire system. Without knowing exactly what method was used in stopping the machines, it would be hard to tell the real cause. If there were any motors on that side of the system, it might possibly have been caused by a "back kick" of one of them at the time of shutting down.

I once had charge of a three-wire system using the same type of machines, one of which frequently became reversed without any apparent cause.

A method of righting a reversed machine on a three-wire system, requiring only a few minutes' time and no change of connections, except temporarily changing one field wire, is shown in the accompanying diagram.

To operate, raise the brushes from the commutator of the reversed machine, disconnect the shunt field wire from the negative side and connect it temporarily to the positive brush of the other machine. Make a "jumper" across the brush leads of the reversed machine [illegible]



METHOD OF RIGHTING A REVERSED MACHINE ON A THREE-WIRE SYSTEM shown, and brings the voltage up on the other machine. Then shut down and remove the "jumper" connection and the temporary field connection, leaving it connected to the neutral winding in the usual way, as shown by the dotted lines at *P*. Then put down the brushes and the polarity will be correct. Either machine can be righted in the same way, but always be careful to have the brushes raised, and to remove the jumper before starting up the machine which has been reversed.

S. KIRLIN.

Dallas, Tex.

An Air-cooled Condensing Plant

In the twelve years that I have read POWER there have been many valuable articles in its columns, treating on condensing plants, their installation, cost of operation, maintenance, etc., but I have failed to read of any that cost practically nothing to install and nothing to operate.

Some years ago in the oilfields of western Pennsylvania all wells were pumped by steam power, gas engines not being in general use at that time. In one particular locality the only water-pumping station was abandoned about this time as a nonpaying investment. As well water was unfit for boiler use, the use of the surface condenser and rainwater were the only means of obtaining the necessary water for operation.

The condenser was made of old 6-inch pipe that had outlived its usefulness in the oil wells. It was laid out on the ground in such a way that the water of condensation would drain back to a barrel sunk in the ground under the pump which was attached to the crosshead of the engine. The amount of pipe required depended on the size of engine and the load it was carrying. Usually 600 to 800 feet were sufficient for each 20-horsepower engine.

The exhaust steam of the engines was expelled into this pipe, where it would be condensed and returned to the pump; in some instances the loss was so small that from six to ten barrels of makeup water was sufficient for 40 horsepower of engines each twenty-four hours. The makeup water was supplied from storage tanks in which was caught rainwater from the roofs.

It might be said that plants were operated twenty-four hours a day, except Sundays, by one man who worked on the lease in daytime and went to his home at night. The boiler was equipped with a gas- and steam-pressure regulator, combined with a low-water alarm which blew a large whistle, calling the pumper from his slumbers in case the water got low in the boiler. There were several plants operated in this manner for a number of years without any serious accidents and no one looked upon it as remarkable.

J. A. MAWHINNEY.

Franklin, Penn.

Testing Watt-hour Meters

In the issue of January 5 I note an article by O. F. Dubruiel on "Testing and Adjusting Watt-hour Meters." A power station not already equipped with stop watches, voltmeters and indicating wattmeters would do much better to buy a portable standard integrating watt-hour meter, otherwise known as a rotating

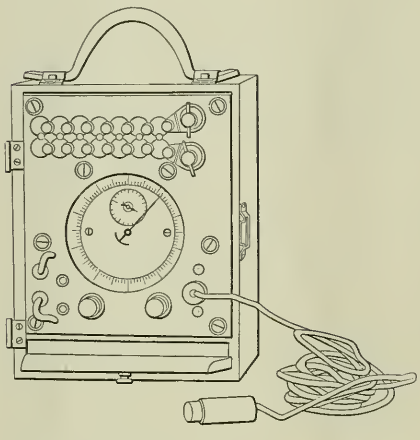


FIG. 1

standard, for from $60 to $65. These are now made by all the large companies and are very much simpler and easier to use. No voltmeter or stop watch is required, as any variation of voltage or load affecting one meter affects the other in the same way.

The meter has the appearance shown in Fig. 1, and can be changed from 110 to 220 volts by simply changing the small leads shown at the lower left-hand corner of the faceplate. The meter is stopped and started by means of a push switch at the end of the cord and the dial registers the number of revolutions of the standard meter; by counting the number of revolutions of the meter under test, clos-

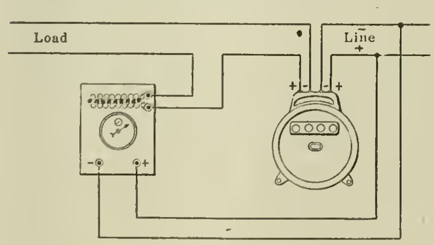


FIG. 2

ing the switch on starting and opening it on stopping, a direct comparison is obtained and the percentage of error may be easily calculated. One man can easily test several meters a day. Better still, it is quite practical with this instrument to test a meter on the customer's premises.

The connections are very simple, as shown by Fig. 2, and a table accompanies each meter giving percentages from 6 per cent. slow to 6 per cent. fast for all standard makes of watt-hour meter. The instrument is adjusted for different current capacities by means of the plugs at the top of the face plate.

JOSEPH B. CRANE.

Broadalbin, N. Y.

Engine Foundations

There can be no hard-and-fast rule for building foundations of any character, especially for engine work. In best practice it is found that foundations for this class of work should be governed by the weight of the machinery placed on them. A safe construction for a foundation is to know the weight of the machinery, and build the foundation one-half heavier than the engine, i.e., if the engine weighs 150,000 pounds the foundation should weigh 225,000 pounds. This applies to small installations, as well as to large and heavy work.

Every heavy foundation should have a base which separates it from the foundation proper. It is better to have a foundation which will have some "give and come" to the action of the engine. The slight movement if taken up on an earth or sand bottom, would in time wear it away, especially where water soaks in alongside, and the settling is liable to make the engine work out of line.

Where concrete floors are used in engine rooms there should be a space of about 1/8 inch between the floor and foundation to permit the vibration of the foundation and not to impart the jar to the floor.

The writer recalls where the floor for an engine was waterproofed at great expense, the earth being of salt-marsh formation, where test piles with a 1500-pound hammer "keep going" after 85 feet of driving. Thirty-foot piles were driven under the engine and the waterproofing placed on the top. When the erecting engineer came to install his work he found only 18 inches between the floor line and top of the waterproofing. The drawings called for a foundation 3 feet 6 inches in hight, or extending 24 inches above the floor line. The "young man" followed his instructions and the top of the engine bed was placed 36 inches above the floor level.

This engine has been in use about 1[illegible] years and is satisfactory in every way except the hight of the engine bed above the floor. Since then there have been two engines of fully as large capacity placed in the same room, with the foundation spreading 14 inches outside of the engine bed in every direction, and only 12 inches above the floor line. These engines have also proved satisfactory.

FRANCIS H. BOYER.

Somerville, Mass.

Some Useful Lessons in Limewater

A Simple Method of Remembering What Has Been Told in Previous Lessons; Softening Temporary-hardness Water; Some Chemical Shorthand

BY CHARLES S. PALMER

The only sensible way for common workaday folk to learn the value of a thing is to use it; and so we will try to put this limewater to work at once. We have found out that the plain lime carbonate is insoluble, and that is what makes most of the soft scale from temporary-hardness water. Then what we want to aim at is to get this plain lime carbonate out of the water before it goes into the boiler. Now you have found out that you can go to the plain carbonate of lime in two ways. One is by starting with limewater, and adding carbonic acid (from the breath, from the gases of burning coal, from bottled "fizz," or from acid and marble or soda); the other way is by taking out the extra carbonic acid from the extra, or double, or bicarbonate of lime (temporary-hardness water) by heating it, when the extra carbonic acid goes off, and down comes the plain carbonate of lime.

You must get these two ways fixed in mind; and one good thing to do is for you to stop right here and set down this simple formula. Don't be satisfied with merely looking at this once, but write it for yourself several times, until it is stamped into your memory so that you can see it in your mind's eye any time. Here it is:

Limewater *Soluble*	<——>	*Plain Lime Carbonate* *Insoluble*	<——>	*Extra Carbonate of Lime* *Soluble*

The double-headed arrows mean that you can go from one substance to another; and if you stop to think of what you have done, you will see that this is a kind of shorthand reminder of it all. You did go from limewater to plain carbonate, by adding some carbonic acid; and you passed from this to the extra carbonate of lime, by adding more carbonic acid; then you came back from the extra carbonate of lime to the plain carbonate by taking out this extra carbonic acid. And this last step is what that heater is for. So you see how handy this formula is.

The double arrows tell, even, much more than can be told here. Thus briefly, the plain carbonate of lime, or limestone, is first changed into lime by burning in limekilns; and you can imitate that by burning some marble in the front part of your furnace. About all the other steps indicated by the arrows have been shown in the various tests that you have made or are making.

Now you begin to get the fundamental chemical notion that "salts," such as plain carbonate of lime and extra carbonate of lime, are made up of acids and bases. In this case, the lime is a base. There are strong acids and there are weak acids, and, also, there are strong bases and there are weak bases. When a base is soluble in water, it will turn litmus blue, and such water-soluble bases are called alkalies; and so it comes that limewater is an alkaline base. Some bases, like iron rust, are good bases, and can neutralize acids, forming "salts," but iron rust is not very soluble in water, and so it is not alkaline like the soap, the ammonia water and the soda. (This "soda," by the way, is really a "salt" made up of carbonic acid and the metal sodium, but the sodium is so much more active as a base than the carbonic acid is active as an acid that the soda, as a whole, acts like an alkali. But we will study that more carefully later.) Now you begin to get this fundamental notion of the base part and the acid part of every "salt." You begin to see that you can get, by mixing the base and the acid in various quantities, "salts" which may be even in base and acid, i.e., plain salts, or "salts" with more of the acid, as in the case of the extra carbonate of lime, and, in other cases, even "basic salts" with more of the base than acid in them. But this is the point that we are aiming at. You have one way to soften temporary-hardness water by driving off the extra carbonic acid with heat. The formula reminds you of that step; but why not work the same scheme in another way? Why not get some handy base to mix with this soluble extra carbonate of lime, and bring it back to the plain carbonate? That is another way to soften temporary-hardness water.

Softening Temporary-hardness Water

It has perhaps occurred to you that if the lime in water is a base, and if the soluble lime salt, lime bicarbonate, is an extra carbonate, why not mix some of the limewater with this extra carbonate and get the insoluble simple carbonate? So we make some more of the artificial temporary-hardness water by blowing through the plain limewater until the white cloudiness that first comes is redissolved, and, as before, we filter it to get as clear a solution as possible. Now we mix the two, the plain limewater and the solution of extra or bicarbonate of lime which you have just made. You have learned that as the limewater had some base, and as the bicarbonate of lime has extra acid, you ought to get the neutral white sediment down; and that is just what happens.

Down it comes, or, rather, it comes out of solution, but it doesn't settle with any surprising quickness. However, you have got it out of solution, and that is something to be thankful for. If you give it time to settle, plain limewater would take the lime sediment out of temporary-hardness water just as well as heating it would, because both methods change the extra or bicarbonate of lime to the neutral or insoluble carbonate. But in the solution you have used you worked with water of the same strength, or having the same relative amounts of lime and bicarbonate, while the water that you would run across in practice will run all the way from only a little carbonate-of-lime hardness to nearly as much as equal volumes of limewater solution and extra-carbonate solution will throw down. You ought to stop and study this process—by the way, the books call this Clark's process for softening temporary-hardness water—and you will see that it amounts to getting the sediment of plain carbonate of lime by mixing the base, lime, with the extra-acid salt of lime. Indeed, you can get a kind of simple chemical equation by the following formula:

Limewater *Soluble*	+	*Extra Carbonate of Lime Soluble*	=	*Plain Carbonate* *Insoluble*

The books write this same process in the form of some curious letters and figures, and pretty soon we will begin to get acquainted with some of these things, for they are only so many helps to thinking and doing. One thing that you want to remember is this: That, within all reasonable limits, you can do anything down in the dusty boiler room that anyone can do in the best laboratory in the world. This is so, since Mother Nature is right at your elbow keeping the action of those chemicals as carefully as though she had a member of the Royal Chemical Society, and whatever she happens to [illegible] laboratory in Paris, Berlin, London, or New York she [illegible] to your boiler room. The laws of chemical action follow [illegible] everywhere. You know this because you learned the laws of mechanics [illegible] boiler rooms [illegible] skyrocket up into the air, follow it in its glorious explosion, and follow each of the glittering sparks as they float down through the air. So no one has any monopoly on chemical action, nor on brains, either.

But to get back to Clark's process of softening temporary-hardness water. You can see that it would be no end of bother to make even a barrel of filtered limewater; and a useless bother, if we could put quite a large quantity of lime in a small bulk of water and make it do its work with the large volumes of water which have to go into the boiler. If you go back to the lime from that barrel, you will remember that it takes several hundred parts of water to dissolve one part of lime as you filtered it clear. But you will note that when you put several lumps of lime into water, it crumbles and can be stirred up to a milk, a thin, porridge-like liquid. This is called "milk of lime," and it is a mixture or "emulsion" of lime in limewater. You can see that very little of this milk of lime will do the work of a whole lot of filtered limewater, in the neutralizing of the extra carbonate of lime, and bringing it back to the insoluble plain carbonate of lime. Thus, you see that you could use this way to soften temporary-hardness water.

But it is best to know how much of the milk of lime to use with any special water, and with the same water at different times of the year, and you can learn all of this by keeping along with these lessons. You will find that the man who learns to figure the problems that he runs up against as a rule comes out ahead in the great game of life; while the man who dodges figures, whether in the office or in the boiler room, is simply letting somebody else do his rightful work and get his rightful pay. So we will gradually get at some of these figures, and the ways of calculating the milk of lime needed to soften any grade of water.

Some Chemical Shorthand

And, now, toward the end of this shift, just a word about some chemical shorthand that you will find very handy, if you don't try to choke yourself with too big a mouthful at the start. Just take it by bits. You know how to read and write; and you would be ashamed not to; and in the same way, you want to know how to read and write chemistry; not all that can be written—and much of that does not concern you at all—only the common elements. Now what is your name? Smith? Well, S is your initial, isn't it, and don't you use it for short? Good, then S stands for Smith, the unit man who walks under your hat. So in the same way, C stands for carbon, the unit chemical that is in coal; O stands for oxygen, the unit thing in the air that helps your coal to burn; Ca stands for the metal calcium that is at the bottom of your friend, lime; and H stands for hydrogen, which is found in water, in wood, in soft coal, and many other things. Thus far we have studied limewater, with a glance at carbonic acid; but there is the burning of the coal that must come as soon as we have got well along with this question of water supply, and you will find it very handy to use some few of these initials of the chemical units or elements. For you will not only want to use this chemical shorthand in a simple way in these boiler-room studies, but you will outgrow this simple material one of these days; you will get gloriously mad with yourself, and go to reading better and bigger books, and you will find that all of them use this chemical shorthand, so we may just as well begin to get acquainted with it right here and now.

Then C stands for carbon; Ca for calcium, the metal at the back of what you call lime in general, with all of its compounds; O stands for oxygen, the thing in the air that helps burning; and H stands for hydrogen, a metallic gas—that is straight—a metallic gas, and yet cousin to carbon and coal in the way it burns. There is a lot of hydrogen burning under your boiler, and there is hydrogen in all water, and, of course, in all water compounds. We will not hurry, for it takes time to get things in the head so they will be right and stay there. But, if you are patient with yourself, you will learn these and many more, so you can handle them easily and surely. But the only way really to learn about a thing is to use it, from the start. Let us use these shorthand symbols for the elements that we have run across in this limewater lesson.

Now, lime is the rust or oxide of a metal, and we tell that long story in this short formula, CaO. That is lime, the stuff in the barrel that you are sitting on. The formula says that lime is made up of calcium and oxygen, and every time that you see or use this formula, you are reminded that lime, common quicklime, is made up of calcium and oxygen. You don't have to remember it; it remembers itself, and reminds you all about its own makeup. So, then, lime is an oxide of the metal calcium; and yet we never lose any flesh worrying over calcium itself. Not that calcium may not have a whole lot of most interesting information of its own. Thus, if you should get some of the metal (and it is a trick to get it), you would see a white metal—very light weight for a metal, about twice as heavy as water, while common iron is nearly eight times as heavy as water, copper nearly nine, and lead more than eleven times as heavy as water.

This metal, calcium, cannot be kept lying around in any old way, as the common metals can; for, if left in the air, it rusts itself away and changes to lime, and you know that lime cannot be kept long, for it takes on water and other things from the air and gets "air-slacked." This metal calcium melts at a higher temperature than lead, but it can be cut, drawn and rolled; in short, it has the "metallic" action in general. But this metal never shows its head in the metallic form, unless one gets after it with special plans and methods; and all that does not bother us a bit, because it is not the metal as metal that we are concerned with, but some few of its compounds that have had the nerve to make your water hard in several facetious ways. It is the compounds of this metal, calcium, which we are studying: Lime, the oxide, CaO; the simple carbonate, $CaCO_3$; the bicarbonate, $Ca(HCO_3)_2$; and the like, that we want to get at, for we have only begun to open up the mystery of that barrel of lime.

But to sum up what we have touched on thus far, there are two ways of softening temporary-hardness water: One is by driving off the extra carbonic acid by warming, as in your heater, and the other by driving down the extra carbonic acid by an extra base as lime; and in both cases we get the plain carbonate of lime thrown down. Of course, we must have the right tank for the water to settle out clear, in either case; but we have laid the fundamentals, and now it is up to you to study what kind of heater or settling tanks you are using, and whether they are suited to your work in design, in material, in size, in the piping and connections, and the like. But you should try this second way of softening temporary-hardness water, by adding a few drops of the limewater emulsion, milk of lime, to some of the temporary-hardness water, say a teaspoonful of the milk of lime to a pint of the hard water, with quick stirring, and then allow time to settle. Each part of this simple experiment will tell you something that will relate to the action of the water softener that you may have in the boiler room. Thus it may take some time for the plain carbonate to settle out, and that may suggest why your settler may not always work as it should.

Some Simple Tests

There is one other thing that you will want to do before you close this shift; that is the way to tell, by a simple test or two, whether you may have temporary-hardness or permanent-hardness water. When you add some of the milk of lime to the water, with good stirring, and then add a teaspoonful of nitric acid, if the whole solution clears up, you have only temporary-hardness water. But if you take some of the solution of barium chloride (or nitrate), and add a few drops to a sample of water, you may get a white cloudiness; now add a teaspoonful of hydrochloric acid or of nitric acid to this, with shaking or stirring, and if it clears up, the water is of the temporary-hardness, or carbonate kind; but if the cloudiness of the water persists after adding the nitric acid or the hydrochloric acid, you have some permanent-hardness water, of the sulphate kind, and that is harder to deal with. But even in that case, it will pay you to know what the trouble is, for sometimes you can conquer it, and at reasonable cost.

The idea that you want to carry with you is this: Temporary-hardness waters have to do mainly with carbonates of lime, while permanent-hardness waters have to do with sulphate of lime. Sulphate of lime is a compound of lime with sulphuric acid, the heavy oil of vitriol that you have seen about shops for cutting the scale off of forgings. There is one thing, too, that you want to remember about this sulphuric acid: It has a great liking for water; therefore, when you dilute the acid, always *pour the acid into the water* (never the water into the acid). The solution of sulphuric acid that came with your outfit is probably already diluted with water, that is part of the chemical story of water, which runs right along with the story of lime.

Screens for Pump Suctions

By Alonzo G. Collins.

In designing the arrangements for a supply of condensing water for the steam engines of an electric-light station some years ago, it was considered advisable to place the fine screen for intercepting the smaller trash in the water, near the station, where it would be more convenient for cleaning, and a coarse rack over the end of the suction pipe in the river to intercept the larger débris.

In addition to such things as logs, cordwood and branches of trees, this river water carried a large amount of semifibrous material, such as grass and small thread-like roots, for which a rather fine screen was required, and the screen must be arranged so as to be readily cleaned of the accumulation without interrupting the water supply.

This was accomplished by duplicating a short section of the suction pipe, just before it entered the building, with a cylindrical screen chamber in each branch and a gate valve each side of the screen chamber, the two branches being connected to the single pipe at each end, as shown in Fig. 1. Fig. 2 is a section through one screen chamber and an elevation of the other. The covers of the screen chambers were fastened by hinged bolts, which could swing through slots in the flanges, and with monkey-tailed nuts so as to avoid the use of wrenches.

The waste-water pipe from the condensers was laid in the same trench, but above the suction pipe, as shown in Fig. 2, and a 2-inch pipe led from the bottom of the waste pipe to each screen chamber, for filling the screen chambers after the screens had been cleaned and replaced.

In regular operation both valves were open in one branch and closed in the other. When the screen in use needed cleaning, which was about every six hours, the two valves on that side were closed and those on the other branch opened, thus diverting the water through a clean screen. The cover of the dirty screen was then removed, the screen frame, which set in grooves in the side of the chamber, was hoisted out, cleaned and replaced, the cover bolted on, the chamber filled with water through the 2-inch pipe from the waste pipe, an air cock in the cover allowing the air to escape.

This device worked so nicely that it

FIG. 1. PIPING CONNECTIONS OF SCREENS

was impossible to tell by observation of the pumps when the change of screens was being made. The vacuum gage would show it, as the clogged screen would cause an increase in the vacuum necessary to raise the water, which increase was not allowed to exceed 2 or 3 inches, and as soon as the engineer started the clean screen the vacuum would drop to its normal condition.

At the river end of the suction pipe, about 800 feet from the building, conditions were not so favorable. The river bank had been riprapped with heavy stone to prevent the bank being washed away, the slope being about 45 degrees and giving a good foundation to work on. Enough of the riprap was removed to make a trench that would cover the pipe, which was finally got into the water by

FIG. 2. STRAINERS IN POSITION

FIG. 3 [illegible]

making up a length of pipe on the bank, with a 45-degree elbow looking up stream on the lower end, and letting it slide part way down the bank with a tackle to prevent it getting away. It was anchored firmly by filling the trench around the pipe with concrete, the irregularities of the riprap making a most excellent anchorage. On the upper end of the pipe another 45-degree elbow brought it to line for the pipe to the building.

A number of old 30-foot railroad rails were procured and laid as a temporary falsework over the inclined pipe projecting out over the water, with the flanges up, and about 2 inches apart in the position shown by the dotted lines in Fig. 3. The reason for placing the flanges up was to ensure that the openings between the rails would be wider on the inside, so that anything that would enter the openings would pass on through and not be wedged fast.

Two pairs of heavy, flat cross bars were bolted across the bed of rails about 5 feet apart at the elbow end and one pair at the opposite end, with bolts between the rails to preserve the alinement. A substantial block of concrete was then built around about 5 feet of the shore end of the rails. When the concrete had hardened, a pair of shear legs was set straddling the nest of rails, with a tackle hitched to the outer end by a sling long enough so that the lower block of the tackle would be above water. Having taken the weight of the rails on the tackle, the falsework was removed and a wood fire built around the rails just where they projected from the concrete, first placing a layer of sand between the fire and the concrete to prevent injury.

As soon as the rails were red hot, the tackle was lowered and the rails bent to a neat curve, making as neat looking and as serviceable a rack as anyone could wish for.

The waste-water pipe was diverted from its position over the suction pipe before the rack was reached, and delivered the waste water downstream from the suction inlet, the velocity of the river giving ample assurance that there was no danger of the suction getting any of the warm waste water.

Burlap bags filled with concrete were then worked under the submerged portion of the suction pipe, and the triangular openings each side of the rails were closed up in the same way. The bags of concrete projected a little above the water line, and wooden forms were set up and filled with concrete to make a neatly finished job. Fig. 3 is a section of the rough screen in the river.

Catechism of Electricity

927. *Why is the word "abnormal" used in connection with the heating of direct-current motors?*

Because all motors in operation develop a certain amount of heat which cannot be prevented and which is not therefore considered a defect.

928. *Explain why a motor in perfect running order develops heat while in operation.*

Considering the motor electrically, heat is developed at the commutator and brushes and in the field and armature coils because it is impossible to force a current of electricity through a conductor without heating it.

Considering the motor mechanically, heat is developed in the bearings, commutator and brushes by reason of friction between moving parts.

Considering the motor magnetically, heat is developed in the iron portions, such as the frame and magnet cores, on account of the passage of magnetic lines of force through them.

929. *Is it an easy or difficult matter to locate the cause of abnormal heating in a direct-current motor?*

It is often difficult because both the defective and perfect parts become of practically the same temperature owing to the ease with which heat is conducted through and between them.

930. *How should such a case be treated?*

Stop the motor until it becomes perfectly cool. Then start it up and operate it under full load for about five minutes. Stop it again and carefully but quickly test each part for abnormal temperature by the sense of feeling.

931. *Give some rules to guide one in testing for temperatures by means of the hand.*

The ability to determine accurately in this manner the amount of heat developed can be acquired only by experience. If the hand can comfortably be held on the iron portion of a machine for several seconds, its temperature may be considered as being within the safe limits.

In connection with this test the condition of the hand must be taken into consideration as well as the conductivity for heat of the surface touched. Inasmuch as the back of the hand is far more sensitive than the palm, more reliable results will be obtained by testing with the back of the hand. If the surface of the iron is rough there will be more radiation than if it is smooth and, in consequence, its internal temperature may be higher than the sense of touch would lead one to suppose. Then, too, any paint on the surface of the iron also affects to a considerable extent the conductivity of the internal heat.

932. *How can more accurate results be secured than by the sense of feeling?*

By using thermometers.

933. *Give some rules for testing motor temperatures by means of thermometers.*

The bulb of the thermometer should be placed against the surface of the part whose temperature is desired and it should be protected from outside influences by a covering of cotton waste, the whole being held in position either by hand or tied by means of a string.

In connection with this test it is well to note the temperature of the surrounding air at the time the other reading or readings are taken, for the atmospheric temperature has, of course, a direct bearing upon the temperatures of the various parts of the machine.

934. *What temperatures of the different parts of a direct-current motor would be considered abnormal?*

For the field or armature, over 50 degrees Centigrade above the surrounding air temperature; for the commutator or brushes, over 55 degrees Centigrade above the surrounding air temperature; for bearings or other parts of the machine, over 40 degrees Centigrade above the surrounding air temperature.

935. *Is there any other method of obtaining temperatures of the parts of a motor?*

Yes, there is an electrical method particularly well adapted for securing the temperatures of the field and armature coils. The inaccessibility of these parts renders the hand and thermometer methods rather inadequate for the purpose. The electrical method is often used as a check on the temperatures obtained on the field and armature coils by means of thermometers.

936. *Explain how to obtain the temperatures of the field and armature coils by the electrical method.*

After the motor has been run under full-load conditions sufficiently long to insure the maximum temperatures being reached, the machine is shut down and a moderate direct-current voltage applied first between any two opposite commutator bars and then between the terminals of the field coils. In each case the amperes of current are carefully noted on an ammeter, and at the same time the drop or pressures between the points of application are also read on a voltmeter. Having, then, the current through the armature coils and through the field coils, and the respective pressures across them, their respective resistances hot may readily be calculated by dividing the latter values by the former ones.

In performing this test care must be observed that the testing voltage does not exceed the normal voltage for which the armature winding or the field winding is designed, in order that the testing current does not injure or unduly increase the temperatures of these parts; it is also necessary to note by aid of a thermometer the temperature of the surrounding air in degrees Centigrade at the time these measurements are being taken.

Having, then, at an atmospheric temperature of $T°$, the resistance in ohms which we will designate $R_{T°}$, the next step is to calculate what this resistance would be at zero degree Centigrade. Designating this unknown quantity by $R_{0°}$, the formula used is

$$R_{0°} = \frac{R_{T°}}{1 + 0.004\,T°}.$$

By substituting for the terms on the right-hand side of this equation their proper values, and dividing the numerator by the denominator, the value of $R_{0°}$ will be obtained. This value, together with that of $R_{T°}$, when substituted in the equation

$$T = \frac{R_T - R_{0°}}{R_{0°} \times 0.004}$$

will give the temperature in degrees Centigrade, at the time the measurements were taken, of the armature coils or of the field coils, depending upon whether $R_{T°}$ is the resistance hot of the one or the other.

Development of the Surface Condenser

Combination Condenser and Feed-water Heater; Condensers for Use with Steam Turbines; Countercurrent, Contraflo and Other Types

BY WARREN O. ROGERS

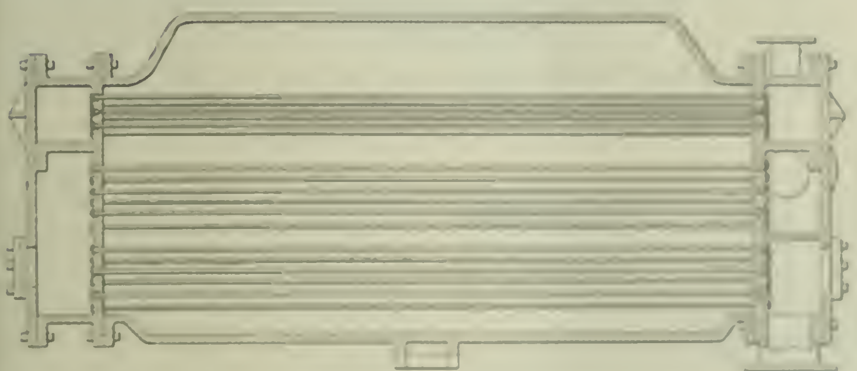


FIG. 15

As a condenser does not deliver the water of condensation to the hotwell at as high a temperature as the exhaust at the condenser, it must either be reheated in a heater or delivered to the boiler at a much lower temperature than is consistent with economy. A form of combined heater and surface condenser is obtained in the Volz surface condenser and feed-water heater, manufactured by the Wheeler Condensing and Engineering Company and illustrated in Fig. 15.

This combination condenser and feed-water heater saves considerable floor space and requires but little more head room than the ordinary type of condenser for a given size. The upper part of the shell contains a set of tubes through which the feed water passes to the boilers. The lower part of the shell contains the condensing tubes. The heater and condensing tubes are connected to their respective chambers, which are separated by a partition wall of iron, by the method adopted by the makers in their regular type of condenser. As the heater tubes are in the direct path of the incoming exhaust steam they are exposed to the hottest vapor.

A type of condenser used in connection with the steam turbine is shown in Fig. 16, and is manufactured by the Fred M. Prescott Steam Pump Company. It is made with a rectangular shell and an exhaust inlet which is especially designed to meet the requirements of the steam turbine. Fig. 17 shows a sectional view of the condenser, which contains the same features as the general run of this type of condenser. The tubes have supporting plates to prevent vibration. The air and uncondensed vapor are removed by a Prescott [illegible] vacuum pump, while the condensed water is removed by either a rotary or [illegible] pump.

In Fig. 18 is shown a type of condenser not often considered in connection with the condensation of steam. It is designed to be placed either on the roof of the building or in a tower where the air has access through the tubes. Water is then used as a condensing medium, flowing, as it does, over the tubes in a thin stream which, being caught at [illegible] the bottom in steel troughs and [illegible] small amount of fresh water [illegible] to replace the waste due to evaporation and other losses. The exhaust steam from the engine enters a header which is connected to several coils of [illegible]

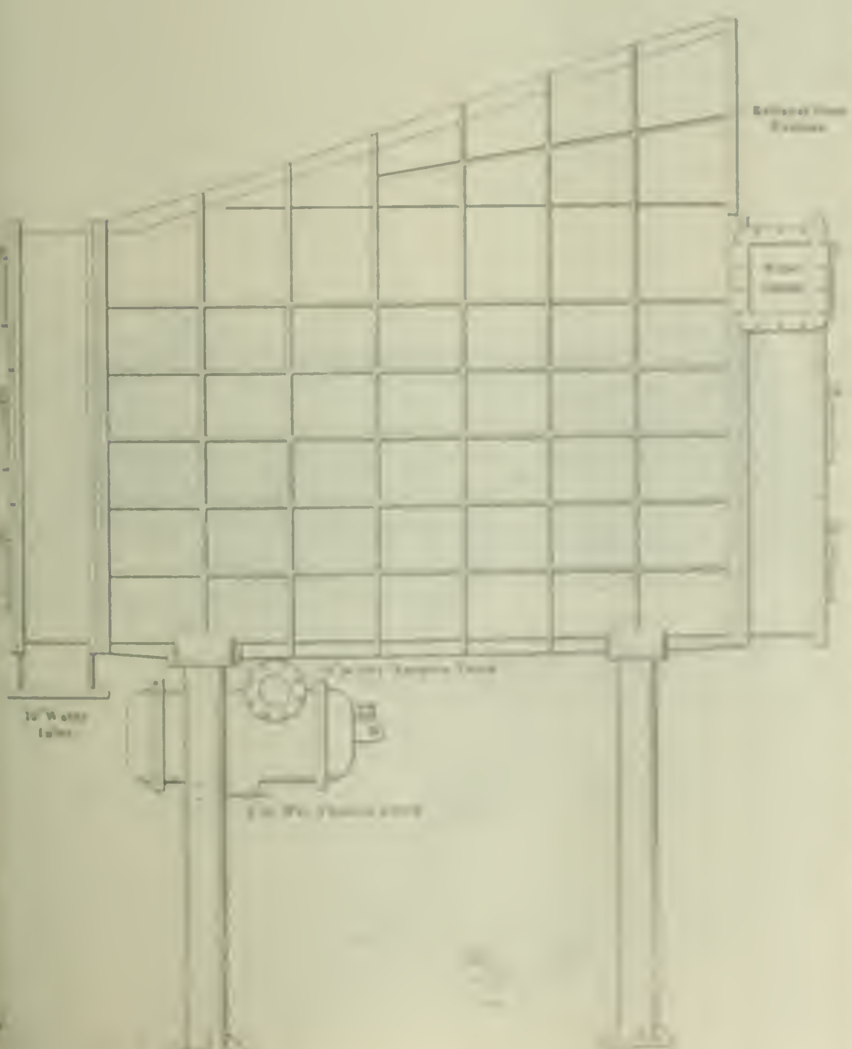


FIG. 16

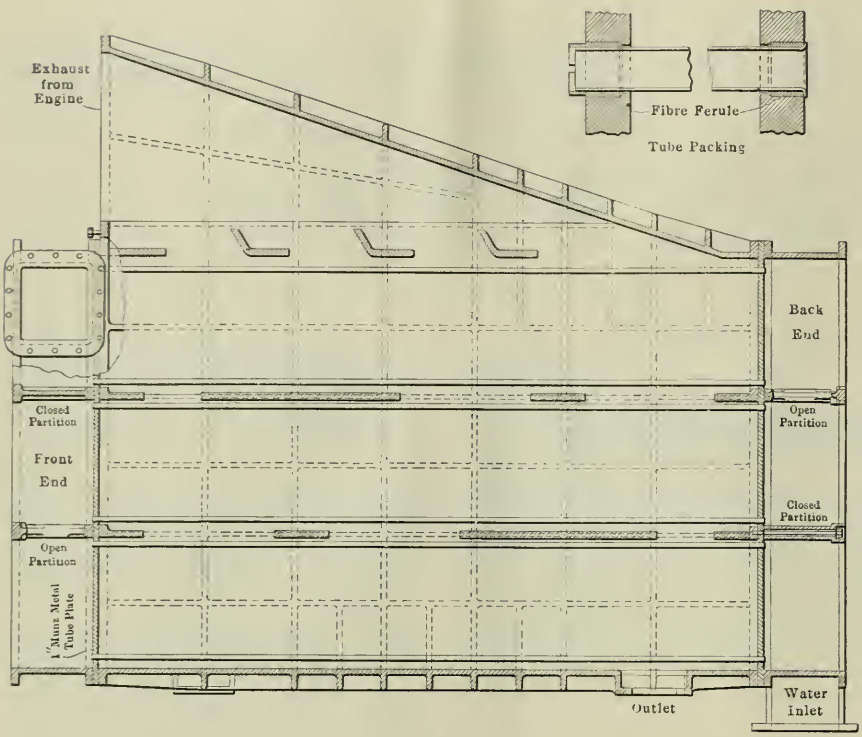


FIG. 17

densing tubes and is circulated through them from the top to the bottom. The top row of tubes in each set of coils contains steam; the next, partly condensed steam, the amount of steam decreasing, and the amount of water increasing as the lower lines of tubes are reached. The water of condensation and air are drawn from the tubes by an air pump located in the pump room, the suction being attached to a return header to which the lower tube of each coil is connected. The circulating water is delivered to a header located over the center of the condenser, with branch distributing pipes for each condensing coil. This type of condenser is manufactured by the Minneapolis Steel and Machinery Company.

In Fig. 19 is shown a countercurrent type of condenser, in which the vapor flows between the tubes, the steam line being parallel with the flow of the condensing water. The baffle plates cause the entering steam to flow in a direction parallel with the upper condensing tubes; when striking the end of the condenser body, the direction of flow is reversed; this operation being repeated as often as there are baffle plates.

Another type of countercurrent surface condenser is illustrated in Fig. 20. In this condenser, which is manufactured by the Alberger Condenser Company, the exhaust steam enters the shell of the condenser at the bottom, while the circulating water enters a water pipe at the top at one end and, after passing back and forth several times through the nest of tubes, becomes heated by the steam and leaves the condenser at the other end, at the bottom. As the exhaust steam enters the body of the chamber it rises and meets the tubes containing the hottest water first, and becomes partially condensed. It then passes up through, and around, the remaining tubes, which are cooler, and the steam is completely condensed. The air and the vapor which has not condensed collect at the top of the condenser shell, where they are dried and cooled by the cold water flowing through the upper nest of tubes before being removed by the air pump.

The water of condensation falls to the bottom of the shell and toward the entering steam. If its temperature is lower than the entering steam it acquires heat from it and, as a consequence, the water of condensation leaves the bottom of the condenser at a temperature equal to that of the entering steam. It will be seen that the distinctive features of this condenser are that the water not only circulates in a complete countercurrent, but the condensed steam and the incoming exhaust steam flow counter to each other. Owing to this arrangement of counter water and steam flow it is possible to reduce the amount of tube surface and circulating water, because the water of condensation carries off heat that under ordinary condenser conditions would have to be transmitted through the tubes to the condensing water. The air is removed from the condenser body from a point farthest from the water of condensation.

In contraflo condensers the steam flows at right angles to the condensing tubes. The latest design of this type of condenser is shown in Fig. 21 and following illustrations. It is manufactured by the Contraflo Condenser Company, Limited, London, and is represented in the United States and Canada by the Elwold Company, North American building, Philadelphia, Penn. The advantages claimed for this type of condenser are minimum cooling surface and circulating water, a high vacuum and high thermal efficiency.

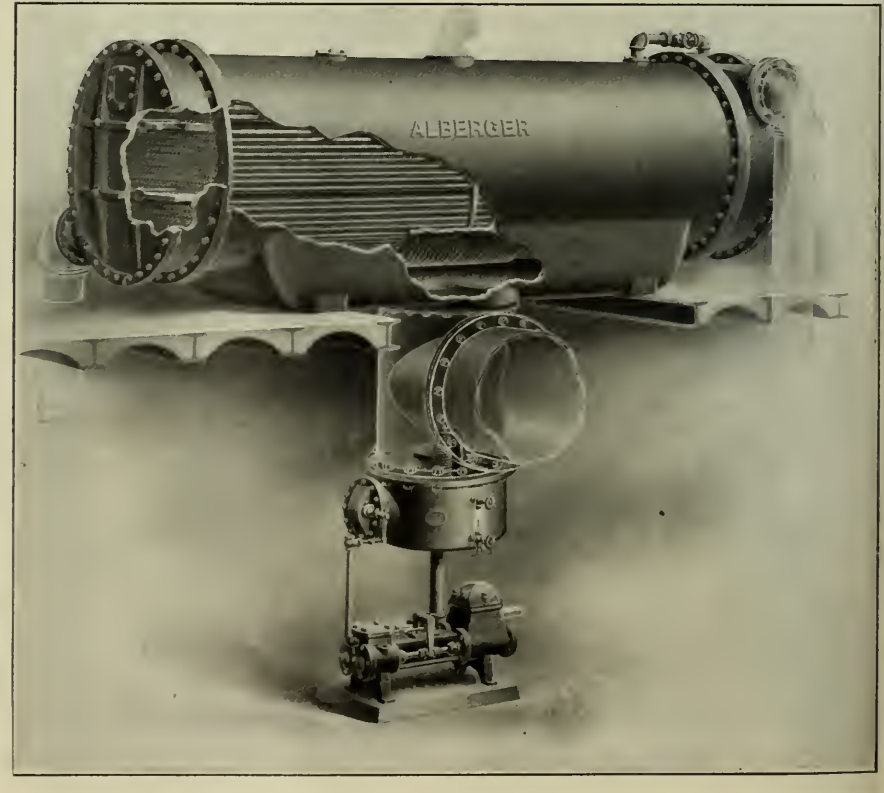


FIG. 20

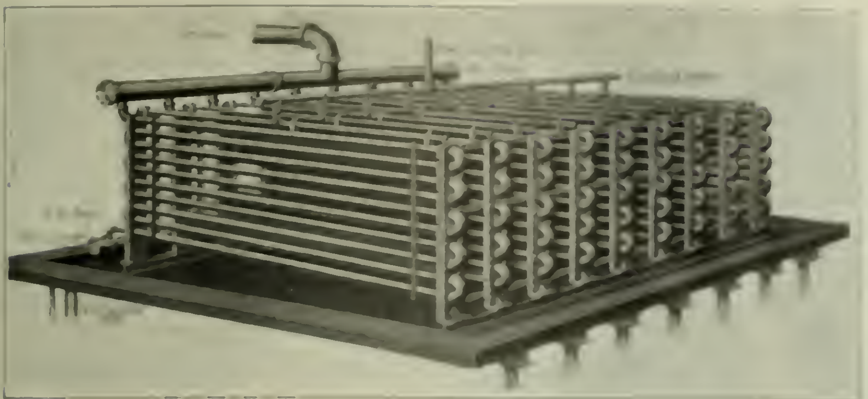


FIG. 18

ferred to, each tube is made to do a proportionate amount of work. The efficiency of the tubes is also increased because the steam in zigzagging down over the several nests of tubes increases its rate of travel, which increases the efficiency of the condensing surface.

The cooling water enters the lower nest of tubes as shown at A, Figs. 22 and 23, and, passing through the horizontal cooling tubes, reverses its direction of flow at the other end and returns through the nest B, reversing again and passing through the nest C to the same end of the condenser, where it is again reversed and returned through the nest D. The cooling water is then discharged through the

In Fig. 22 is shown an end elevation of a contraflo condenser connected to a triple-expansion engine. The condensing tubes are arranged in compartments, as shown. The steam coming from the engine cylinder follows the path indicated by the arrows through the upper nest of tubes in an even flow over the entire length of each tube, and at right angles to them. As the steam reaches the upper tubeless chamber it reverses its direction of flow, because of the upper baffle plate, and passes over the second bank of tubes, reversing again in the next lower tubeless chamber and passing over the third and lowest nest of condensing tubes. As the tubeless chambers have ample area, the change in the direction of the flow of steam is not sudden. From the lowest nest of tubes the water of condensation passes to the air pump, changing its direction of flow for the last time in the tubeless space in the bottom of the condenser base. By this successive passing of the steam over all the tubes in one compartment, and again being uniformly distributed in the tubeless chambers already re-

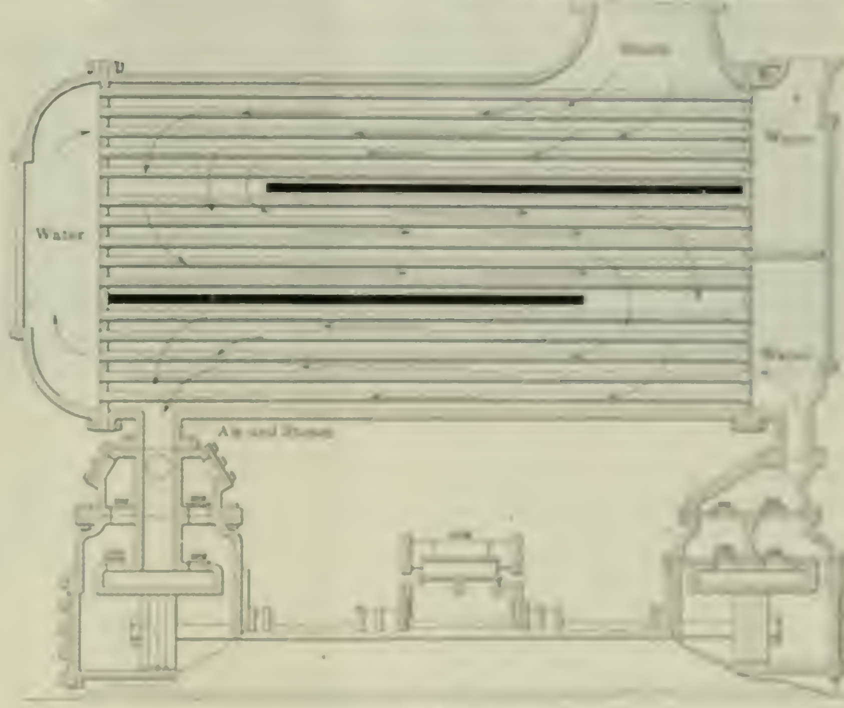


FIG. 23

outlet E, Fig. 23. From this it will be noted that the hottest water and steam are brought in contact with the cooling tubes at the top, while the coldest water and coldest steam and vapor are brought in contact with the cooling tubes at the bottom of the condenser body.

One of the reasons why the cooling tubes are very effective is because as the exhaust steam is condensed it falls on the baffle plate under the nest of tubes over which the steam is passing. As these baffle plates have [illegible] slope at the [illegible] tubes overhanging the condenser tubes, the water of condensation [illegible] to the bottom of the condenser body without coming in contact with the nest of other tubes. This same process of removing the water of condensation is carried out with each nest of cooling tubes, thus preventing them from becoming flooded by falling streams of water.

In order that the air pump may remove the greatest quantity of air from the condenser, it is necessary to [illegible]

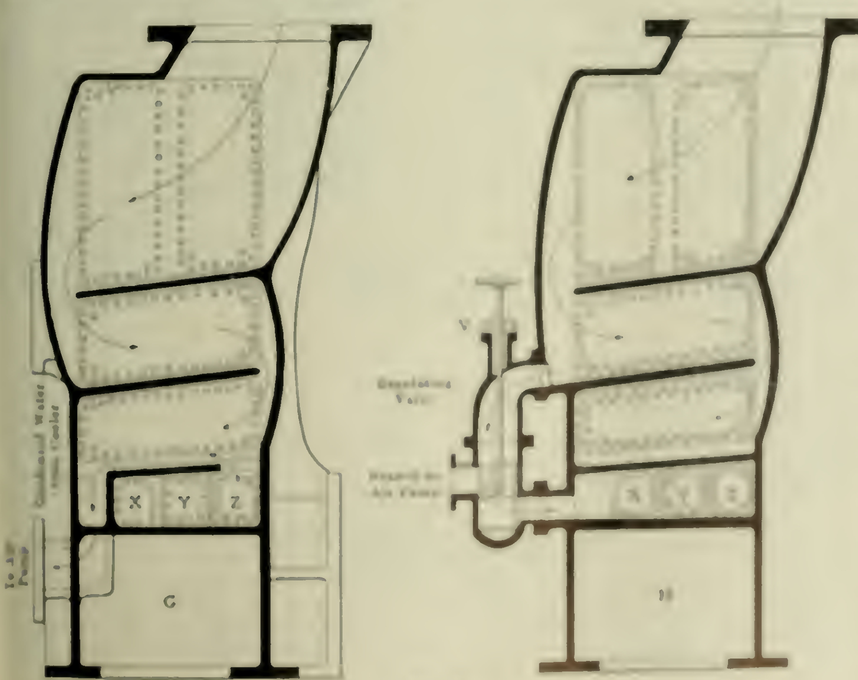


FIG. 22

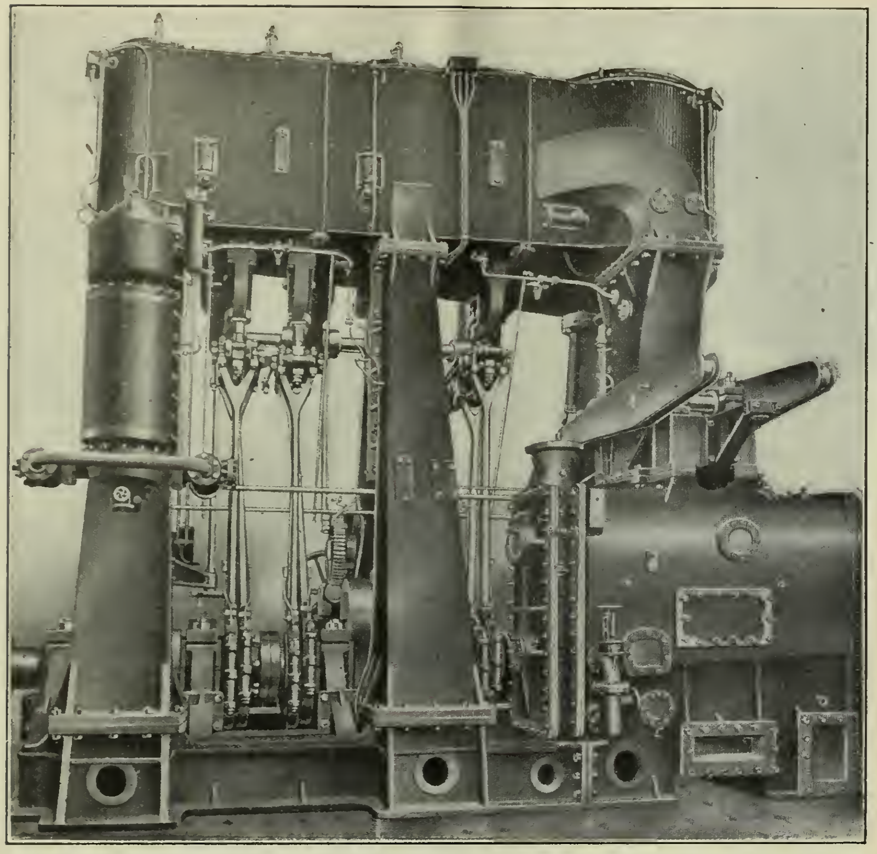


FIG. 21

passes through division Y, and finally returns through Z to the outlet. By this arrangement of regulating the water of condensation and cooling water, the highest temperature of feed water under any given condition, and the ability to maintain the most economical vacuum at all seasons of the year, may be attained; at the same time, the power efficiency of the engine may also be raised to a maximum when desired, by raising the degree of vacuum considerably above the normal.

Dinner of Alumni of Stevens Institute

The Alumni of the Stevens Institute of Technology will give their annual dinner on Friday, February 19, at the Hotel Astor, New York. A large attendance is expected, and among the speakers will be Alex. C. Humphreys, president of Stevens Institute; Alfred Noble, past president of the American Society of Civil Engineers and a former member of the Panama Canal Commission, whose topic will be the Panama Canal; Col. H. G. Prout, vice-president of the Union Switch and Signal Company; Dr. John A. Bensel, commissioner of the Board of Water Supply of New York City, and Col. George Harvey, editor of *Harper's Weekly*.

vapor with which the air is mixed. In this instance a cooling chamber has been incorporated in the design of the condenser, which is placed in the bottom, as shown at F, Figs. 22 and 23. The sealing water, after passing through the air pump, is returned to the cooler, so that the same water is used over and over again. In case it is desired to obtain the highest vacuum, the entire feed water can be cooled down before passing into the air pump. On the other hand, when it is desired to maintain a fairly high thermal efficiency, the amount of water admitted to the cooler can be regulated so as to reduce the amount of water admitted to the cooler and lower the temperature of the air-pump discharge sufficiently to obtain just the vacuum desired. The cooler is, therefore, a ready means of increasing the effective capacity of the air pump. In Fig. 24 is shown a sectional view of the condenser and cooling chamber. In G is shown a sectional view of the condenser through F. In Fig. 23 is shown the outlet to the air pump for the condensed water after passing through the cooler. The sectional view H, Fig. 24, shows a section on CD, Fig. 23, and the arrangement for passing the condensed water direct to the air pump or through the cooler. This is made possible by the regulating valve V, Fig. 24. In H, the cooler is in three divisions; the condensing water first passes through the division X, entering the end on which is located the regulating valve; it then

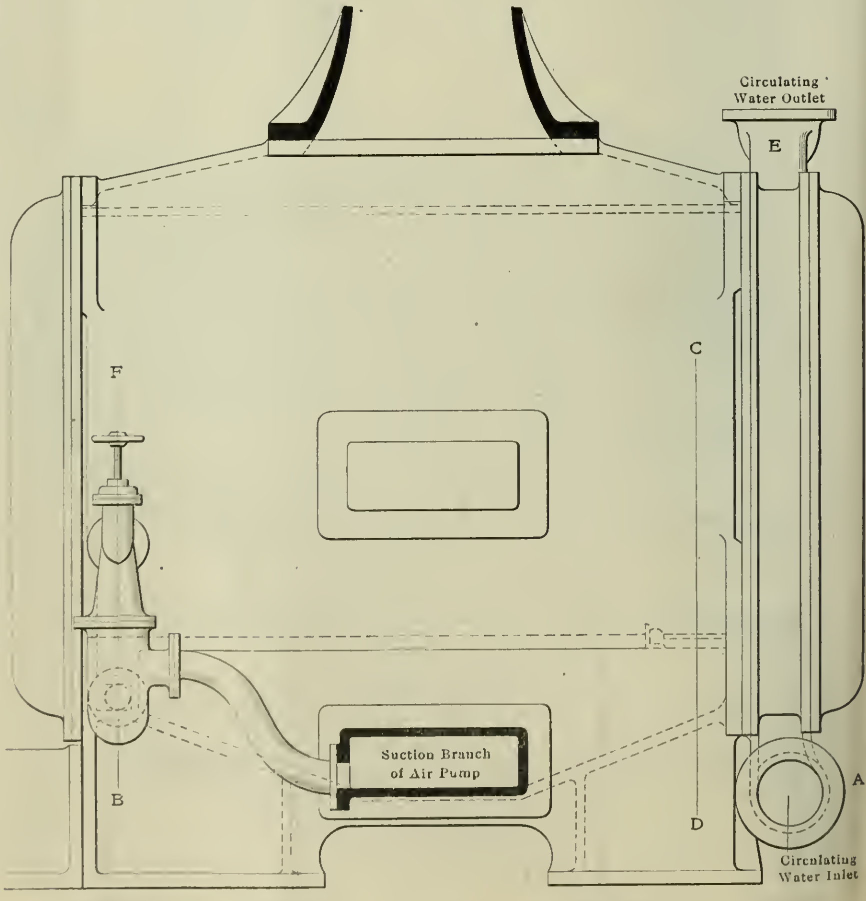


FIG. 23

Monthly Meeting A. S. M. E.

The next monthly meeting of the American Society of Mechanical Engineers will be held on February 23, the fourth Tuesday of the month, instead of the second Tuesday, as usual. The subject of the evening's discussion will be "Safety Valves," introduced by a brief paper by Frederic M. Whyte, general mechanical engineer of the New York Central lines.

Mr. Whyte will discuss the principles of the application of safety valves to steam boilers with special reference to locomotive practice, including questions of design and construction, and the requirements and limitations of valves. His paper will be followed by a general discussion covering marine and stationary practice and conditions existing in connection with low-pressure heating boilers.

Wisconsin Society of Engineers

It is proposed by forty or more engineers of the State of Wisconsin, representing cities, public utilities, manufacturing plants and colleges, to organize a State society along the same lines as those which are now in existence in Illinois, Indiana and other States.

The purposes of this society are to get the engineers of the State better acquainted with each other and to get a better understanding of problems that are of mutual interest to all, and to discuss some of the leading municipal and other problems of the day.

It is proposed to hold the first meeting in Madison, Wis., in the engineering building at the University on February 25 and 26. Prof. F. E. Turneaure, dean of the College of Engineering, is chairman of the program committee and [illegible] Kirchoffer is secretary of the committee, to whom all correspondence should be addressed.

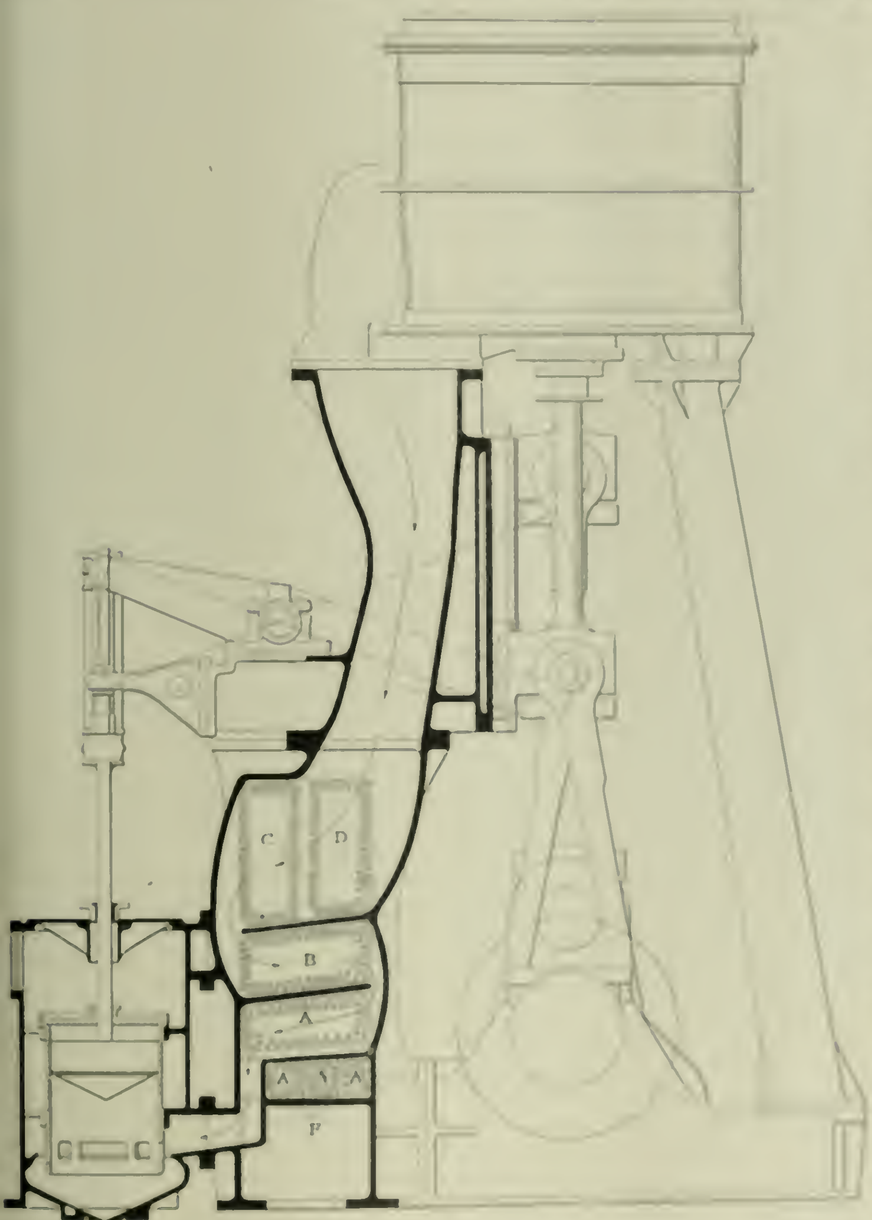


FIG. 22

Phoenix Association Banquet

Phoenix Association No. 24, N. A. S. E., of New York, held its annual dinner on Wednesday evening, February 3, at the Broadway Central hotel. More than four hundred members and friends were seated at the tables. Although some were inconvenienced by the crowded condition of the large dining room, the committee succeeded in keeping everybody in good humor and a most enjoyable evening was the result. When the service reached the coffee and cigars, W. J. Farr, the toastmaster, introduced W. T. [illegible], national vice-president; Joseph F. Carey and Herbert Stone, past national presidents; Thomas Cole, national president; James [illegible], S. J. Schaff and Arthur Vincent. The entertainers were "Joe" McKenna, "Billy" Murray, "Bob" Welsh, Frank Corbett and "Jack" Arnold. [illegible]'s orchestra furnished the music. It is the social affairs of this kind that are drawing the engineers closer together for mutual benefit.

Personal

George A. Orrok, secretary of the Gas Power Section of the A. S. M. E., lectured on Wednesday evening, February 3, on the subject of the gas engine, before the Blue Room Engineering Society, in the society rooms of the United Engineering Societies building, 29 West Thirty-ninth street, New York.

George F. Swain, professor of civil engineering at the Massachusetts Institute of Technology, and H. E. Clifford, professor of electrical engineering at the Institute, have been elected professors at Harvard University in the School of Applied Science, established under the McKay bequest.

Samuel S. Spalding recently resigned as superintendent of motive power of the Brooklyn Rapid Transit Company to go with the Pennsylvania Railroad Company. His associates in the electrical-engineering department of the Brooklyn company gave a dinner in his honor, and later the power-house and substation employees presented him a diamond ring, at the same time honoring Mrs. Spalding by presenting her a cut-glass centerpiece for the table.

According to Consul-General [illegible] at Gothenburg, windmills are principally used in Holland for the purpose of pumping water out of flush ditches, which must be done regularly in order to keep the fields and meadows dry, the ground itself of the Netherlands lying below the level of the sea. [illegible]

POWER
AND THE ENGINEER

DEVOTED TO THE GENERATION AND TRANSMISSION OF POWER

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February 2............ 40,000
February 9............ 37,000
February 16.......... 37,000,

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

Contents

"Available" Heat

In considering any engineering problem involving the transfer of heat one needs to keep constantly in mind the distinction between the heat units contained by a liquid or a vapor or a gas and the heat units in that liquid, vapor or gas that are available for the purpose under consideration. For example, exhaust steam at atmospheric pressure contains 1146 heat units, reckoning from the freezing point of water, but it does not necessarily follow that 1146 B.t.u. are available for heating purposes. If the substance being heated escapes at 148 degrees, then 1030 of the 1146 heat units can be utilized, theoretically. But if the substance being heated escapes at a temperature of 198 degrees, only 980 heat units can be extracted by it from each pound of the steam and condensate. (With "counterflow" heating the range would be increased.) With gases and liquids the case is even worse because there is no latent heat of evaporation as with steam. Gases at one thousand degrees thermometer temperature are 1460 degrees above absolute zero, and if they are applied to a substance which must be raised to 270 degrees (730 degrees absolute) then only one-half of the heat contained by the gases will be available, because when that one-half has been extracted, the temperature will have fallen to 730 degrees absolute and a condition of heat equilibrium between the gases and the receiving substance will be established. It is this phenomenon, coupled with the high latent heat in steam, which militates against utilizing exhaust gases from an engine for raising steam for power purposes, and it was the ignoring of these facts which led Mr. A. T. Kasley into error when he undertook to correct our figures on the quantity of steam that can be made with gas-engine exhaust heat. On page 61, in the January 5 number, he assumes that because the exhaust gases of an engine contain about 4000 B.t.u. per brake horsepower of engine output, this entire quantity is available for making steam, subject to the efficiency of the boiler. The facts in the case are that the absolute temperature of steam at 150 pounds gage pressure is 810 degrees, so that if the temperature of the gases were 1620 degrees absolute, only one-half of the heat, or 2000 B.t.u., would be available; and that if all of the heat could be extracted from the gases, as Mr. Kasley's computation makes it necessary to assume, then their pressure and temperature, and consequently their volume, would be reduced to absolute zero!

Without intending the least discourtesy toward our correspondent, we are moved by the incident to caution students and beginners in work involving heat phenomena to keep constantly in mind the significance of absolute temperature and the fact that heat, like water, cannot flow from a lower to a higher level (temperature). The proportion of the total heat that is "available" is determined by the difference between the temperature of the source and that of the receiving substance.

Replacing Old Equipment

It is the disposition of most steam engineers and managers to retain old equipment as long as it will do the work, regardless of its efficiency. It is a great mistake, however, to keep in operation a machine that can be replaced by one that will do more work at the same cost or equal work at a lower cost. That this assertion is true can be proved by a visit to any large, progressive steel mill, where in the "scrap yard" will be found thousands of dollars worth of machines with which nothing is the matter except that they are out of date—they have been discarded because there are newer types of machines that will do the work better, faster and cheaper. The same principle applies to the steam plant.

Much of the objection raised is due to the expense of replacing old units. It makes the man of money wince to see good hard cash put out for a machine to replace one that has been doing the work for years and is still able to do it. What the cost has been through lost time for repairs, low production in the factory due to unsteady speed, and waste of steam and fuel because of obsolete design, is not taken into serious consideration, mainly because the loss is not known, and "anyway it occurred a little at a time, so what is the odds?" The little losses do not hit so hard a blow, apparently, as the sum invested to prevent them; therefore they are allowed to continue. Some day the manager will wake up to the real significance of operating second-rate machinery, or a new manager will take matters in hand who knows that inefficient apparatus will not permit him to compete with the up-to-date establishment, and will bring about changes. The weeding-out process, although it costs money, pays.

Every steam plant contains drones that produce nothing. They should be removed and the space devoted to something that will produce results. In one instance an electric-light plant was operated day and night. The day load was small; so was the night load after midnight. The units consisted of one large engine belted to a line shaft from which were belt-driven three generators. Owing to the friction load of the shafting, belts, etc., it was necessary to fire two boilers during the light-load periods, although the use of a small engine and generator capable of handling the light load during the day and the greater part of the night would have allowed one boiler to be cut out, the wear and tear on the large engine and belting to be eliminated, and a considerable saving in steam and coal consumption to be effected. Such a unit was finally installed and the saving has shown that its purchase was justifiable.

There are many steam plants in which may be found an old wornout engine carefully held for a reserve unit. Its days of continuous service have long since passed and the chances that it will ever be used again are most remote, but it will run if required, and its efficiency during the short and infrequent periods of its probable use is a matter of small moment. In this case the advantage of a standby or reserve unit is obtained at the expense of the interest upon what the old unit would be sold for practically as junk. In the same plant, perhaps, the feed-water pump "limps along on one leg."

Every engineer and manager can look about his steam plant and see where changes can be instituted that will be a means of increasing the economy of operation. "Improvements" can very easily be carried to excess, however, and a decision must be tempered with common-sense. An old slide-valve engine is just as adaptable for a sawmill as a Corliss engine, provided it will give steady speed, a factor which is usually lacking because of overloads. It is just as adaptable because in most cases the fuel not only is of no value, as it consists of sawdust, but must be got rid of, and burning it in the boiler furnace is the easiest way to dispose of it.

Homemade Appliances

From time to time correspondence describing various "homemade" devices is received, and we usually give it a place because engineers who might never appreciate the possibilities of such devices, or who might never be able to induce their employers to purchase them, may be induced to make them and be led into their use. As a general thing, however, appliances of such advantage as to be in general demand are to be had from the dealers in so much more efficient and presentable forms and at such reasonable prices that it hardly pays the user, especially if his time is worth anything, to build them on his own account. It stands to reason that a manufacturer, making things by special machinery and in quantities, devoting special study to their manufacture and profiting by the wide experience of the users of his wares, can turn out a more satisfactory article than the man who with pipe fittings and soft solder works out a single one. Nevertheless, the man who makes an automatically feeding oil cup, or a filter, or any of the many devices proposed, will find out some things about it which he might not otherwise have learned, and be in better position to take care of the regular "store" article which he will doubtless eventually acquire.

The Surface Condenser

The steadily increasing use of the steam turbine has caused the condenser and its accessories to assume an importance entirely disproportionate to that accorded to it but a few years ago by builders and users of reciprocating engines. As has been many times pointed out, the turbine can use a high vacuum, and the reciprocating engine cannot. Theory shows that an increase of vacuum from 24 inches to 28 inches should increase the power developed from 1 pound of steam by some 18 per cent., and with some types of turbine it is claimed that the actual gain is very nearly equal to that theoretically due. More commonly, however, the actual saving is slightly less than the theoretical, a rise of vacuum from 24 inches to 28 inches reducing the steam consumption by nearly 17 per cent. Though this saving is less than that theoretically due, it is, nevertheless, sufficiently substantial, and fully accounts for the importance attached to a high vacuum by all those engaged in the manufacture or supply of turbine-driven machinery. Any attempt to realize with a reciprocating engine any like proportion of the work due to a similar increase in vacuum would necessitate the employment of low-pressure cylinders rivaling in dimensions those 14 feet in diameter, adopted by Captain Ericsson in his famous hot-air engine. In actual practice the saving effected by increasing the vacuum of a reciprocating engine from 24 inches to 28 inches is only about 2 per cent., so that the lightheartedness with which the average marine engineer regards a bad vacuum is readily intelligible, and we have known even transatlantic liners worked regularly with a vacuum in the condensers of but 24 inches or so. Specifications even for tramp steamers often demand a 28-inch vacuum, and this may be obtained on trial, but in actual service anything above 25 inches to 26 inches may be reckoned exceptionally good in ordinary marine service. Higher vacua, though frequently recorded, are not often actually realized, and, when achieved, are very difficult to maintain, [illegible] vigilance being absolutely essential to success. Moreover, many records of such are undoubtedly due to the use of defective gages. As Mr. Morison pointed out at a discussion on this subject before the Institution of Marine Engineers, the ordinary Bourdon vacuum gage is most unreliable, forming a [illegible] in this regard, to the famous [illegible] of [illegible] in which the [illegible] stood. We have known a vacuum of over 30 inches recorded on both gages of a [illegible] fresh from the builder's hands, [illegible] the barometer stood at 30 [illegible] and the condensers were [illegible] as a vacuum [illegible]. Mr. Morison [illegible]

[illegible] in a power station in which three gages on the same service all recorded widely different vacua. On remarking to the engineer-in-charge that the gages seemed a bit wrong, the functionary agreed, with the added remark that "it was only Wednesday as this." In explanation of this it may be stated that these gages were corrected every week-end, but had, nevertheless, agreed to differ in the [illegible] by midweek.

Great ignorance in regard to the principles governing condenser practice is to be found even in quarters where better might be expected. It is but three or four years since a prominent Rand engineer refused to adopt steam turbines because, owing to the height above the sea, it is not possible in the *Johannesburg* district to obtain a vacuum of more than 28 inches, and better guarantees were obtained from reciprocating-engine builders than from turbine makers for plants to work with low vacua. As a matter of fact, the normal low barometer renders easier the maintenance of a low absolute pressure in the condenser, as part of the work of the air pump is already done by nature. The confusion doubtless originated in the English practice of reckoning vacua negatively—that is to say, an absolute pressure equal to 1 inch of mercury is reckoned as a vacuum of 29 inches. It is, of course, on a low absolute pressure that the economy of the steam turbine rests, and not on inches of vacuum recorded by an ordinary gage, which may mean almost anything, varying with each change in the atmospheric pressure.

The discussion at the Institute of Marine Engineers turned, to a large extent, on the claims for the "contraflo" condenser. In the "[illegible]," engined by [illegible] & Co., the tube surface in the contraflo condenser is only 1 square foot per indicated horsepower in place of the usual 1½ square feet, yet, with sea water at 60 degrees Fahrenheit, there has been, it was stated, no difficulty in maintaining a vacuum of 28 inches, making use of a [illegible] [illegible] of the condenser to lower the temperature of the air entering the air pump. It is reported, moreover, that the economical results, in the matter of fuel actually obtained by Messrs. [illegible] with the "[illegible]," which is, it will be remembered, fitted with reciprocating engines combined with a turbine, were at least partially due to the excellent vacuum, averaging about 28½ inches, maintained in the contraflo condenser. Other builders claim that equally good results can be obtained with other forms of condenser, and [illegible] Messrs. [illegible] and Wrightson for a clear exposition of the principles involved in [illegible] condenser design.—*Engineering*.

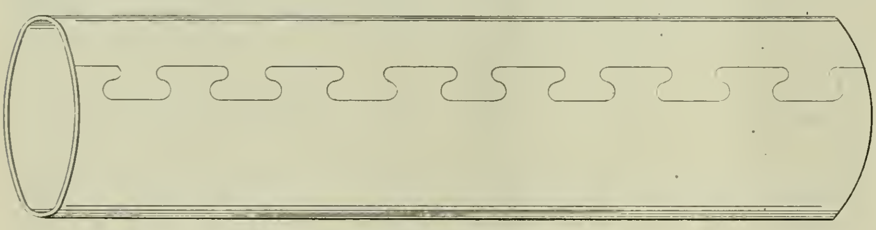
Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

Copper and Brass Pump Lining

The copper and brass lining shown herewith is manufactured by the Hamilton Copper and Brass Works, Hamilton, Ohio. These linings are used to line cylinders of large diameter, where seamless tubing above a certain diameter, say about 8 inches, becomes too expensive, when a lining made of composition sheet brass and sheet copper is substituted.



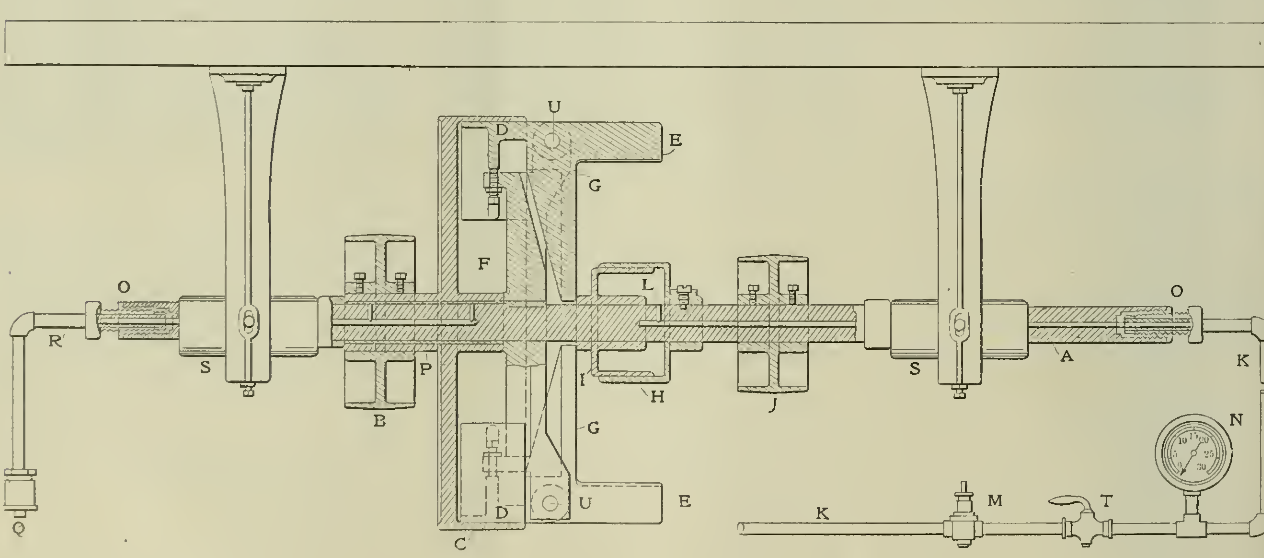
NEW PUMP LINING

The cylinders are bored out the size of the outside diameter of the lining and left in a somewhat rough cut. The linings are then pushed into the rough-bored cylinder. After this is done a burnisher or round-faced tool is placed in the boring bar and rubbed or burnished slowly, with a uniform pressure, against the lining from one end to the other. This brings the lining tight against the cylinder and also makes a smooth and polished surface. Plenty of oil is used when the lining is being rubbed against the cylinder. When this is done the ends of the lining, which should extend out about ¼ inch from the ends of the cylinder, are turned over the ends of the cylinder, making a water-tight fit.

A Variable Speed Clutch

The principles involved in this clutch and the method of speed control may be readily understood by reference to the diagram, where *A* represents a shaft supported by hangers *S S*, *B* a pulley driven by a belt from the line shaft, and rigidly mounted on the long hub *P* of the drum *C*. The pulley, hub and drum revolve together loosely on shaft *A*. At *D D* are clutch shoes, fulcrumed on the pivot bolts *U U* in the ends of the spider *F*. Integral with these shoes are the weights *E E* and the inwardly extending arms *G G*. The spider *F* is rigidly keyed to the shaft *A*. At *J* is a pulley fastened to the shaft. From this pulley, a belt passes to the machine to be driven. The cylinder *H* is secured to the shaft *A*, and rotates with it. One end of this cylinder is open and from this end projects the sliding piston *I* engaging the arms *G G*. An opening through the shaft communicates with the interior of the cylinder. When air or any fluid under pressure is admitted through the opening into the cylinder, the piston is forced against the clutch arms *G G*, thus forcing the weights *E E* inward and the clutch shoes *D D* outward toward and against the inner face of the drum *C*, causing the drum to impart its motion to the shoes. Acting against this tendency to impart motion, is the centrifugal force of the weights *E E*, which tends to separate the shoes from the drum and overcome the tendency of the drum to impart motion. It is the balance between these two forces that determines the speed transmitted.

In practice, the pressure on the piston, acting on the shoes and against the centrifugal force of the weights, imparts to the shoes a series of minute impulses that are apparently uniform, conveying steady rotary motion from the driving member to the driven member, the speed under no circumstances exceeding that which the regulating valve is set for. When pressure is released from the piston *I*, causing the clutch shoes to break contact with the drum, the drum acts as a loose pulley on the shaft. The controlling force is admitted to the cylinder from the supply pipe *K* through the stuffing box *O* and inlet *L*, regulation being effected by the



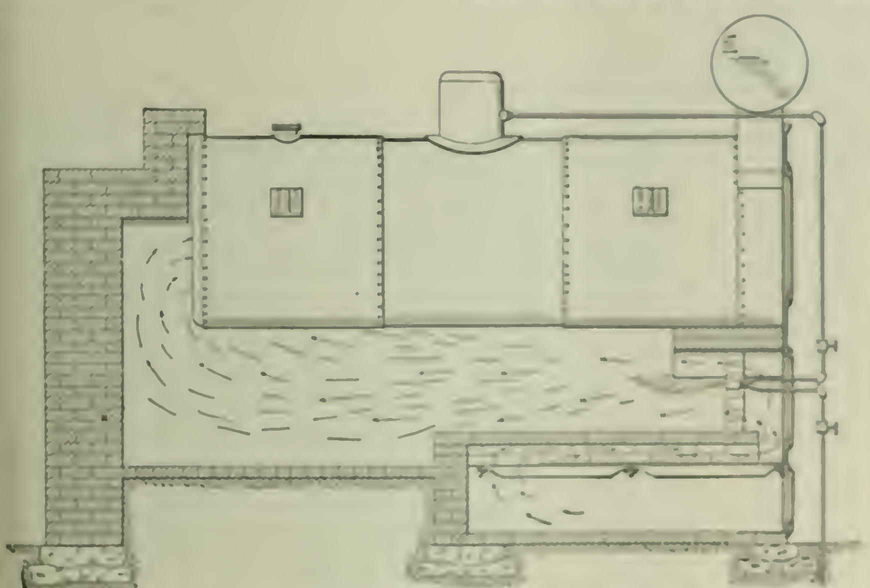
SECTIONAL VIEW OF VARIABLE SPEED CLUTCH

pressure-regulating valve M, the pressure being indicated by a gage N, the valve M being readily set to give any desired pressure. The cock T is used to turn on or off the supply of air, to start or stop rotation. At Q is a grease cup from which lubricant is fed through the pipe R and the central hole in the shaft and a small radial hole to the bearing surfaces of the sleeve P.

This clutch is manufactured by the Variable Speed Clutch Company, Milwaukee, Wis.

Mason Furnace

The accompanying illustration shows one style of preheated-air oil furnace constructed by the Mason Smokeless Combustion Company, 201 Kerckhoff building, Los Angeles, Cal. The method used in burning oil is the introduction of highly preheated air at the point of combustion.



MASON PREHEATED-AIR OIL FURNACE

As will be seen, the furnace is equipped with a brick arch over the grate, so constructed that the air in passing up through the grate is heated before entering the furnace proper, due to its contact with the brick arch.

It is claimed that by this method the air used at the burner is greatly expanded, heated by the heat produced in the combustion chamber, resulting in an instantaneous and complete gasifying of the oil.

The combustion is said to take place in the form of a short flame, the clear and transparent flux showing complete combustion of the gases and a very high intensity of heat which is rapidly imparted to the boiler body.

Greatly increased furnace temperature together with an even distribution of the heat is said to be the result, and all the available units of heat are therefore enabled to do their proper work of increasing the evaporation of water.

A New Line of Belt Driven Alternators

A new line of polyphase belt-driven alternators has been brought out by the General Electric Company for use in small generating plants and in isolated lighting and power plants where rapidly increasing inductive loads and consequently low-power factors are encountered. The machines are designed for 80 per cent. power-factor service, but will of course operate satisfactorily on higher power factors.

Fig. 1 is a general view of one of these generators. Although designed for belt drive, they are readily adapted for direct connection to prime movers of suitable speed by omitting the driving pulley and subbase and adding a coupling. Each generator has on the collector-ring end of the shaft an extension to receive the exciter driving pulley.

The armature frame is of cast iron with cored ventilating openings which allow free circulation of air around the ends of the windings and through ducts in the laminated core, as illustrated in Fig. 2. The armature coils are form-wound and individually insulated, so that any coil may be readily replaced if necessary.

The field structure, which is the revolving member, consists of laminated rotary cores dovetailed into a laminated spider. The punchings are carefully punched and riveted together, forming a [illegible] well adapted to withstand high speeds. Two methods of building the field-magnet coils are used. For the [illegible] and [illegible] kilowatt sizes the wire is wound on spools through which are slipped the magnet poles, the spools being held in place by the enlarged pole tips. In the larger sizes, the coils consist of a single strip of flat copper wound on edge so that one surface of every turn is exposed to the air. The collector rings are mounted on insulating sleeves on the shaft and are exposed to the air on all three sides. Two or more carbon brushes are provided for each ring.

At [illegible] factors these generators have

FIG. 1. A NEW BELT-DRIVEN ALTERNATOR

been especially designed for use in isolated plants where mixed lighting and motor loads are the rule rather than the exception. It is practically impossible in such cases to obtain good voltage regulation by hand control and some form of automatic voltage regulator must be

FIG. 2. ARMATURE FRAME OF BELT-DRIVEN ALTERNATOR

used. For this service the well known T A regulator manufactured by the General Electric Company is recommended and, when used in connection with the exciters for the [illegible] alternators, automatically maintains practically constant voltage at the bus-bars or at the center of the system, according to adjustment. The exciters have a normal voltage of 125 volts, but are capable of delivering 150 volts continuously. This margin of power enables them easily to overcome the demagnetizing effect of the armature current on circuits.

When intended for operation as synchronous motors, these generators are equipped with squirrel-cage windings set in the field-magnet pole faces. These windings are said to give ample starting torque with a moderate starting current and they do not in the least affect the operation of the machines as generators. The generators are at present available with either two- or three-phase windings and for 240, 480, 600, 1150 or 2300 volts.

Atlantic City A. O. S. E. Dinner

The twelfth annual dinner of Atlantic City Council No. 4, of the American Order of Steam Engineers, was held at the Hotel Jackson, Atlantic City, N. J., on Saturday evening, February 6. An excellent collation was served to over 150 members, friends and guests, among them being several prominent citizens of the city, and also many familiar faces of the engineering fraternity. Short addresses were made by Mayor F. B. Stoy, Harry Wooten, Fred Marcoe, supreme president of the A. O. S. E., and Commodore Louis Klunnel. An enjoyable entertainment was given by Charles E. Carpenter and "Jack" Armour. T. D. Just was the affable toastmaster. The committee in charge of the successful occasion were W. S. Price, A. H. Francks, J. W. Frampton, C. F. Noble, E. N. Meloney.

Business Items

J. Everton & Son, of Deer River, Minn., has placed an order with the Minneapolis Steel and Machinery Company for an 80-horsepower Muenzel producer gas engine and gas producer plant, and a 53-kilowatt double-cylinder generator, which will be direct-connected to the engine. This machinery will be installed in the electric light plant at Deer River.

The Southern Engineering and Supply Company has opened offices at 220 Avenue D, Henry Terrell building, San Antonio, Tex. They propose to make a specialty of pumping and irrigating machinery, also isolated and small light and refrigerating plants. Manufacturers interested in southwestern territory not having representatives are invited to send catalogs and descriptive literature.

The Burnite Machinery Company, with Thomas B. Burnite as manager, has succeeded the Burnite-Leonard Engineering Company, of Denver, Colo. The company has moved into a commodious office and storeroom at Seventeenth and Glenarm streets and represents the Hardsocg Wonder Drill Company, the Erie City Iron Works, the Bury Compressor Company, the Krogh Centrifugal Pump Company, and various other lines, making equipment for mine, mill or power plants of all descriptions.

The Fountain-Shaw Engineering Company, which began business the first of this year as civil, sanitary, electrical and mechanical engineers, with offices in the Binz building, Houston, Tex., is composed of Thomas L. Fountain and Joseph D. Shaw, with P. S. Tilson as collaborator. Until recently Mr. Fountain was assistant to Alexander Potter, civil and sanitary engineer, of New York City, and Mr. Shaw was assistant to the chief engineer of the Pittsburg Railways Company and the Allegheny Company.

The Crocker-Wheeler Company, of Ampere, N. J., has just closed a contract to equip with motor drive the new woodworking factory of the John Hofman Company, Rochester, N. Y. The order includes 40 induction motors ranging from 1 to 30 horsepower, with a total capacity of about 200 horsepower. These motors will be used for individual drive, each machine being equipped with its own motor. The motors, with the exception of one, are of the squirrel-cage type. The generator for this plant and three lighting transformers are also included in the order placed with the Crocker-Wheeler Company.

The Buckeye Boiler Skimmer Company, South End, Toledo, O., has received a letter dated January 28, 1909, from Gilmore Brothers, contractors, Toledo, in which they say: "We have used your skimmer on our two dredges the past three years and find that they do all that you claim for them. We have worked alongside of other dredges, equipped with the same style of boiler, and whereas the others have had to clean their boilers every two weeks, we ran eight weeks before cleaning and then found no mud or scale. We open up our boilers every eight weeks, more to inspect them than in the expectation of finding mud or scale. We figure we save double the price of the skimmer each season, in fuel and time."

The Nelson Valve Company, Philadelphia, Penn., which was originally incorporated in the State of New Jersey, has surrendered its charter and has been incorporated in the State of Pennsylvania. This company began in 1893 to manufacture valves of all kinds under the Nelson patents and made such a success of the business that it now employs from 200 to 250 men. It is now proposed largely to increase the facilities so as to meet the growing demand for the company's product. The new charter will empower the company to manufacture and sell pipe, valves, machinery, fittings and steam specialties, and will have an authorized capital of one million dollars. The president of the new company, who was also president of the old one, is Samuel F. Houston, who is vice-president of the Real Estate Trust Company, and vice-president of the Winifrede Coal Company and of the Winifrede Railroad Company. Carlisle Mason is the vice-president and, as heretofore, general manager, and Russell Bonnell, the secretary-treasurer. Henry H. Bonnell is also one of the incorporators.

New Equipment

City of Elgin, Texas, has voted $30,000 bonds for construction of water works.

The Deer Lodge (Mont.) Electric Company contemplates installing engine, alternator, etc.

The Gilmer (Tex.) Ice, Light and Power Company has been incorporated with $40,000 capital by T. E. Barnwell, Lewis Monroe and J. E. Barwell.

The city council, Hartshorne, Okla., is said to have decided to construct water-works at a cost of $80,000.

The citizens of Ashburn, Ga., voted to issue $55,000 bonds for construction of electric-light plant, water works, etc.

It is reported the Le Roy (Ill.) Electric Light, Power and Heating Company contemplates the installation of a new heating and ice plant.

New Catalogs

Lehigh Stoker Company, Fullerton, Penn. Catalog. Mechanical stoker. Illustrated, 12 pages, 6x9½ inches.

Weber Steel-Concrete Chimney Company, Chicago, Ill. Catalog. Chimneys. Illustrated, 48 pages, 4x9 inches.

The Corbett Supply Company, Trenton, N. J. Catalog. General mill supplies. Illustrated, 520 pages, 6x9 inches.

Joseph Dixon Crucible Company, Jersey City, N. J. Pamphlet. Lubricating the Motor. Illustrated, 24 pages, 5½x8½ inches.

Dean Bros. Steam Pump Works, Indianapolis, Ind. Catalog No. 74. Condensing machinery. Illustrated, 56 pages, 6x7½ inches.

The Caskey Valve Company, 422 Arcade building, Philadelphia, Penn. Catalog. Valves. Illustrated, 19 pages, 3½x6½ inches.

The Jeffrey Manufacturing Company, Columbus, Ohio. Catalog 67D. Rubber-belt conveyers. Illustrated, 48 pages, 6x9 inches.

Eck Dynamo and Motor Company, Belleville, N. J. Sectional catalog and data book. Motors and dynamos. Illustrated, 5½x8½ inches.

C. O. Bartlett & Snow Company, Cleveland, Ohio. Catalog No. 28. Coal and ash handling machinery. Illustrated, 48 pages, 6x9 inches.

Jacobson Machine Manufacturing Company, Warren, Penn. Bulletin L. Gasolene power sprayers. Illustrated, 30 pages, 6x9 inches.

The Climax Smoke Preventer Company, Equitable building, Boston, Mass. Catalog. Climax smoke preventer. Illustrated, 16 pages, 6x9 inches.

Bush Terminal Company, 100 Broad street, New York. Catalog. Model loft buildings for shipper and manufacturer. Illustrated, 12 pages, 9½x12 inches.

Recent Refinements in Boiler Testing

Descriptions of Apparatus and Methods Employed in Conducting Tests Along Uptodate Lines; Special Devices Used by the Author

BY ALBERT A. CARY

During many years of boiler-testing experience the writer has constantly endeavored to improve his testing equipment, so as to reduce the possibility of error to a minimum, to diminish the number of expert assistants required during a test and to make it possible *personally* to take all of the required observations with sufficient frequency to obtain ample data showing every important varying condition occurring during the test.

Probably one of the most troublesome matters connected with the equipment for boiler testing where the engineer is called to conduct a special test, is the feed-water apparatus. I have used tanks, one of which is fitted upon a special scale platform and each charge of water is actually weighed before it is dumped into the lower tank which, acting as a pump, holding a reserve supply to be delivered directly to the feed pump. This arrangement requires the construction of a heavy platform of sufficient hight to allow the lower tank to be placed beneath it and it must be strong enough to carry both the scale and the upper weighing tank with (usually) two men who weigh the water and check each other's results.

If it is desired to keep track of the amount of water actually evaporated over each small interval of time during the [illegible]

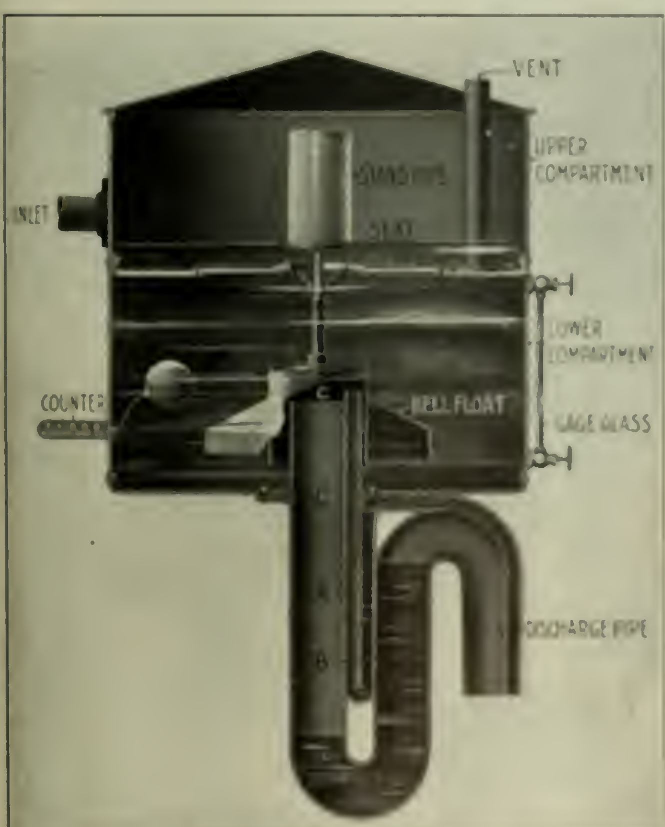


FIG. 1

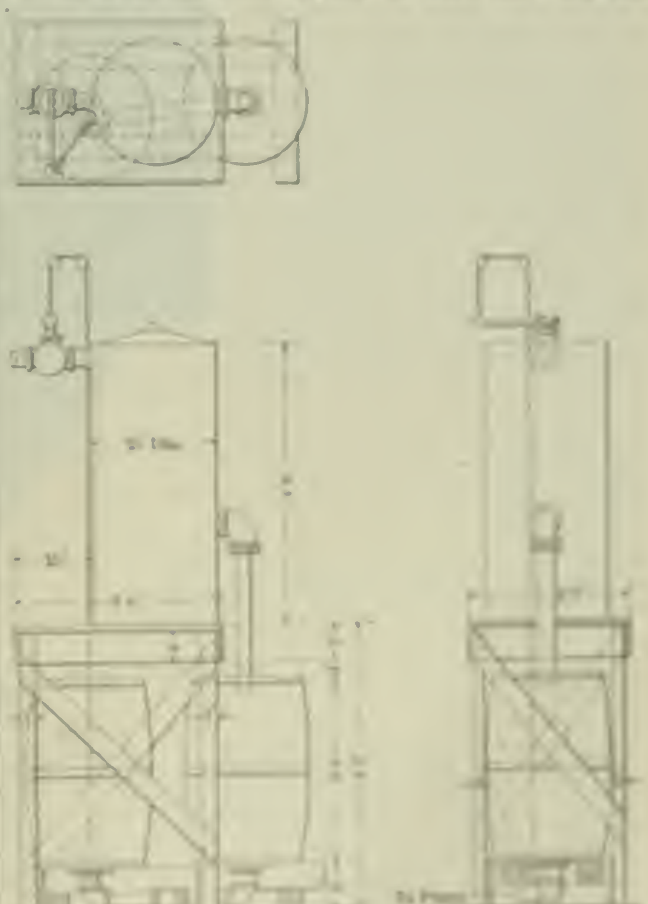


FIG. 2

as disarranged during shipment, and to the expense usually incurred upon the owner of the plant for a properly built platform.

Water measuring is quite generally used in place of weighing apparatus, which admits of the use of a somewhat simpler equipment but with some sacrifice of accuracy. I have several designs for mounting such apparatus in place, one of which is sent to the steam-plant owner with instructions for erection. This equipment requires the lower sump tank and [illegible] heads having been removed) a hole is bored through each bottom head and a 2- or 2½-inch pipe flange is bolted to this bottom with a rubber gasket between the wood and the flange.

In the bottom flange of each of the upper (or measuring) tanks is screwed a nipple with a valve holding another lower nipple from which the water is discharged into the lower sump tanks placed below the level of the elevated platform. A hole is bored into the side of each of the upper, or measuring barrels, near the top of one of the staves, and into this is screwed a short length of pipe projecting into and outside of the barrel. Error is introduced in this form of apparatus in filling the barrel (from the lower closed valve to a level where the overflow pipe ceases to deliver water), due to the speed of manipulation sometimes found necessary, and to carelessness (often due to fatigue) on the part of those in charge.

Many special arrangements have been introduced by users of such apparatus to diminish this error. The opening and closing of the supply valves delivering water to these measuring tanks and the proper opening and closing of the discharge valves under these barrels involve considerable activity on the part of the man or men manipulating the apparatus, especially when it is worked anywhere near its capacity, to which work is generally added the clerical duty of keeping the water log, on which should be noted the exact time of each dump. Errors are sometimes introduced by opening the discharge valve before the overflow pipe has ceased to drip, by imperfectly closing the lower valves and occasionally owing to forgetfulness or to a rush when a sudden demand for more water occurs, due to failure in closing the discharge valve before the water-supply valve is opened to fill the barrel.

Where intention to deceive exists, this form of apparatus lends itself to easy manipulation despite the careful watching of the man conducting the test.

The lower barrels are connected by bottom piping so as to form practically one sump tank, from which lower connection water is piped to the feed pump.

In carefully conducted tests the common level of the water in the lower tanks should be noted in the log at the time of each dump from the measuring tanks, together with the level of the water in boiler-gage glass. With such information it is possible to determine whether a number of rapidly dumped barrels has been necessitated by a momentary large evaporation in the boiler, or by neglect in keeping the water in the boiler up to the level selected for the trial; or neglect in keeping the sump tanks full of water.

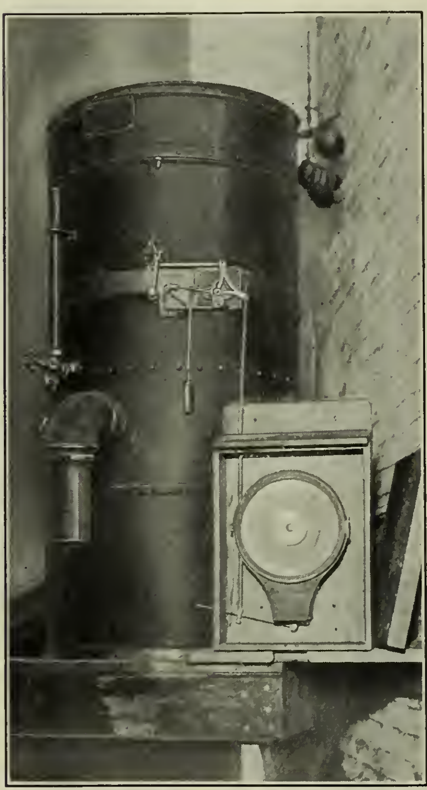


FIG. 3

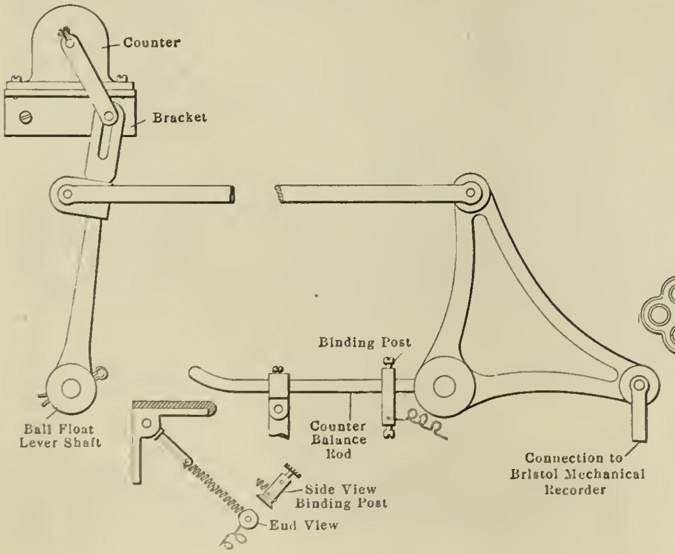


FIG. 4

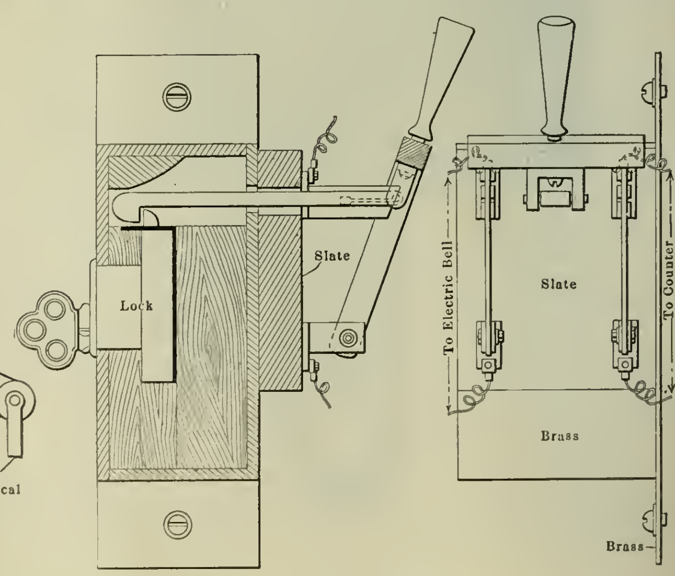


FIG. 5

Automatic Liquid Weigher

There have been many more or less automatic weighing or measuring tanks presented, to reduce the labor required in keeping account of the feed water used during a boiler trial, but nearly all of these have proved undesirable as portable apparatus, due to their considerable bulk or weight, or due to their delicate or complicated parts, to say nothing of their considerable cost in some cases; but finally, after investigating a number of these devices, the writer found what he has been looking for in a comparatively recent apparatus known as the Wilcox automatic liquid weigher. This weigher was described in a paper presented before the American Society of Mechanical Engineers at the May, 1906, meeting and it was also described in Power in the issue of June, 1906.

It is piped directly to the water system supplying the boiler, and after receiving a charge of water in its upper compartment, which charge is carefully weighed by balancing it against a column of water of a predetermined hight, the water supply is cut off within the tank automatically and the weighed charge is dumped; and then follows one weighed charge after the other, each successively dumped into the sump from which the water is delivered to the boiler-feed pump. A section of the apparatus is shown in Fig. 1.

If the supply of water to the weigher was not restricted, the continuous working of the apparatus would be apt to overflow the sump tank, but by placing a float in the sump tank and by connecting it to a balanced valve placed in the inlet piping to the tank (the tank being mounted upon an elevated platform) this valve automatically cuts off the supply of entering water when the level of the water in the sump tank rises above a predetermined level.

Each time this weighing apparatus tilts and dumps, the rising and falling water level lifts and lowers a ball float within the lower compartment. This causes a small shaft, passing through the side of the apparatus, to make a partial revolution, first in one direction and then in the opposite direction, being actuated by the float to which the shaft is attached by a lever.

By referring to Figs. 3 and 4, it will be seen that the outer end of this shaft carries a lever, projecting upward, and having a slot at its upper extremity. This slot engages a pin placed at the bottom of the lever of a counter mechanism and as the top of the float lever moves backward and forward the counter is made to add one to the figure previously registered. Thus each dump is automatically registered on the counter.

The foregoing description presents the automatic weigher as it reached the writer, but after testing it carefully, and finding that it could be relied upon to deliver water with an error in weight of not over one-quarter of one per cent., and after subsequently using it in a boiler test it was found that the mere counter, showing the number of dumps, did not give sufficient information to follow the irregularities in evaporation occurring during the course of the boiler trial, unless very frequent readings were taken. The labor required in climbing up to the counter, located some 10 feet above the floor to obtain a reading every few minutes during the test (when numerous other readings had to be taken) was found to be quite fatiguing before the test was completed, so means were devised by the writer to overcome this objectionable feature.

To illustrate, roughly, what is meant by the necessity for frequent readings, let us suppose that the boiler evaporated 6000 pounds of water in one hour and 12,000 pounds of water during the second hour, and the counter reading was taken at the end of the second hour. It would be found that 18,000 pounds had been evaporated since the last reading. One would, by averaging, say that there was an evaporation of 9000 pounds per hour, which conclusion would give a very erroneous idea of what had actually occurred during [illegible] part of the test.

When carrying the regular steam load of one plant tested, I found that [illegible] dumping [illegible] during [illegible] interval [illegible] seconds, while later in the test the dumps occurred about [illegible] apart. In another test, where the [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] I found that the average load for the day was only [illegible] boiler horsepower, but during one-half hour in the afternoon the steam requirements ran up to [illegible] boiler horsepower.

In order to obtain the full required data from the apparatus, I devised the attachments shown in Fig. 3 and shown with greater clearness in Fig. 4. To attach these to the sheet-metal weighing tank, a strip or band of brass, 2 inches wide, was firmly secured around the tank, running past the counter mechanism between the ball-float shaft and the bracket holding the counter. To this brass band a bracket was secured, carrying a lever with right-angled arms, similar to the so-called "bell-crank lever" used by bell hangers. It will be seen that the vertical arm of this crank is attached by a link to the vertical lever of the counter mechanism, which lever is oscillated by the rising and falling ball float in the tank. To the horizontal lever arm of this crank a second link is secured, dropping to the actuating lever of a Bristol float recorder, which instrument accurately revolves the recording paper chart by clockwork.

By this arrangement, when the ball float in the tank rises with the inflowing water, the stylus of the recorder is moved away from the center of the chart (placed on the face of the recorder) toward its outer circumference. There it remains until the dump occurs, when the falling water level causes the stylus to move back toward the center of the chart.

These two approximately radial lines are traced on the paper chart with ink, when the stylus holds ink, but I have found a paper chart having its face coated with smoke much more satisfactory, as with very frequent dumps, causing these "radial" lines to occur quite close together, the closely adjoining fresh ink lines are apt to run into each other, thus causing an obliteration of the lines into a continuous blot. With the smoked charts (furnished by the Bristol company) lines lying quite closely together can be distinctly distinguished, and the very accurately smoked lines, with its contained record, is easily "fixed" after the test, so as to preserve the writing or soot from rubbing off.

Fig. 6 shows one of these charts with a record obtained during a test. The clock mechanism used in this case revolves the chart one complete revolution in twelve hours. The paper chart shown is made for use with a twenty-four-hour clock and, therefore, two of the hour divisions must be counted for one hour to maintain the record correctly. It will be understood that with double the number of small divisions [illegible] based on the twenty-four-hour chart the number of dumps in a given time interval [illegible] [illegible] [illegible] [illegible].

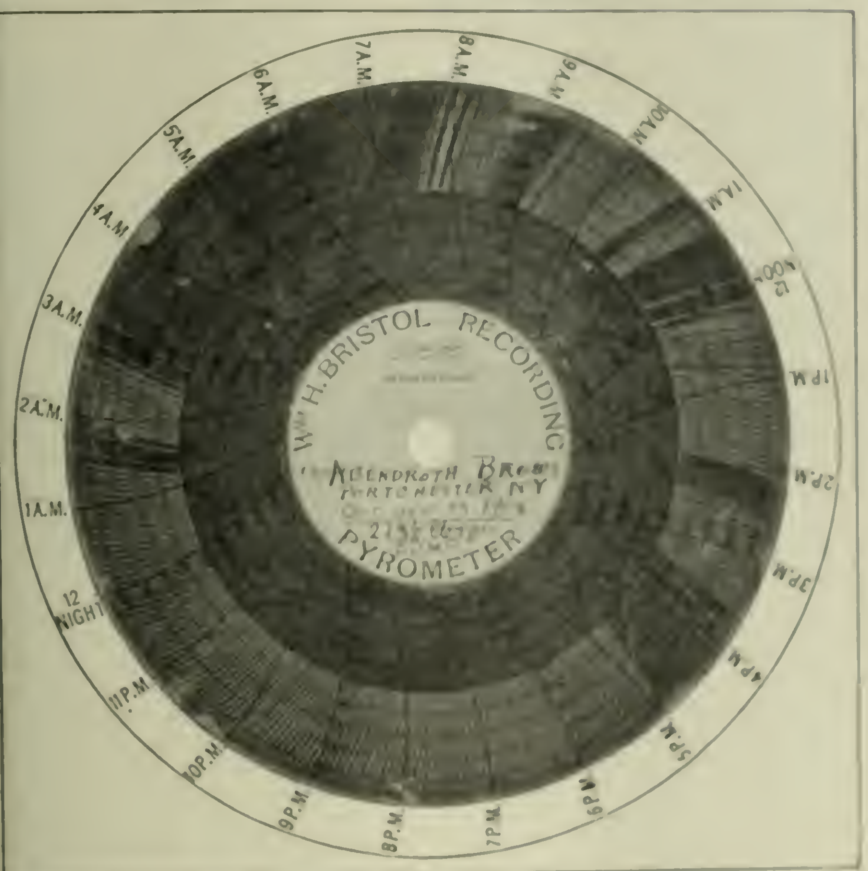


FIG. 6

[illegible] [illegible] [illegible]

[illegible] [illegible] to the [illegible] shown in Figs. 3 and 4 [illegible] [illegible] will be [illegible] [illegible] [illegible] [illegible] [illegible] of the bell crank toward the float shaft. Weights are suspended from this rod to counterbalance the weight which has been imposed upon the lever operating the counter by adding the attachments to the clock mechanism. Having this convenient projecting rod, the writer was tempted to add another refinement to this weighing-tank mechanism which has proved a great convenience. I refer to an electric counter.

The inconvenience of using the regular mechanically actuated counter provided with the machine, and located some 10 feet above the floor, has already been referred to. To actuate the Mandi electric counter a circuit from a battery (of three dry cells) must be closed and then opened. The closed circuit from the battery must not be maintained long, otherwise the battery will soon be exhausted. In order to accomplish this result, I borrowed (by permission) part of the patented mechanism used in the Desper elevated-travel recorder. This is plainly shown in Fig. 4, where will be seen the outer end of the counterbalance rod projecting from the hub of the bell crank, placed directly over an angle-shaped brass wiper. This wiper is secured to the blocking holding the bell crank by an easy-fitting pin passing through the hub of the wiper near the apex of the angle.

To hold the wiper in the position shown with the least interference to its movement around its supporting pin, a short rod is secured in its hub, projecting at right angles to the pivotal pin and standing midway between the two arms of the angular wiper. To the outer end of this rod one end of a spring is attached, the other end being fastened to an electric binding post secured to the supporting blocking, and with this extension spring in tension the angular wiper must be held with its upper face horizontal but a very slight pressure applied near the end of this horizontal face will cause it to deflect and turn around the pivotal pin, and it will recover its normal position the instant this pressure is removed.

The upper or horizontal face of this wiper is covered with an insulating material which projects over its outer edge, but the under horizontal face presents a bare metal surface.

Electrical connections are made with the batteries and the Mandi electrical counter by connecting one wire to a binding post secured to the counterweight rod near the hub of the bell crank, while the other wire is connected to the binding post at the outer end of the wiper spring, the current being conducted through the spring and rod to the angle piece, as shown.

With this equipment, it will be seen that as the tank fills with water, the outer end of the counterbalance rod is made to descend and, striking the top insulated surface of the wiper, no current will pass through the system. As the water continues to fill the tank, the end of the counterbalance rod continues to descend and finally it slips over the edge of the insulated face, when the wiper springs back to its normal position, leaving the end of the counterbalance rod beneath the horizontal face, and out of contact with it.

The discharging operation of the automatic weigher requires a very short space of time, and as the water level falls the end of the counterbalance rod rises, striking the lower horizontal metal face of the angle and wiping over it as it rises thus closes the circuit and causes the electric current to flow through the magnets which operate the counter. As the end of the counterbalance rod continues its upward motion, it soon slips over the edge of the wiper, thus breaking the circuit, and this rod soon reassumes the position shown in Fig. 4.

With this device, it is possible to place the electric counter in any convenient position about the boiler room, where the readings can be taken with the least effort. With an autographic record, showing not only the number of dumps but also the exact time of each dump, the use of this electric counter may be questioned. I have found it most useful during the course of the test, showing as it does, almost immediately, the general evaporative result accomplished up to the time of the reading. With the many lines found on the recording chart, it is difficult to find time, during the test, to count them. By pasting a piece of paper on the front of the electric recorder just below the line of moving figures on its face, and by writing thereon the figure recorded immediately before the start of the test, it is a very simple matter to subtract this written figure from the recorded figure above, and then one has, almost at a glance, the number of dumps which have occurred during the test, up to the time of taking the reading.

Just below the initial figure on the pasted slip I write the exact number of pounds of water discharged at each dump, as determined by a previous calibration of the automatic weigher. With all of this information in plain view, anyone interested in the test may, by multiplying the number of dumps by the weight of each dump, which I do very rapidly on a slide rule, obtain the number of pounds of water fed to the boiler up to that time.

The average temperature of the feed water and the steam pressure are soon found, and we can then easily determine the number of pounds of water evaporated under these conditions; required to show a heat absorption of 33,305 B.t.u., which constitutes a boiler horsepower. This is found to be 30 pounds with feed water at 100 degrees Fahrenheit and with a steam pressure of 70 pounds, and 34.488 pounds with feed water at 212 degrees Fahrenheit and with steam at standard atmospheric pressure.

We have merely to multiply this "horsepower conversion figure" by the time elapsed since the test began (in hours) and divide this product into the pounds of water fed to the boiler, to obtain with close approximation the average boiler horsepower that has been developed. This is done quickly on the slide rule, and with equal rapidity, by the use of another apparatus described hereinafter, there can be known at any instant the average evaporation of water per pound of coal stoked to the boiler. Such information is not ordinarily obtainable until after the conclusion of the test, and then it is often too late to straighten out mistakes or irregularities that may have occurred.

Advantages Gained by the Use of This Apparatus

The advantages gained by use of an automatic water apparatus of this kind must be quite apparent. In the first place, the stand required to mount this weigher, as shown in Fig. 2, costs but about $5, and by using two whiskey barrels for a sump there is added but $2.50 to this amount. No extra observers are required to note the quantity of water delivered to the boiler and check each other's results.

With the float operating in one of the sump barrels, the one which does not receive the discharge from the weigher, and with this float connected by a small "jack chain" to the lever of the balanced valve which regulates the flow of supply water to the automatic weigher, the necessity of constantly noting the hight of the water level in the sump tanks is done away with, as I have found the level of the water in the sump constantly falling and rising between two fixed levels which do not vary ⅛ inch. We therefore have only to note the level of the water in the boiler's gage glass to make corrections for periodic water readings, and as long as the water level in the boiler is kept at a constant hight the necessity for all such water-level readings is done away with.

The regularity with which the water is supplied to the boiler may thus be noted by a mere glance at the lines shown on the chart of the autographic recorder. If the demand for steam from the tested boiler is constant, these lines should be very regular in their spacing; otherwise, the trouble may be traced to a careless water tender, who may allow the water to drop or rise to an inexcusable distance below or above the string tied around the water-gage glass. The best results in a boiler test are generally obtained by keeping the water at a constant level, rather than allowing this level to fall far below the selected hight and then periodically rapidly forcing in large quantities of cold water.

If the fluctuating load of a plant is carried by the boiler tested, and the water level in the boiler is kept constant, the recording chart will show the exact fluctuation of the load by the unequal spacing of its lines. This fact proved very useful in a plant I tested where an electrical equipment was to be substituted for the steam-operated plant. The whole characteristics of the load were thus exhibited, showing the variations in load to be cared for by the electric generator.

In testing steam engines or turbines for their steam consumption, when they are operated under a varying load, the indicator card or brake load at any instant is easily compared with the chart of the automatic weigher by noting the amount of water evaporated at that same time. In competitive boiler or furnace trials, the regularity with which each boiler is operated is easily compared by reference to the autographic chart, and there are numerous other advantages to be gained by use of this water-recording apparatus, which I will not attempt to recite.

Coal Recording

Having thus developed the water-accounting apparatus, I turned my attention to coal recording, which is hardly capable of equal refinement without considerable complication.

Where a good iron wheelbarrow is found, as is the case in most boiler rooms, a runway from the floor is usually constructed upon which the wheelbarrow can be wheeled on and off a platform scale. The tare weight of the empty wheelbarrow is then noted and a 200- or 300-pound weight is added to this tare weight on the scale beam (according to the size of the wheelbarrow) and the wheelbarrow is filled with coal to balance this weight.

I usually have about half a shovel of coal in addition in each barrow load, which is thrown into a convenient dry iron ash can, to obtain an average sample of coal used during the test. This sample is carefully crushed and quartered down at the end of the test, and the last quarter is filled into a Mason fruit jar of two quarts capacity and hermetically sealed.

In order to keep track of the quantity of coal used over definite intervals of time during the test, I have the floor in front of the tested boiler carefully cleaned, so that there will be considerable distance preserved between the coal used for the test and any other coal in the boiler room. I then have dumped a single barrow load of coal at a time in this cleared space. If the smaller wheelbarrow is used it is known that each dump represents exactly 200 pounds of coal, and no more coal is delivered to the fireman until this last barrow load has been entirely stoked to the furnace.

In order to obtain a useful record of this coal, and have my attention positively called to each delivery of coal to the fireman, I invented a simple apparatus which is operated by the fireman, combining a two-pole electric switch with a Yale lock from which is operated an electric bell which can be heard throughout the boiler room, and an electric counter the same as is used with the automatic water weigher.

When the last weighed charge of coal is completely stoked to the furnace, the fireman throws in the switch, which rings the bell and registers one more on the electric counter. To avoid the possibility of mistake by the fireman, or meddling by someone else, this switch is constructed so as to be securely locked (by the Yale lock) the instant the electric contact is made. Thus it is impossible to pull the knife of the switch out of the clip contact until I open the lock with my key.

The moment the bell rings I note the time on my log and, going to the scale, I see that the proper weight of coal is in the wheelbarrow. I also assure myself that the last of the previous charge of coal is in the furnace, and then I see the next charge of coal dumped. In the meantime I insert my key in the lock and thus release the switch which stops the ringing of the bell and throws the switch handle back in position to be operated again by the fireman.

The electric coal recorder thus adds up the number of fixed charges of coal stoked to the boiler and, by subtracting the number noted on the pasted paper slip on the face of the recorder, which is the number found on the counter immediately before the commencement of the test, from the last number automatically recorded, anyone interested may quickly see the number of wheelbarrow loads used since the test was started. By multiplying this result by the weight of each barrow load (also noted on the pasted slip) he may quickly determine the weight of coal used up to that time.

As I place both the electric coal and water recorders next to each other, in some convenient location, it is easy to determine approximately the number of pounds of water evaporated per pound of coal up to the time of the observation and any change in the result thus obtained during the course of the test can be immediately accounted for. Events are thus noted which are apt to be lost sight of or unaccounted for satisfactorily in cases where the results of test are not known until after the test has been concluded.

Some discretion must, of course, be used in interpreting these results during the course of a test. Early in the test a considerable excess of coal consumption will generally be shown, due to building up the fires and heating the boiler walls and surroundings; while the reverse condition may be shown near the conclusion of the test when the fire bed is being burned down. Thickness or cleaning the fire bed during the test, as well as the time of cleaning, must be taken into consideration, and also the amount of unburned fuel in the ashes; but one experienced in furnace work should have no difficulty in making such allowances and the noting of such conditions will be [illegible] of value when the results of a test are found to be in any way out of the ordinary.

The duration of a test should be continued until a sufficient number of even and regular results are obtained to show the normal characteristics of the furnace or boiler under trial, and the system described for recording results during the course of the test will enable the testing engineer-in-charge to know before he finishes whether he has secured the desired information. It is a very simple matter to obtain an autographic record of the coal consumption during the test by using a second mechanical recorder operated by an electric solenoid. The writer has worked out the details of such an apparatus and may adopt it in future test work.

Yale-locking Switch

As the details of the locking switch used may be of interest, the following description is given. By referring to Fig. 5 it will be seen that the Yale cylinder lock used is inclosed within a brass case. A regular two-pole electric knife switch is secured to one side of this brass case and between the two knives of the switch, and in line with the central handle, a fork bracket is secured. Between the two prongs of this bracket a brass tongue or latch is hinged by an easy-fitting pivot. This latch, projected within the lock case, has a hook-shaped end which engages the spring bolt or latch of the lock. When the key is turned, the bolt is drawn into the body of the lock and the switch latch is then free, so that when the handle of the switch is moved out its knives may be withdrawn from its clips or contact pieces.

In my latest design this operation of opening the switch is performed by the action of a tension spring, the switch knives being set automatically [illegible] as soon as the key in the lock is turned. The switch, thus opened, is then ready for the fireman, who closes it when his last charge of coal is entirely stoked into the furnace. As one pair of poles of this switch are connected to the electric bell, and as the second pair of poles are connected to the electric counter, the closing operation operates both of these apparatus and the moment this double operation takes place the switch is locked so that it cannot be opened without the key. I locate this locking switch in a convenient position for the fireman, usually upon a vertical plank secured to the boiler front between two adjoining boilers.

Competitive Tests

With the coal and water records thus carried out, so as to secure the greatest accuracy with the least amount of labor, there will be found another [illegible] in boiler testing which [illegible] and [illegible] on the observer before the end of the test. [illegible] readings of the [illegible] the throttling steam calorimeter. In most cases I place the perforated collecting nipple of the calorimeter in the vertical run of pipe leaving the steam outlet from the boiler. With the calorimeter placed at this position, an observation means a climb to the top of the boiler, a walk across the hot and dirty roof of the boiler setting, frequently with several steam pipes to climb over or dodge, and then the troublesome thermometer reading in an atmosphere of steam (which steam is necessarily emitted from the calorimeter), and this trouble is greatly aggravated if one wears glasses, which become clouded with vapor. To overcome this trouble, I use the telescope borrowed from my surveyor's level.

Frequently, the telescope can be placed in a convenient position on the boiler-room floor, and as it magnifies the thermometer scale and mercury the readings are taken with the greatest ease, a gas or electric light being placed in front of the thermometers to illuminate the scales. When the calorimeter is placed in a position where the thermometers cannot be seen from the boiler-room floor, I am sometimes able to place my telescope near the top of a ladder, on the outside wall of a battery of boilers, which merely necessitates a climb to the top of the ladder, without the hot objectionable trip over the top of the boilers, when a reading is to be taken.

I have also used another means for obtaining the readings from these inaccessible thermometers by placing concave mirrors (similar to those used as shaving mirrors) back of the calorimeter and after thus magnifying the thermometer scale I obtain a reflection of these images from the concave mirrors upon a plane mirror, placed in a position where it can be seen from the boiler-room floor. I then take my reading from below the plane mirror through the telescope.

To prevent these mirrors from clouding with the steam I rub their faces with pure castile soap, cleaning them afterward with a soft rag until they are bright. The same method can be employed in coating the lenses of eye glasses, to prevent their clouding in an atmosphere filled with escaping steam.

The foregoing means for making observations during a boiler trial reduce the amount of fatiguing work necessary in conducting such tests very materially, and with the least amount of energy expended the engineer-in-charge will find himself in better condition to follow all the details of the test very closely from start to finish.

There are other minor details used by me which also contribute to this end. For example, in reading the steam gage, draft gages, the nitrogen-filled thermometer for temperature of escaping gases, the feed-water thermometer, etc., I frequently use opera glasses to excellent advantage. Sometimes, for taking temperatures through the boiler setting, between the furnace and the chimney, I use thermoelectric couples, protected in quartz tubes which are connected to a multipole switch. By throwing the switch to its several pairs of poles, the readings are taken one after the other in rapid succession on a single millivoltmeter. I have under consideration, with Mr. Bristol, the construction of a pair of sensitive thermoelectric couples for use with the throttling steam calorimeter, which will be quite unique in principle of operation.

The testing engineer finds it very necessary to keep close track of the time during the course of the test and in order to do this with the least effort I use a leather wrist bracelet which holds a watch. When holding the board carrying the log sheets, the face of this watch is in plain view, and the exact time of the observation is thus easily read and entered on the log sheet.

With this equipment I have been able to take, *personally*, with comparative ease, every reading of instruments used during a commercial boiler test, with intervals between all readings of not over 15 minutes, and have a good check on the coal and water observations in the recording and autographic apparatus.

In such tests I have also been able to find time to make numerous gas analyses, by the use of a special gas-collecting and analyzing apparatus which allows me to obtain the percentage of CO_2, O, CO and N (by difference) contained in the furnace gases in five minutes' time.

The only assistance I have needed in these tests is a fireman and a man to load, wheel and dump the coal. Further, the use of these means has enabled me to remain the greater part of the time in front of the boiler, where I can personally observe all that occurs there during the time of the test.

The Tuileries hydroelectric works, the largest of the kind in France, now nearing completion, is 10 miles from Bergerac (Dordogne). It is designed to develop 23,000 horsepower. It is built on the Dordogne river, which has been dammed. The water drives nine 2700-horsepower turbines. The hydraulic works is supplemented by a steam works with Curtis turbines and 6000 kilowatts of Thomson-Houston alternators. The current is supplied at 55,000 volts, and conveyed 62 miles to Bordeaux, 28 miles to Periguex and 74 miles to Aledin Angouleme.

A movement has been set on foot by the English Ceramic Society for a conference of representatives of the various technical institutes and societies, to consider ways and means of arranging for the "grading" and standardizing, as far as possible, of the refractory materials, such as fireclay, magnesite, etc., used in the construction of furnaces, kilns and ovens.

Wave Motors and Windmills

By F. L. Johnson

One of the office boys asked me if I was too busy to see Mr. Sawyer this morning. Of course I am never too busy to listen to anything my young friend has to offer and he was admitted. Seating himself on the edge of the chair as a sort of an intimation that his visit was to be a short one, and refusing for the first time within my memory the cigar I offered, he said:

"I did not intend to come in at all this trip, as my time is limited, but I saw something on Broadway, near Thirtieth street, that carried me back to my childhood days. In a brilliantly lighted window I saw what was called a new wave motor; in general appearance it looked like one rather tall turbine wheel set inside another. The outer wheel was composed of carved slats intended to deflect the current of water which passed between them at a proper angle against the slats or blades of the inner wheel which revolved on an axis, as the old school books used to say.

"The sight carried me farther back to childhood memories than could even Wrigley's spearmint gum. It was a breath from the Illinois prairies where I was born. I went inside and talked with the man at the desk, who explained the construction and operation of the motor. He went into a whole lot of demonstration of the power that could be developed from a thirty-mile-per-hour wave or current, just as though the Coney Island surf rolled in all the time at an average rate of thirty miles an hour or more. And then he told me that the power of the wave varied as the cube of the speed, and said that with a sixty-mile wave eight times as much power could be developed as with a thirty-mile wave.

"He showed me photographs of a four-thousand-horsepower installation now under construction, with a windmill appendix intended to operate the machinery at a slightly reduced capacity in case there should come a few hours when there were no waves but plenty of wind. I intended to ask him whether storage batteries had been provided to keep up production in the event of a dead calm on both land and sea, but forgot it. I had not much time, so did not stay long, but came away with a pocketful of literature and blank applications for blocks of stock.

"While the man was telling me the usual promoters' stories of the wonderful progress of the last few years I almost had to ask him how he knew that forty years ago there were no looms or sewing machines; no typewriter and no Pullman cars. For I had seen a sewing machine that was built in 1840, a typewriting machine that was used in 1863, and the body of the martyred Lincoln was transported to the West in a Pullman car.

"He showed me a copy of a letter from a man who said that President Roosevelt and Speaker Cannon were delighted with it and pronounced it, if successful, the greatest fuel-saver of the age. I remembered of reading somewhere about a machinist who made a machine to do a certain kind of work, and when the machine was done he showed it to all of the lawyers, doctors, preachers and school teachers that he could get to look at it, and they all pronounced it the work of a mechanical genius. But he never showed it to a mechanic because he knew what mechanics would think and say. I wondered a little if the same reason actuated the selection of politicians for trumpeters of the new motive power.

"But I am forgetting about my boyhood days. These were passed near a town in Illinois named Urbana, and the prairie around the village was dotted with windmills built, as nearly as I can remember, just like this new wave motor. From a distance one of these mills looked like a turret from the deck of one of Ericsson's monitors set up in the air on posts. The mill or rotor proper, as I recall it, was about 20 feet in diameter and 6 feet high, and as it revolved it operated a pump which supplied water for stock.

"One of my boyhood tasks was to take the place of the mill and operate the pump when the wind was not brisk enough for the work, and a part of my mischief was the cutting of short sticks from the osage or the willow hedges, which I used as a sort of 'trig' to place in a neighbor's mill to keep it from starting when the wind came. A little stick no bigger than my finger and a foot or so long, braced between a stationary and a moving vane, would hold the rotor from turning in a good stiff breeze, and my fun came from watching the irate farm hand hunt for the cause of the stoppage of the motive power.

"The starting power of the mill was so small that I do not think it would take anything much stronger than a cotton thread to hold it from turning in a good stiff breeze. But these Western mills, although they looked, as I remember them, just like the new wave and wind motor, may be different. After I came East I saw a great many tide mills along the Atlantic coast, but one after another they have dropped out of sight and out of the field of economical power producers. One mill, I remember distinctly, had a pond of about 250 acres area and ground corn for the horses that drew the cars from one town to another. The cars are not drawn by horses now and the little cornmeal that comes to town is ground by steam where the corn is raised, and the old tide mill has gone to join the stagecoach in the collection of things our daddies used.

"I guess I won't stop to moralize. I would be glad to see heat, light and power made and transmitted by better methods than are now used, but I hardly think the shortest road to this end leads through obsolete windmill designs.

"I have some stray ideas on the future of power production, but time is too short today even to outline them, so I will leave them for a chat the next time I am in town."

Testing of a Three Phase Induction Motor

By E. H. Stacey

Nowadays, when the induction motor is used for such a wide range of service conditions it most frequently happens that the operation of such a motor becomes unsatisfactory for some reason or other. There are many causes for trouble which take some little investigation to reveal, but the chief trouble is excessive heating and consequent danger of charring the insulation, followed by the inability of the motor to carry its normal load. The question must then be determined whether the motor is capable of carrying its rated load. If not, and it is a new machine, of course it is up to the maker to fulfil his guarantee, but if it is overloaded, either the load must be reduced, or a larger motor put in; otherwise the smaller one may be permanently ruined by the continuous overload.

To decide this question of overload the rotor should first be examined to see whether the bars are all tightly screwed to the short-circuiting rings, and also whether the insulation separating the bars from the iron is in good condition. This insulation may have been burned by a temporary overload and only require renewing for the motor to run all right. While the bars are practically short-circuited to the iron the local currents generated in the rotor will be excessive and the power which should be used to drive the machinery will be largely wasted in heating the rotor, so that the motor will be able to transmit only part of its rated power to the shaft.

Supposing, however, the bars to be tight and the insulation in good condition, the only course open is a test to ascertain the actual work the motor is doing, by measuring the input in watts and the output in horsepower. For this are required a voltmeter, an ammeter and a wattmeter, and, depending on the voltage and current used, a potential transformer or series transformer, or both, may be needed. For controlling the circuits, two single-pole single-throw switches and a double-pole double-throw switch capable of carrying the full-load current of the motor are needed, also a small double-pole double-throw baby knife switch. With these appliances the motor [illegible]

[illegible] which may be used for any motor up to [illegible] horsepower. As the majority of motors up to this capacity are operated on 220 volts, this is assumed to be the voltage in the present case, though by changing the transformer ratios and exercising more care with the insulation, motors of higher voltages may be tested in exactly the same manner. Arrange the switches on a board, as shown in the accompanying sketch, and wire up the motors as indicated.

Suppose, for example, that the motor to be tested is rated at 50 horsepower. The meters must be able to carry [illegible] amperes, or if they are of smaller capacity, a current transformer must be inserted in the line and the meters connected to the transformer secondary circuit. A convenient rule for finding the approximate current that a three-phase motor should require at 220 volts is to take the horsepower rating and assume that as the amperes per leg.

Or it may be worked out thus:

$$\frac{\text{Watts output}}{\text{Power factor} \times \text{volts} \times \text{efficiency} \times \sqrt{3}} = \text{amperes per leg.}$$

Example

A 50-horsepower motor with a power factor of [illegible] and an efficiency of [illegible]

$$\frac{50 \times 746}{220 \times 1.732 \times 0.9 \times 0.85} = [illegible]$$

amperes per leg. The voltmeter and the potential lines to the wattmeter should be connected as shown in the sketch, with transformers of [illegible] ratio, the voltmeters and wattmeters being connected for 110 volts. Multipliers, if supplied with the instruments, may be used instead of transformers.

When the board is wired up, close the single-pole switches and open the double-throw switch until the motor comes up to speed, in order to avoid having the large starting current pass through the meters. When the motor has attained normal speed, put the load on and throw the double-pole switch to one side; open the single-throw switch on that side and close the small switch in some direction to get the voltage between the third wire and the one in which current is being measured.

Read the volts, amperes and watts and record the readings. Now throw the switches over to the other side and take readings again, being careful to get the voltage between the line connected to the meters and the third line, as before. Possibly one wattmeter will read in the wrong direction, and all that is necessary to correct this is to transpose the connections of either the current or the potential circuit, but not both.

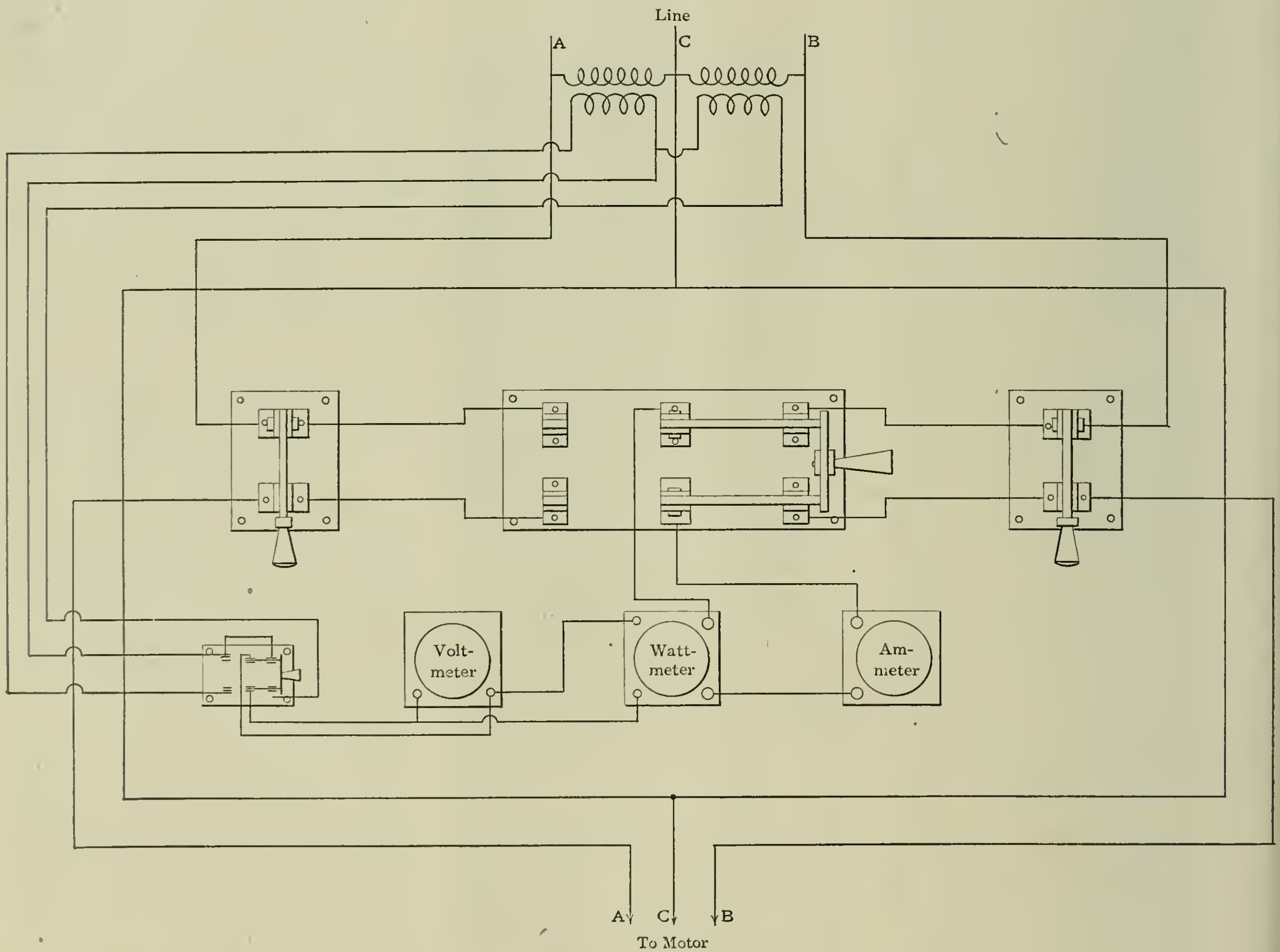
Having taken the readings in the two legs, add the watts and divide by [illegible]. This will give the horsepower of input, and multiplying this input by [illegible] [illegible] sumed efficiency, will give very nearly the power that the motor is delivering. An efficiency of 85 per cent. is assumed because this is a fair average for motors of this size, and the process of ascertaining the actual efficiency is hardly practicable outside a testing room or laboratory.

The next step is to multiply the average amperes by the average volts; multiply again by the transformer ratios, if any, and by $\sqrt{3}$; divide the watts by the final result and the power factor is obtained. If this is 0.85 or greater and the motor is fully loaded, it may be considered fairly satisfactory in this respect, though many motors of this size show as high as 92 or 93 per cent. power factor at full load.

The temperature of the iron of the stator should be taken by placing a thermometer in contact with the laminated core and covering the bulb with putty or a small wad of waste to screen it from the cooler air.

Take also the temperature of the air about 2 feet from the motor. The difference is the temperature rise, usually guaranteed by makers not to exceed 45 degrees Centigrade at full load. If the air temperature is 20 degrees Centigrade this would allow the motor temperature to reach 65 degrees and yet be within the guarantee. This is quite hot, too hot for the hand to be held long on the iron, but many motors run well up to 70 degrees Centigrade without injury to the insulation; inferior insulating material, however, would doubtless be injured in time by this degree of heat. If the temperature exceeds this and the motor is not overloaded the trouble may be caused by the machine being located where there is no circulation of air which, if remedied by ventilation, may remove the heating difficulty. To sum up, then, if the rotor insulation is good and the bars tight, and the temperature of the stator higher than 65 or 70 degrees Centigrade, the machine is either below standard in construction or is overloaded.

If the test shows the input to be more than 1.2 times the rating of motor, the machine must be of poor design, in bad condition, or else overloaded; if the latter, it should be replaced by a larger motor as soon as possible, or the load reduced to suit the motor.



WIRING OF SWITCHES AND METERS FOR TESTING THREE-PHASE INDUCTION MOTORS

In these days of high-speed machinery there may be a difference of as much as 5 per cent. in the efficiency of an engine by using an inferior grade of oil.

Blowing Soot Out of the Boilers

C. J. Larson, chief engineer of the Union Electric Company, of Dubuque, Ia., has rigged up a simple device to blow soot out of the combustion chambers of the boilers without cooling the boilers down. A 1½-inch pipe leads from the main steam riser between the boiler and the main steam header, down the side of the boiler and enters the combustion chamber. The boilers are Babcock & Wilcox type and the soot rapidly collects back of the furnace, the trouble probably being augmented because of the fine grade of coal burned at this station. The end of the pipe within the combustion chamber is fitted with a spray nozzle. By opening a check valve, the steam enters the pipe at about 190 pounds pressure and 125 degrees of superheat, entering the chamber in a strong blast which effectively loosens the soot from the floor and side walls and blows it up the stack. By using the steam blast for five minutes every week or two, the combustion chamber is kept entirely free from soot. Without the blast it would be necessary to shut the boilers down at frequent intervals for cleaning.
—*Electric Traction Weekly.*

High Pressure Steam Piping Systems

Some Notes on Recent Design, Including a Discussion of Expansion, Vibration, Pipe and Pipe Fittings, Joints, Separators and Valves

BY WILLIAM F. FISCHER

In laying out a piping system the designer should aim to do away with all unnecessary piping, and carry his lines as direct as possible, making proper allowance for expansion and contraction. The piping should be dripped wherever necessary, and all water of condensation returned to the boilers. Where the piping is carried through a wall or floor, what is known as pipe sleeves or thimbles should be built in around it. The inside diameter of these thimbles should be greater than the outside diameter of the pipe flanges to allow for the removal of the pipe when necessary. A steam pipe should never under any circumstances be built rigidly into the walls of a building, as the expansion strains or vibration in the line are almost sure to loosen the wall in time. A piece of pipe of the proper diameter and length with a plain-faced, undrilled flange at each end is a good substitute for a cast pipe thimble, although if a number of the same size are to be used, the casting will be found to be the cheaper of the two.

No definite rule can be given for the arrangement of steam lines, for the conditions met with in different stations vary greatly. As a general rule, however, in most of the modern power houses of today, no main steam header is being used larger than 14 inches inside diameter, or, as they are designated, 15 inches outside diameter. The station is subdivided into complete and independent units, the piping being so arranged that the boilers feed the main steam header uniformly, or nearly so, throughout its length, and provision is made to feed the engines or turbines in a similar manner. In this way each unit is taken care of by a certain number of boilers, the header being divided up into sections by the use of gate valves so placed that any section of the header may be cut out of service for repairs if necessary without interfering in any way with the successful operation of the station, or, in other words, by closing valves in the main steam header each unit is made entirely independent of the others. In some cases a valve is placed in the main steam header between each connection to or from the header. Steam to the auxiliaries is taken direct from the main steam header, or from a separate auxiliary header. Where it is desired to use superheated steam for the main engines and saturated steam for the auxiliaries, a separate header and separate boiler connections are required for each case.

The elaborate system of duplicating steam mains and connections is not necessary to a good design, although on rare occasions the designer may find it an advantage. Some few years ago, in order to overcome deficiencies in valves, fittings and workmanship, and also to insure greater reliability, the duplicate system was introduced and became a fad for awhile, but seeing the steam gages in the larger stations stand at from 200 to 250 pounds, and still indicating a tendency to creep higher, the manufacturers did a little figuring, and as a result they are today, and have been for the past few years, meeting the demand with all necessary materials for a first-class single piping system. As a consequence, the duplicate system is rapidly becoming a thing of the past. Reliability is better insured by the careful design of all valves and fittings, combined with the use of higher grade materials and superior workmanship. The judicious placing of cutout and bypass valves, properly providing for expansion and contraction, locating separators and drip pockets where necessary and trapping all water of condensation back to the boilers as fast as it forms, will result in a system far superior to the elaborate and expensive duplication of the past.

Valves

Two valves should be placed in a line connecting a battery of boilers with the header. One of these valves should preferably be an automatic stop and check valve placed at the outlet of the boiler, and the other a gate valve placed next to the main steam header. There should also be a valve in each connection from the header.

As globe valves introduce considerable friction and form water pockets in the line, they are seldom, if ever, used on a good job, except as throttle valves placed next to the engine or pump cylinders.

Gate valves over 6 inches in size should be provided with bypass connections, to enable them to be easily opened by equalizing the pressure on both sides of the gate, also permitting steam to be admitted slowly into the cold end of the line, warming it up gradually. This prevents water hammer, and also distributes the expansion strains more uniformly throughout the piping system.

All gate valves 8 inches and larger are, as a rule, specified outside screw and yoke, with [illegible] handwheel and rising stem. With this type the rising stem shows at a glance the approximate position of the gate or disk. These valves are furnished with indicators graduated to show the exact opening at all times, if so specified when ordering. The threaded stem being outside the stuffing box, does not come in contact with the hot steam, and is therefore easily lubricated. If desired to operate the valve from the floor line or other accessible position, the stationary handwheel may be replaced by a system of gearing with a [illegible] extension stem and handwheel carried to the desired position.

Expansion

The average main steam header, unless firmly anchored, has a tendency to creep or move out of position parallel to the length of the line. This is due to the expansion and contraction strains set up in other branches of the system and also to vibration. The header should be firmly anchored to prevent as far as possible this shifting of position, as it brings the strain on the connections to and from the header, and also to steady the piping against vibration. In piping of any length proper provision should always be made to take up or relieve the expansion strains in that section, to prevent the straining of the joints, which is almost sure to cause leakage or perhaps rupture at the weakest point. When a pipe line is anchored or fixed at two points an expansion bend should be installed in the line somewhere between the points, as the ordinary elbow or [illegible] will [illegible] the [illegible] of [illegible], even if they did the [illegible] would fall on the [illegible].

Steel pipe bends of long radius are used in preference to cast elbows of short radius, as they reduce the number of joints in the system and secure greater flexibility throughout. Where possible all bends should be curved to a radius of not less than five pipe diameters, a greater radius being preferred in all cases where the expansion strains are [illegible].

Bends can now be made from pipe of [illegible] in lengths [illegible]. This is accomplished by welding two or more pieces of pipe together, either before or after bending. Expansion bends made from pipe greater than [illegible] inches in diameter are necessarily [illegible] radius [illegible] bends made up from the smaller sizes.

and as any distortion of a bend beyond a certain stage leads to high strains on the joints, this stiffness should be taken into account when designing. A thorough knowledge of the effects of expansion on the piping system is essential to every engineer, and the writer feels he can do no better than to refer the reader to the June 2 and October 20, 1908, numbers of Power and The Engineer, where the subject is covered to some length.

Vibration

Steam flowing at a velocity of from 5000 to 6000 feet per minute in the supply pipe of a modern high-speed engine, is alternately stopped and raised again to this velocity several hundred times a minute, due to the quick opening and closing of the steam valves. This intermittent motion of the steam in many cases causes vibration and hammering in the supply pipe, which in turn is transmitted to other branches of the piping system. Vibration is also caused by suddenly changing the direction of the steam flow through short-turn elbows or tees, and also to an unequal velocity of the steam flowing through different branches of the system. Where possible to do so, the pipes should be so proportioned that the velocity will be as near uniform as possible in all branches to and from the main header.

In one case of the writer's knowledge, a vibrating pipe line was anchored at a certain point. This decreased the vibration to a large extent, but no provision was made to take up the expansion in that section of the piping between the anchor and the boiler nozzles. The plant was shut down each night, and started up again early each morning. In about a week's time the joints in the piping farthest away from the anchor were found to leak badly. They were repacked with new gaskets and made up steam-tight, but about a week later were leaking almost as badly as before. The engineer-in-charge, being a practical mechanic, at once decided that the anchor was causing the trouble, as these leaks had not occurred before the anchor was placed in position, so in place of wasting more time and material in repacking the flanges, he decided to investigate, and soon found the cause of the trouble. It appears that the anchor, which was very rigid, was installed while the line was hot and the piping clamped firmly in position. The expansion in this line was found to be nearly 1⅞ inches; consequently at night when the plant was shut down, the line shortened, throwing a heavy strain on the pipe and bolts at each joint and causing the leakage.

The engineer removed a section of the piping and installed an expansion loop of long radius. He decided it would be better to throw part of the strain on, the piping while cold, so the bend was sprung into position. The next morning steam was turned on as usual, and there was no more trouble from leakage or vibration.

Separators

A large "slug" of water is not a very healthful "dose" for a steam-engine cylinder, especially in high-speed engines where the clearance space between the cylinder head and piston is reduced to a minimum. In all modern work each engine supply pipe is usually equipped with a separator of large volume, placed as near the engine throttle as possible, and all main steam headers are equipped with drip pockets.

Besides intercepting the moisture in the steam the separator performs another function of great value, in that it provides a reservoir where the steam is stored after the steam valves close at each stroke of the engine piston. This insures a more uniform pressure in the engine cylinder up to the point of cutoff and also provides a cushion of steam near the engine cylinder to take the reaction caused by the quick cutoff in the steam chest, thus preventing vibration from being transmitted to the piping system.

Separators also tend toward a continuous and steady flow of steam in the direction of the engine instead of the otherwise necessary stopping and starting of the flow with every movement of the engine valve, in this way preventing to a large extent the usual drop in pressure between the boilers and the steam chest, also reducing the tendency of the boilers to prime during a momentary excessive demand.

Separators having a capacity of from three to four times that of the high-pressure cylinder are making it possible in many cases to reduce the size of the engine supply pipe, up to the inlet side of the separator, from 5 to 15 per cent. over that called for by the engine builders, the piping between the separator and the engine remaining the same size as called for.

This last rule does not seem to apply to separators where used in connection with steam turbines, as the velocity is much higher and more uniform throughout. The piping should therefore be of full size throughout its length, from the main steam header to the throttle inlet. Separators of the receiver type are preferred.

Mechanics are sometimes careless in erecting new work, leaving bolts, nuts, wrenches, cold chisels, oil cans, etc., inside the piping. The operating engineer comes across this junk some few week later in a place where only an engineer would ever expect to find such things. Small junk, unless stopped by a separator, eventually locates in the engine cylinders, scoring and cutting them so badly that in many cases they have to be rebored. A small bolt or nut going over with the flow of steam would rip the blades from a steam-turbine rotor, owing to the small clearances between the blades and casing. For this reason the turbine supply pipe is nearly always equipped with a net or strainer to stop such junk before it reaches the turbine inlet. These strainers are furnished with the turbines.

Loose junk remaining in the piping system after erection also has a tendency to come to rest directly under the seats of stop valves, making it impossible to close them. A good separator will remove nearly, if not all of this small junk before it could reach the engine cylinder, and prevent injury to the interior parts, or even engine wrecks.

Pipe

Wrought-steel pipe, especially in the larger sizes, is preferable to wrought-iron pipe for general use. As ordinary commercial pipe may vary in thickness from the standard, as listed in catalogs, "full-weight pipe" should be specified. As a rule full-weight pipe will be found to run full card weight, but should never vary more than 5 per cent. either way.

Full-weight pipe of steel or wrought iron is suitable for working pressures up to 250 pounds per square inch, if not reduced in thickness by threading outside the hub of the flanges. For bending purposes lap-welded steel pipe is better than butt-welded, as the seam is less liable to open up under the stress of bending to a short radius. For threaded joints, if sharp dies are used, steel pipe has been found to cut and thread as readily as wrought-iron pipe, but blunt dies have a tendency to tear or break the threads.

Where used in connection with Van Stone joints or joints where the pipe is turned over the face of the flange, wrought-iron pipe has been found to split badly, both at the weld and all around the outer circumference when rolling or flanging over. Steel pipe is better in all cases, and open-hearth steel pipe is preferred to bessemer steel, both for Van Stoning and welding purposes, as the quality of the metal is more uniform and low in carbon.

The following tests, taken from a Crane catalog, will serve to demonstrate the strength of steel pipe as compared with wrought-iron pipe. The pipe was picked from stock at random:

Ten-inch standard wrought-iron pipe burst at 1900 pounds; 10-inch extra-strong wrought-iron pipe burst at 2700 pounds; 10-inch standard wrought-steel pipe burst at 3000 pounds.

None of this pipe burst at the weld, but some distance from it, showing the weld to be in this case at least as strong as the pipe itself. Extra-strong and double extra-strong pipe is used more in hydraulic work, for turbine step-bearing oiling systems or boiler-feed lines, than for steam.

Pipe Joints

Many of the earlier stations are using screwed or threaded joints in their steam mains successfully where the pressure is 150 pounds or even greater. In man cases, extra-heavy pipe is used in connection with the screwed and peened joint, where the end of the pipe is peened or rolled into a recess at the face of the flange to prevent leakage through the threads, and to prevent the loosening of the flange at the threads. This is a good joint if properly made and is still used quite extensively in new work. For pressures above 150 pounds and for superheated-steam work the general tendency is to specify either the Van Stone or welded type of joint in sizes 5 inches in diameter and larger, the screwed or screwed and peened joints being used only in the smaller sizes.

There seems to be one objection to the old type of Van Stone joint, in that the turned over or flanged portion of the pipe is thinned down considerably in rolling and finishing the face of the joint, making this the weakest point, as shown in Figs. 1 and 2. In the first illustration the dotted lines *C* show the position of the pipe before rolling. Line *A A*, slightly exaggerated for clearness, shows the bevel of the face of the joint after rolling, due to the gradual thinning down of the metal at the edge *B*, which is due to the stretching of the metal on the outer circumference of the flanged portion. Fig. 2 shows the same joint after the face has been finished off true in the lathe. Note the thinning down of the metal at *D* as compared with *T*, the original thickness of the pipe.

To overcome this defect joints known as the "Cranelap" and "improved Van Stone" were put on the market some years ago, and are now used in preference to the old type. The method of constructing the Cranelap joint is shown in Fig. 3. At *E* the face of the flange is shown beveled inward to compensate for the difference in the thickness of the pipe between the inside and outside portions of the lap. This brings the face of the joint almost true after rolling, a light cut being all that is necessary in facing.

The improved Van Stone joint is made by securely welding a tapering band of steel to the end of the pipe around the outer circumference as shown in Fig. 4. Fig. 5 shows the same joint after rolling and facing. The flange is bored out to a slight taper, as shown at *G*. The thickness of the pipe *F* at the face of the joint is greater after finishing than the original thickness *T*.

Both of these joints are being used extensively for superheated-steam work. The flanges on all joints of the Van Stone type are loose and swivel on the pipe, a fact appreciated by erecting engineers, as it is sometimes necessary to change the position of bolt holes in the field.

Another joint coming into use for high pressures is the welded joint, made by welding a wrought-steel flange direct to the end of the pipe. Fig. 6 shows what is known as the screwed-and-peened joint. The pipe is screwed into the flange steam-tight, leaving a short length projecting beyond the face of the flange. This end is then heated and either rolled or peened over, filling the recess *H* at the face of the flange. The flange is then faced off true in the lathe and drilled. This is a good joint if properly made, and is much superior to the ordinary screwed joint, which is too well known to require any description.

FLANGES

Cast-iron and cast-steel flanges are sometimes used in connection with the Van Stone and similar joints, but in all cases a good rolled-steel flange is to be preferred. The cast-steel flange in many cases costs nearly as much as the flange of rolled steel and is far inferior, as the metal may not run uniform throughout. The writer has seen cases where cast-steel flanges in the rough looked sound and perfect in all respects, but upon facing and drilling were found to be honeycombed with blowholes beneath the surface, and as a consequence were rejected. Blowholes can be entirely prevented in steel castings by the addition of manganese and silicon in sufficient quantities, but both of these elements cause brittleness and should be added with caution on this account.

GASKETS

The gasket might be called the connecting link of the piping system, and is of more importance than would appear at first thought. Much trouble has been experienced in an otherwise perfect system of piping, due to bad gaskets. The cost of renewing gaskets is so far greater than [illegible] and should not be overlooked. First it is necessary to shut off pressure on that part of the line, open the joint, scrape and clean the face of the flanges, insert the new gasket and make up the joint again steam-tight. From two-thirds to three-fourths of the actual expense of renewing a gasket under favorable conditions is for labor alone, and shutting off pressure from any one section will probably cause shutting down one or more units, boilers or engines as the case may be.

There are many different ways, too numerous to mention here, of forming the face of flanges to prevent the gasket from blowing out. With flanges of the tongue and groove, or male and female type, it is necessary to spring the pipe apart at the joints to remove the old gasket and replace the new one, and at times this cannot be done without taking down a section of the piping. The straight-face joint, if properly put together with a good gasket suitable to the work, will stand a test of [illegible] pounds without blowing out.

On Van Stone work a ground joint is quite often used without a gasket, that is, the face of the joint is ground to [illegible] a fine finish. This is much more expensive than a joint having a fine-tool finish, and made up with a gasket. The corrugated copper, corrugated soft steel, and gaskets of long-fiber asbestos [illegible] or covered with copper or bronze all seem to give excellent service for all pressures and temperatures. Other gaskets containing rubber or alloys of soft metal are quickly destroyed if used in connection with superheated steam.

WELDED STEAM HEADERS

The latest practice among engineers is to do away with fittings in the main steam lines entirely and substitute what is known as the welded header, where [illegible] up to 40 feet or more in length is welded from one piece, and all nozzles or outlets welded directly to the header itself. The piping will have [illegible] per cent. [illegible] the strength at the weld in many cases, unless reinforced at this point. One of the large concerns doing this class of work makes the metal at the weld from 25 to 100 per cent. thicker than the pipe.

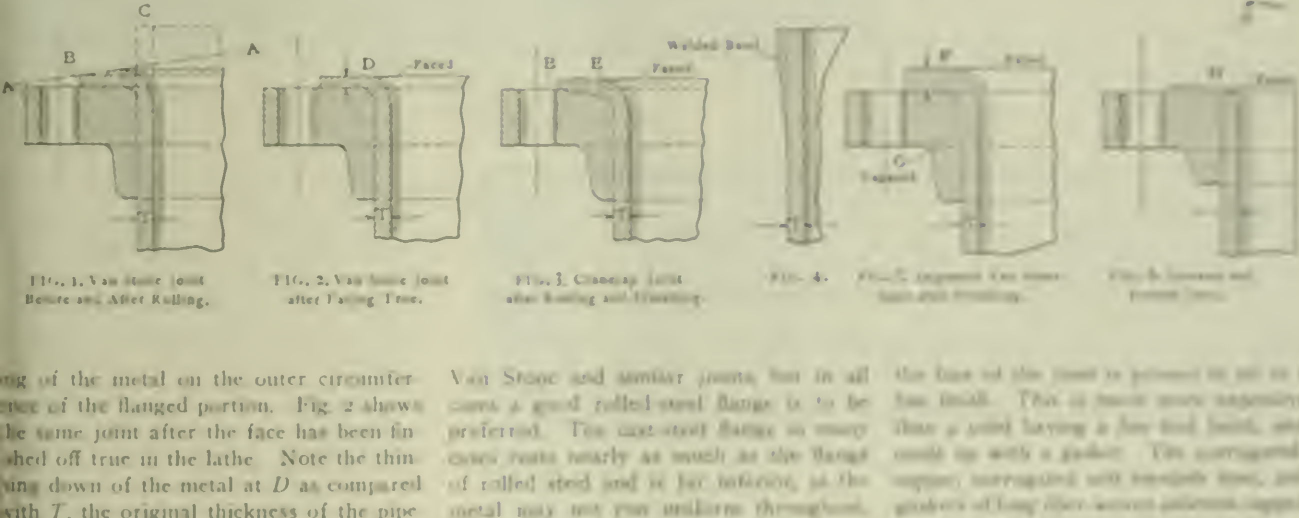


FIG. 1. Van Stone Joint Before and After Rolling.

FIG. 2. Van Stone Joint after Facing True.

FIG. 3. Cranelap Joint after Rolling and Finishing.

FIG. 4.

FIG. 5. Improved Van Stone Joint after Finishing.

FIG. 6. Screwed and Peened Joint.

to insure the joint being stronger than the pipe itself. With the welded header, rolled-steel or cast-steel flanges may be used in connection with Van Stone or similar joints, or if preferred, the welded joint, having all flanges welded to the pipe.

Some advantages of the welded header are: The lightening of the entire work, better quality of material used, decreased number of joints liable to leak and the saving of time, labor and expense in erecting. There seems to be one objection to the welded header, however, in that it is difficult to make a new connection to the header if required to do so after the piping is installed. This difficulty can be overcome by allowing one or two extra nozzles when making up and blanking them with a blind flange until needed.

Fittings and Valves for Superheated Steam

Cast iron does not seem to stand up to its record under the action of superheated steam as well as it has been doing with saturated steam, as several tests made after a few years' service show quite a reduction in strength. The following case is copied from Power and The Engineer, November 24 number: A 20-inch tee recently removed from a superheated-steam line, after three years' service under a pressure of 160 pounds per square inch, with 125 degrees of superheat, making the ultimate temperature less than 500 degrees Fahrenheit, showed cracks open as much as 1/8 inch on the outside, through which steam leaked. The casting was nearly 3/4 inch longer and 1 inch greater in diameter than when installed. The inside surface was found covered with a hard, reddish oxide, with no cracks visible.

The Crane Company recently cited a case showing where a 14-inch cast-iron high-pressure gate valve, after four years' service in a superheated-steam line, showed a loss of strength of 49 per cent. in the material in the body of the valve, and 33 1/3 per cent. in the material in the flanges. The steam pressure in this case was 200 pounds per square inch and steam temperature 590 degrees Fahrenheit. The valve was found to be 5/16 inch longer than when installed.

As a general rule for all superheated-steam work and for high temperatures, fittings and valves are specified to be of cast steel.

Making Ice Cream in a Large Ice Plant

By John N. Swartzell

On August 4, last, the Chapin-Sacks Manufacturing Company, of Washington, D. C., held a formal opening of one of the most uptodate and sanitary ice-cream factories in the country. For many years this company has operated a large ice-manufacturing establishment and only comparatively recently has been making plans and preparations for the erection of the ice-cream factory which is now run so successfully in connection with the ice-making business. The company's buildings, which occupy the entire eastern end of the block between North Capitol, First, Patterson and M streets, northeast, are two in number and are located conveniently with respect to the Union station and the tracks over which the milk arrives.

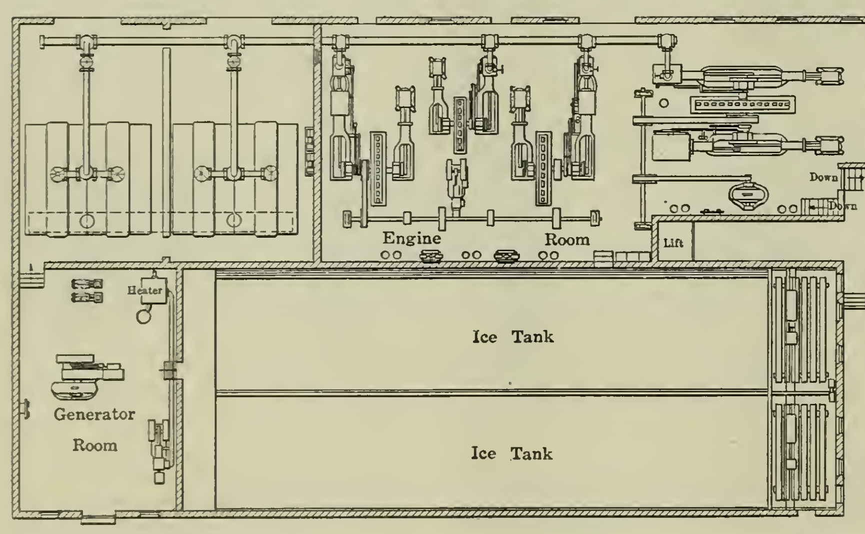


FIG. 1. PLAN VIEW OF ICE PLANT

Methods of Handling Milk

Milk used at the plant is delivered in refrigerator cans and cars from Jefferson county, New York, and is chemically tested before being used. Upon arriving at the factory it is carried to the second floor of the building and placed in a cold-storage vault until ready for pasteurization and mixing prior to being made into ice cream. Next to the storage room and communicating with it is the mixing room. This room contains the pasteurizer and the mixers. The pasteurizer heats the milk to a temperature of 175 degrees Fahrenheit, then cools it down by water to 75 degrees Fahrenheit and finally reduces its temperature to 38 degrees Fahrenheit by cool brine.

There are four machines for mixing the ingredients of the ice cream. These are huge galvanized-iron tanks, each having a capacity of 150 gallons. In the center of each tank there is a vertical shaft fitted with two dashers, these being arranged to revolve in opposite directions, and the shaft supporting them is driven by a bevel gear and shaft from a Crocker-Wheeler 110-volt direct-current motor. The mixers are set in two groups, one motor sufficing to operate each group. The driving shaft is divided and furnished with a clutch so that the mixers can be run singly when desired.

Located on the first floor of the building directly under the mixing room is the freezing room. There are six horizontal and one vertical freezer, each having a capacity of 12 gallons. The freezers are cooled by brine circulated by a small centrifugal pump, which is located in the mixing room, and is direct-connected to a 3-horsepower direct-current motor having a speed of 1650 revolutions per minute. The cream to be frozen flows by gravity from the mixing tanks to the freezers through pipes put up in short sections, so arranged that they may be taken down each day and thoroughly washed. The horizontal freezers are equipped with individual 1 1/2-horsepower Crocker-Wheeler direct-current motors while the vertical machine, used only for freezing fancy creams, is driven by a Lincoln 2-horsepower variable-speed motor. Each motor is connected to its respective freezer by a noiseless chain-and-sprocket drive.

The freezers are elevated a sufficient distance from the floor to permit the frozen cream to be drawn off by merely opening a valve, placed conveniently in one end. Cream upon being drawn from the freezer is placed in the hardening room, where it may become firm, and allowed to remain there until ready for shipment. For the purpose of crushing the ice used in packing the frozen cream for delivery, two motor-driven ice crushers are installed, one emptying directly into the shipping department, the other discharging into a chute through the outside wall of the building for filling the delivery wagons. Ice to be crushed is carried to the second floor of the building from the ice-storage room on the first floor by an ice hoist driven by a Gener

Electric 115-volt direct-current motor. Here it is dumped into a chute and delivered to the crushers.

Adjoining the freezer room is the washing and sterilizing room. The cans upon being returned by customers are brought to the rear of the building and received through a small doorway for that purpose and placed in the tubs, where they are thoroughly washed. After the process of washing is finished the cans are placed in a wire basket moving upon a track and passed into a steam sterilizer. The sterilizer was built and installed by the Kensington Engine Works, of Philadelphia, Penn., and resembles in appearance a small horizontal boiler, being about 8 feet long by 4 feet in diameter. The method of operating is as follows:

Steam at 80 pounds pressure is admitted to the reducing valve and the pressure lowered to 10 pounds. At this pressure it is permitted to enter the jacket surrounding the internal chamber. When this has been accomplished the chamber is ready to receive the material to be sterilized. After the temperature of the chamber has risen considerably the air exhauster is opened until the vacuum gage shows 15 inches of vacuum. The valve to the inner chamber is then opened slightly, and when the pressure has risen the valve is closed and the air exhauster again started. When the vacuum gage indicates 15 inches the steam valve is again opened until the thermometer reads 236 degrees Fahrenheit. The steam is then allowed to circulate through the chamber for a short time, after which it is shut off and the exhauster opened once more to draw off the steam and vapor. In a few moments, when the heat of the jacket has had an opportunity to dry any moisture remaining inside the chamber, the doors may be thrown open and the contents of the basket removed.

FIG. 2. FREEZER ROOM

FIG. 3. BOILER INSTALLATION

ICE PLANT

The plant of the company is fitted with five ice tanks, each 99 feet long, 20 feet wide and 20 inches deep for manufacturing plate ice, the direct-expansion system being employed. The blocks of ice, each weighing six tons in weight, are removed from the tanks at intervals by an overhead traveling crane. Six and one-third days are required for an entire freeze. The cranes for handling the huge blocks of ice are operated by a hydraulic pressure of 150 pounds, maintained in tanks by small duplex steam pumps located at the farther end of each crane, one sufficing to operate the cranes of two tanks.

The blocks of ice, of which there are about 96 in each tank, are cut up into blocks by means of an iron frame heated by steam. As the blocks are cut they are placed in a chute and slid into the ice house. During the summer season the total output of the plant is 140 tons per day, and in winter it varies between 80 and 90 tons per day.

There was once a time when plate ice could not be manufactured from anything but distilled water, but this difficulty has in later years been overcome by circulating air at low pressure through the ice tanks during the process of freezing. The circulator employed at this plant was built by the Bury Air Compressor Company, of Erie, Penn., and is located in a small room in the older part of the building, which also contains the boiler feeders, the heater and an electric-generating unit. This unit consists of a Buckeye single heavy-duty high-speed engine and a Sprague 40-kilowatt 110-volt direct-current generator. The circuits supplied by the company are controlled by a ten-panel switchboard located nearby, using Weston instruments and furnished by the Trumbull Electric Manufacturing Company of Plainville, Conn.

The boiler feeders consist of two Knowles outside-packed plunger pumps.

sizes 7½x5x6-inch and 7½x5x10-inch, respectively. These, as well as the compressor and generator engines, exhaust into a Cochrane open heater which raises the temperature of feed water to 210 degrees Fahrenheit before delivering it to the pumps.

Located next to this room and communicating by means of a low arched doorway is the boiler room, which is 48 feet long by 41 feet wide and is divided into two parts by a brick partition, one room being 41x23 feet and the other 41x25 feet. The larger room contains two 250-horsepower boilers fitted with Hawley down-draft furnaces. In the other room are located two of 228 horsepower each. The entire boiler equipment was furnished by the E. Keeler Company, of Williamsport, Penn., and was built to carry a working pressure of 160 pounds. The boilers have one steam and water drum 20 feet 5 inches in length by 48 inches in diameter, contain one hundred and thirteen 18-foot tubes 4 inches in diameter, and are fitted with horizontal baffles. In addition to the feed pumps located in the generator room there is another battery in the larger section of the boiler room, comprising two Snow duplex pumps, size 5¼x3½x5 inches. These are held in reserve. The waste gases are conducted to the atmosphere by a rectangular uptake and two steel stacks.

West of the boiler room in the same building is the engine room containing four Corliss-driven ice machines. These were built by the Vilter Manufacturing Company, of Milwaukee, Wis. There is one 125-ton machine, consisting of two 18x36-inch double-acting ammonia compressors driven by a 400-horsepower cross-compound condensing engine; two machines of 55 tons capacity, each consisting of one 17x34-inch ammonia compressor operated by a tandem compound-condensing engine, and one machine of 10 tons capacity operated by a simple non-condensing engine. On the cross-compound an automatic oiling system keeps the bearings flooded, oil being pumped from reservoirs under the base of the engine by a small pump operated from the rocker arm of the low-pressure eccentric. The bearings of the other engines are arranged for oil-cup lubrication, while the cylinders are furnished with Phoenix force-feed oil pumps driven from the wristplates. All the engines have heavy-duty frames, and with the exception of the simple engine are belted to a line shaft. The 400-horsepower unit drives an overhead line shaft which in turn is belted to a Westinghouse 30-kilowatt 125-volt direct-current generator. On the wall of the engine room there are gage panels indicating steam, receiver, ammonia head and back pressures as follows: Steam, 135 pounds; receiver, 15 pounds; ammonia head pressure, 210 pounds; ammonia back pressure, 18 pounds.

The ammonia condensers are of the countercurrent type and are located in a covered area upon the roof of the old building. These are two in number and are composed of 24 coils of 2-inch pipe, 24 pipes to the coil and 22 feet long. For the raising of condensing water over the cooling towers, a Goulds triplex power pump is employed and is driven by a belt from a line shaft in the engine room, which also drives the fans of the cooling towers. The two cooling towers, located above the condensers, are built of wood and are each equipped with two 60-inch fans. The steam condensers in connection with all three of the ice machines are of the counter-barometric type and are supplied with water which has previously been used for condensing purposes in the ammonia condensers. They are located on the roof of the building containing the engine room.

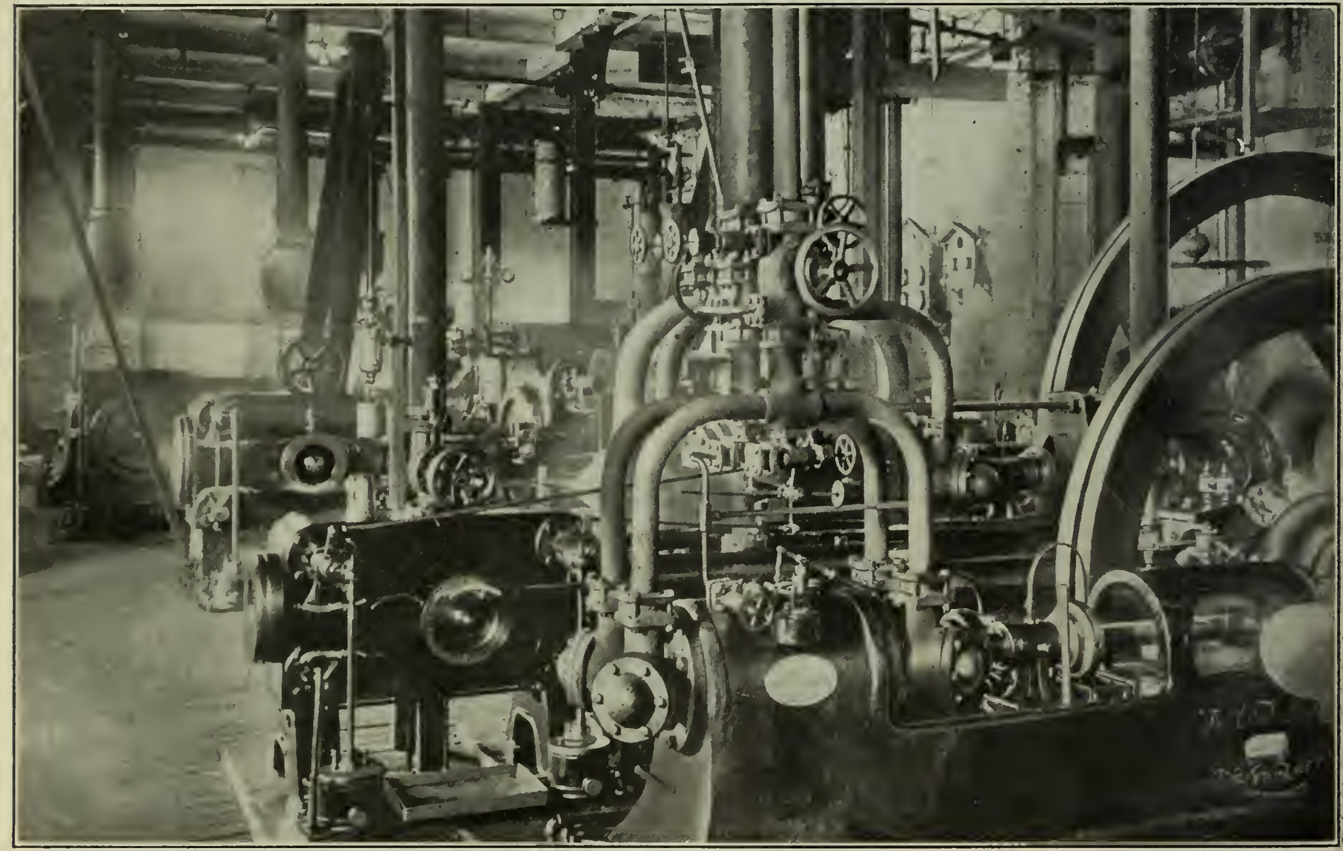


FIG. 4. ENGINE ROOM

There are three vacuum pumps on the condensing system. Two of these are located in the engine room and the other in the basement. The two in the engine room are small horizontal flywheel pumps for wet-vacuum service, while the third is a dry-vacuum pump.

For the information contained in this article the writer is indebted to A. A. Chapin, president of the company, who cordially invites public inspection of the plant.

Modern British High-Speed Steam Engines

Description of What Is Believed to Be Practically the Only Single Acting Compound Engine Built in Numbers in England, Other Makes

BY JOHN DAVIDSON

Allen. Another firm which makes a specialty of high-speed engines is that of W. H. Allen, Son & Co., Ltd., of Bedford, England. The company's design of two-crank compound engine is illustrated in Fig. 20. This engine differs somewhat from those already described, as flat guides of marine type are provided in place of bored ones. These are formed in the back of the frame and not as an extension of the distance piece carrying the cylinders. Again, the distance piece supporting the cylinder from the main frame of the engine is cast in one with the cylinders. This does away with the necessity of a joint underneath the cylinder, but somewhat complicates the cylinder casting. The two cylinders are also placed side by side and the valves on the outside. By this means the cranks are brought closer together and probably a slightly better balance is obtained.

The design of triple-expansion engine manufactured by this firm is shown in Fig. 21. Details of construction of the engine are similar in most respects to those of the two-crank compound engine. The piston valves are formed in one solid piece in the form of a tube, no rings whatsoever being fitted. The frame ends are arranged for driving as shown, and by fitting these ends, the valve can be made of uniform shape and thickness and distortion due to alterations of temperature entirely prevented.

An exterior view of a standard three-crank triple-expansion engine of 600 kilowatts capacity is illustrated in Fig. 22. One very noticeable feature is the use of the doors which are provided to give access to the working parts.

Reavell. Practically the only single-acting engine which is manufactured in any number is the Reavell engine which is made by Reavell & Co., Limited, of Ipswich. The construction of this engine is shown in Fig. 23. In a compound or two-stage expansion engine the second stage is usually obtained by transferring to a larger cylinder the steam which has completed its first stage of expansion in the smaller, or high-pressure, cylinder. The same effect, however, can be obtained by transferring only a portion of the steam which is already expanded in the first cylinder, in which case the second cylinder may be of the same size as the first cylinder, and the portion transferred will be further expanded in the second cylinder, the portion remaining in the first cylinder being utilized as will be described later. The first cylinder would be equivalent to the high-pressure cylinder, and the second cylinder to the low-pressure cylinder in an ordinary compound engine. This latter method is adopted in the Scott compound engine, the only difference being that instead of employing two cylinders, the first stage of expansion takes place at the top of the piston and the second stage on the bottom of the piston in one cylinder.

The cycle will be made clear by reference to the theoretical diagram shown in Fig. 24. Steam is admitted at B' into a cylinder having a considerable clearance volume above the piston at the beginning of the stroke. This clearance volume is already filled with steam at boiler pressure, having been compressed during the latter part of the preceding stroke. Cutoff takes place at E, the actual point being varied by the governor to suit the variations of load. The total steam in the cylinder, which includes that already in the clearance space at the beginning of the stroke, then expands during the remainder of the down-stroke to F. As the piston is nearing the bottom, where a communication is opened between the [illegible]

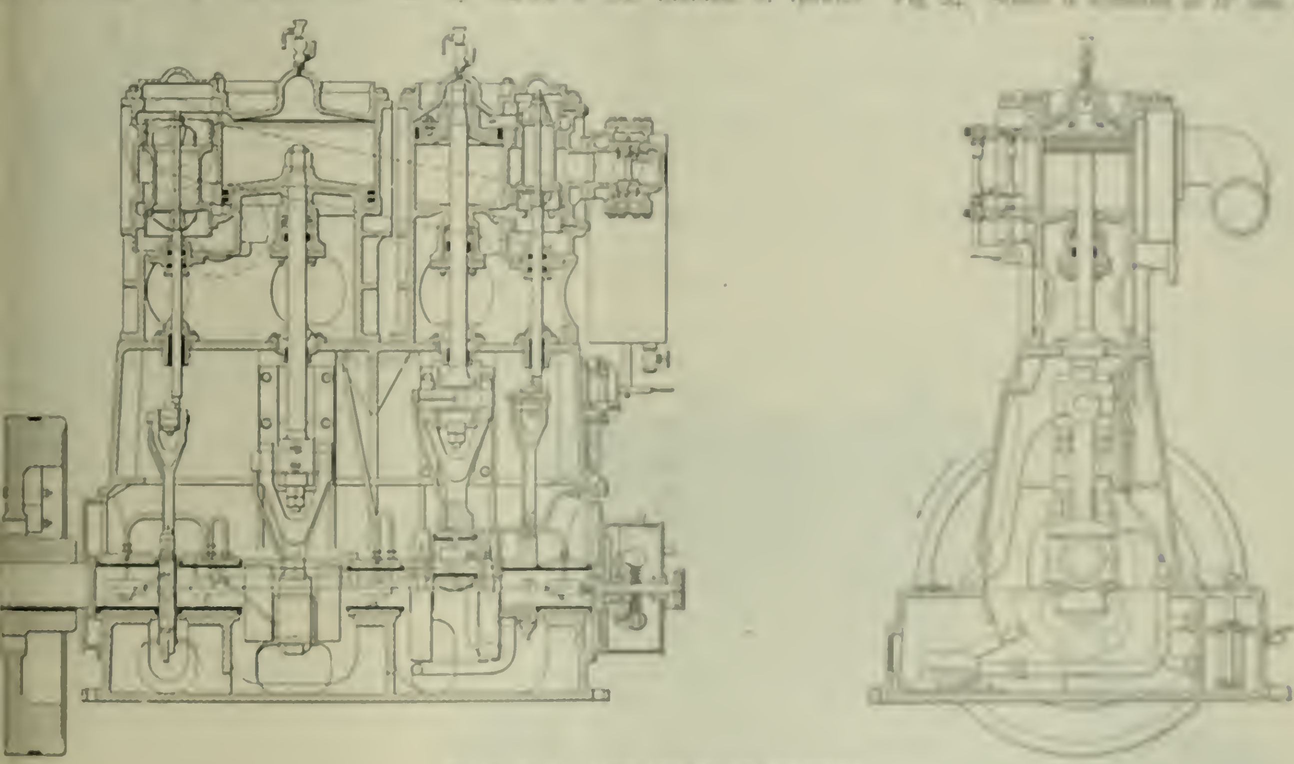


FIG. 20. W. H. ALLEN TWO-CRANK COMPOUND

and the bottom of the cylinder, which remains open to Z, transferring a portion of the steam to the under side where its second stage of expansion takes place, until the termination of the up stroke, just in the same way as it would do if transferred or exhausted to a separate cylinder.

The steam which remained above the piston at the point Z, when the communication from the top to the bottom of the cylinder was closed, is compressed up to initial pressure W.

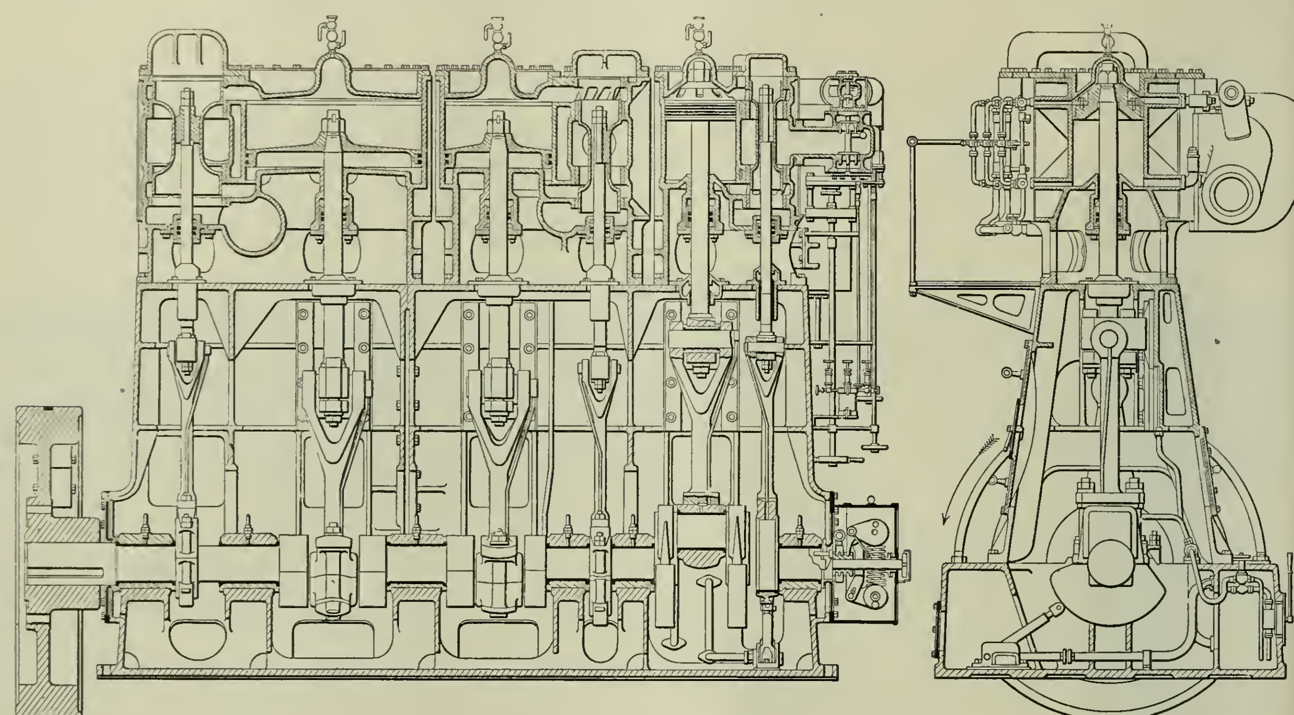


FIG. 21. W. H. ALLEN TRIPLE-EXPANSION ENGINE

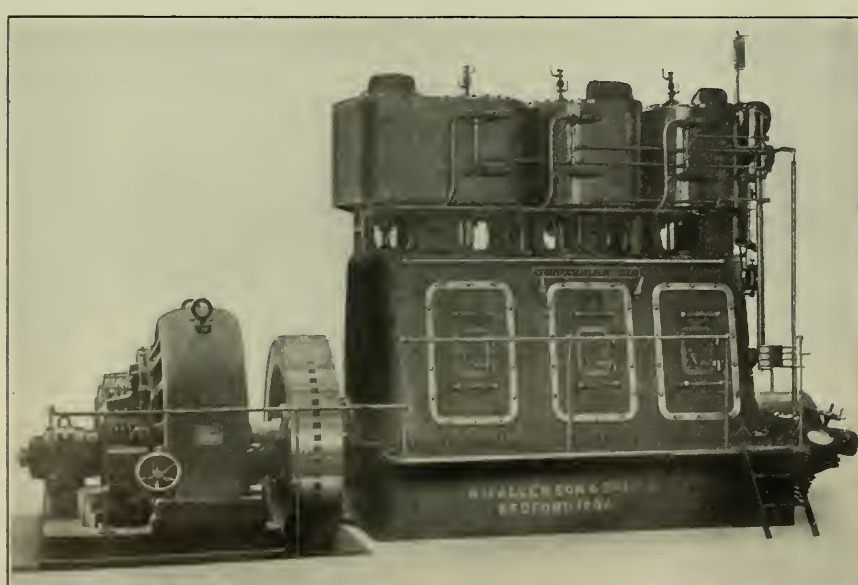


FIG. 22. EXTERIOR OF W. H. ALLEN TRIPLE-EXPANSION ENGINE

Referring to the sectional illustrations, Fig. 23, it will be seen that the steam-inlet flange is on the body of the cylinder itself, there being a steam jacket of considerable size between the working barrel and the outside of the cylinder, and between the inner and outer cover. The valves of the engine reciprocate in a central valve liner secured in the bottom of the cylinder as shown, and the piston reciprocates in the annular space between this liner and the cylinder walls. The steam, entering through the stop valve, passes up between the inner and outer cylinder walls and covers, and is admitted into the valve liner through ports A near the top. From the inside of the liner the steam passes into the cylinder through spiral ports C up to the point of cutoff, the clearance space shown above the piston being already filled with steam up to initial pressure, as before stated, and the cutoff being effected by the valve D driven by a slide rod.

After an early cutoff, the precise point of which is controlled directly by the governor, the steam expands during the remainder of the down stroke, and while the crank is turning the bottom center the ports E in the center of the liner ar[e] opened by the valve F, called the transfe[r] and exhaust valve. This valve F at th[e] same time opens the ports G at the bot[t]om of the cylinder, so that while the piston is making its up stroke a communication is made between the top and bottom of the cylinder, transferring steam a[t] equal pressure and temperature from th[e] top to the bottom of the piston. Thi[s] transfer continues for about half th[e] stroke. In other words, about one-ha[lf] of the steam which was above the pisto[n] is transferred to the other side. Th[e] transfer is closed first by the piston ove[r]running the ports E in its upward strok[e] and immediately afterward by the valv[e] F closing the ports E and G. The stea[m]

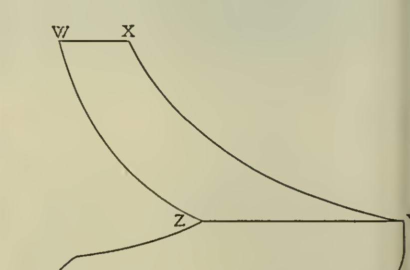


FIG. 24. TREORETICAL DIAGRAM FROM SINGL[E] ACTING COMPOUND ENGINE

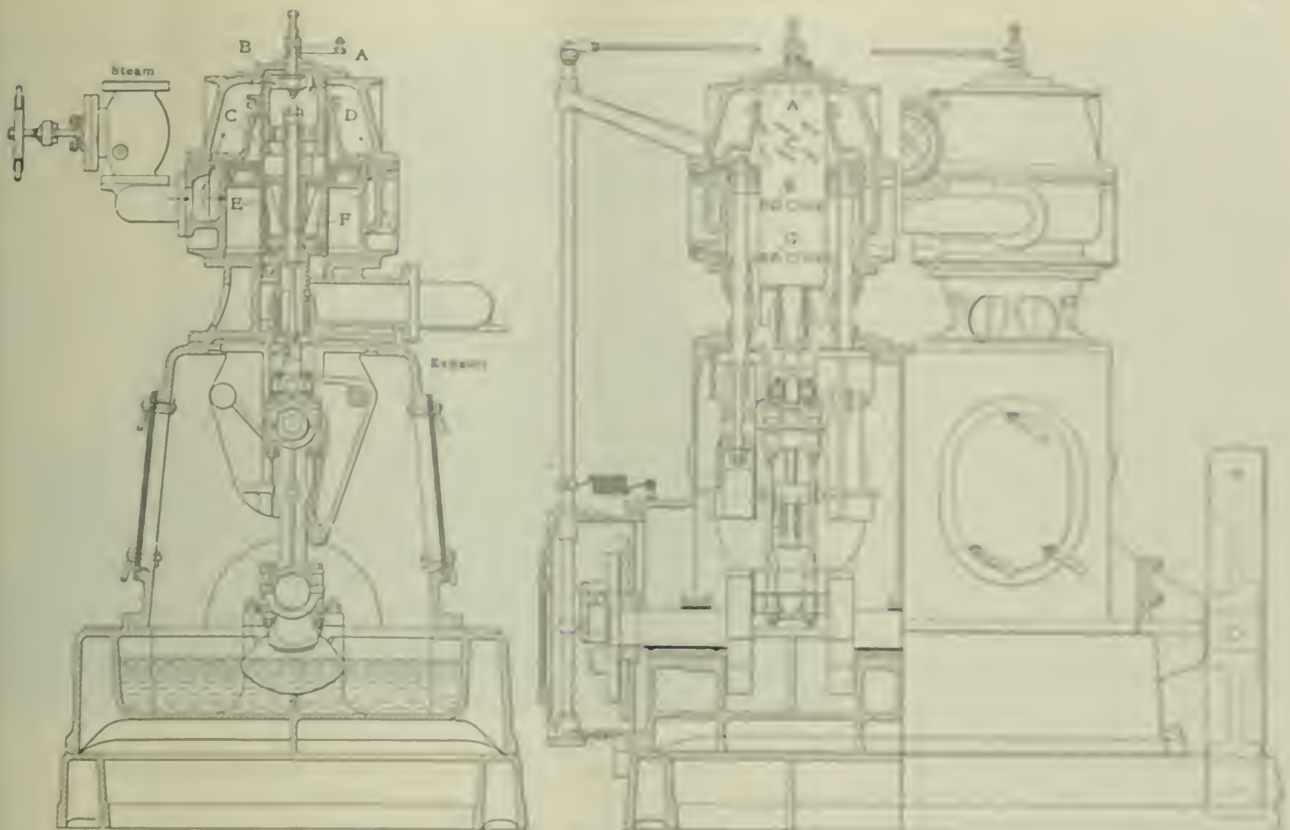
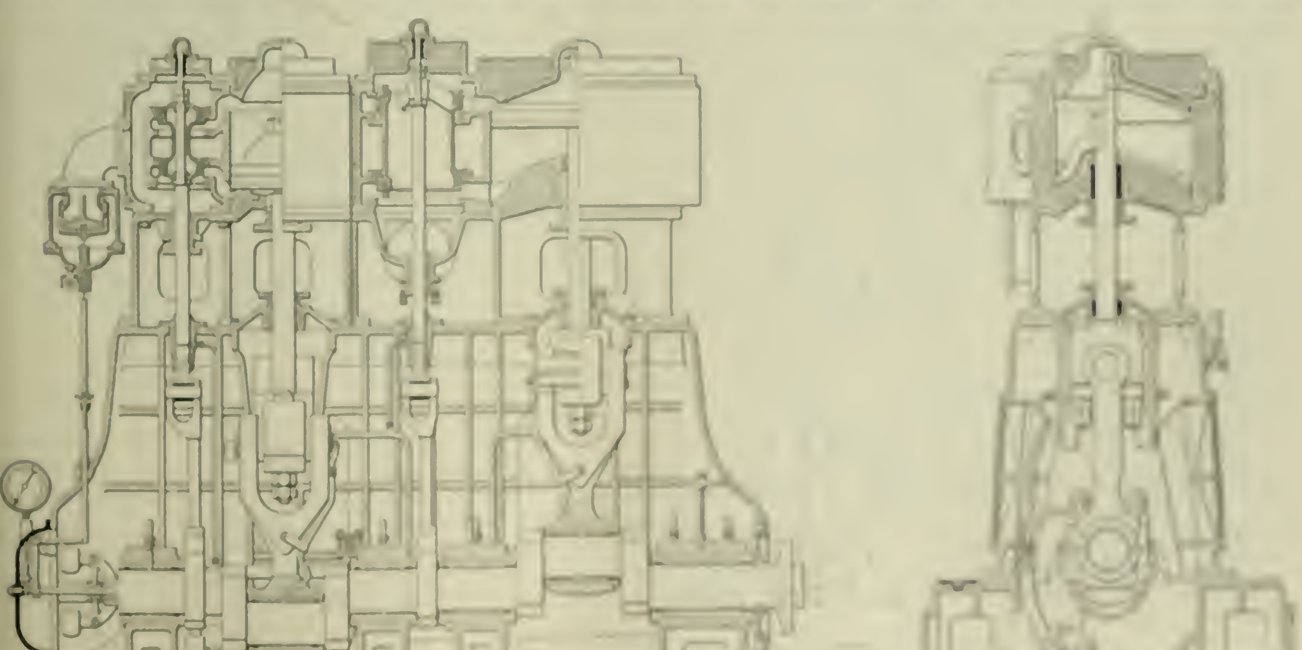


FIG. 23 REAVELL SINGLE-ACTING COMPOUND ENGINE

transferred to the under side then completes its second stage of expansion, and at the end of the upward stroke the exhaust valve opens and allows this steam to escape to the atmosphere or the condenser.

In the meantime, the steam which remained in the cylinder above the piston, when the transfer closed, is compressed during the latter half of the upward stroke, and the clearance space in the cylinder is so proportioned that this steam shall be compressed to initial pressure, when the termination of the stroke is reached, and the valve *D* opens for the next admission of steam. By this means the reciprocating parts are brought to rest, and the inertia is taken up by means of the working fluid itself, while at the same time the parts which will be first touched by the entering steam are already heated up to initial temperature and thus cylinder condensation is reduced.

Accurate and regular governing of the speed of the engine is obtained by a crank-shaft governor which acts through the levers and governor bridge *B* and varies the point of cutoff of the admission valve *D*. This governor bridge has two guide studs fixed to it, which pass through holes



[illegible]

in the admission valve *D*. The valve *D*, though reciprocated by the slide rod and having a constant stroke, is free to be rotated by the guide studs on the bridge *B* and the ports in the admission valve are so arranged in connection with the ports in the valve liner itself that a slight axial movement will cause an alteration in the point of cutoff.

The valves are driven by a radial form of valve gear operating from a point on the connecting rod, and the positions of the valve-gear centers are so chosen as to enable a considerable variation in the point of cutoff to be obtained, with an exceedingly slight change in the amount of lead.

Lubrication is effected by the splash system. An oil and water bath is formed in the bottom of the crank chamber into which the bottom end of the connecting rod dips at every revolution, throwing a constant stream of oil over the working surfaces.

These engines are built only on the compound principle, but they are very economical, as will be seen from the results given in Tables 1 and 2. This is no doubt due to the small port clearances and the efficient jacketing made possible with this type of engine. Also cylinder condensation is greatly reduced by reason of the high compression which heats up the surface above the piston to the initial temperature of the steam before the valve opens to lead.

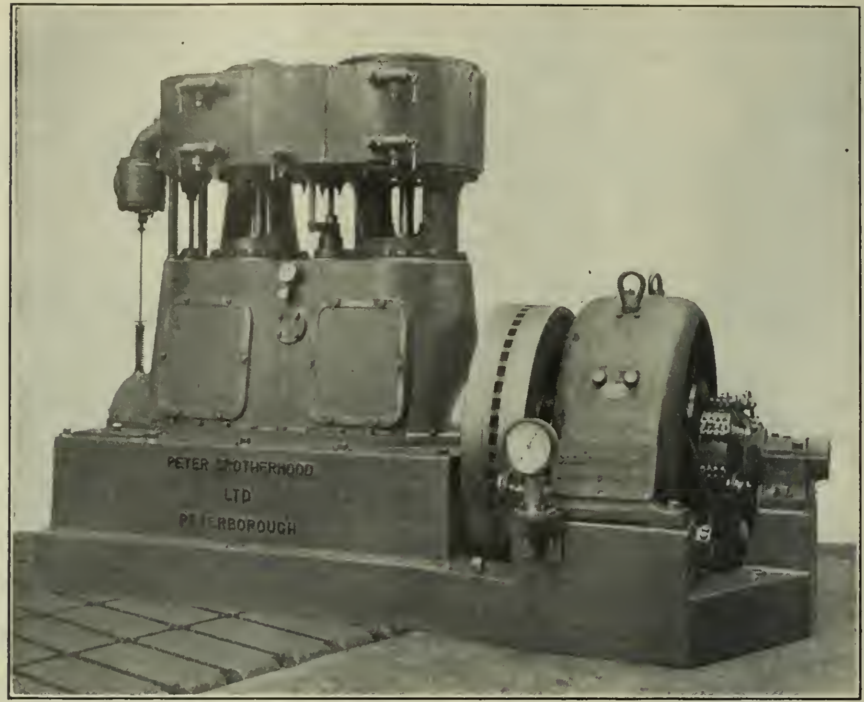


FIG. 26. BROTHERHOOD ENGINE COUPLED TO CROMPTON DYNAMO

Brotherhood. The firm of Peter Brotherhood, Ltd., whose productions are illustrated in Figs. 25 and 26, was really the first high-speed engine builder in this country. In 1883 the late Peter Brotherhood patented his three-cylinder engine. The cylinders in this engine were placed radially at equal distances round the crankshaft, and the three connecting rods were coupled to one crank pin. Further improvements were patented in 1885. A

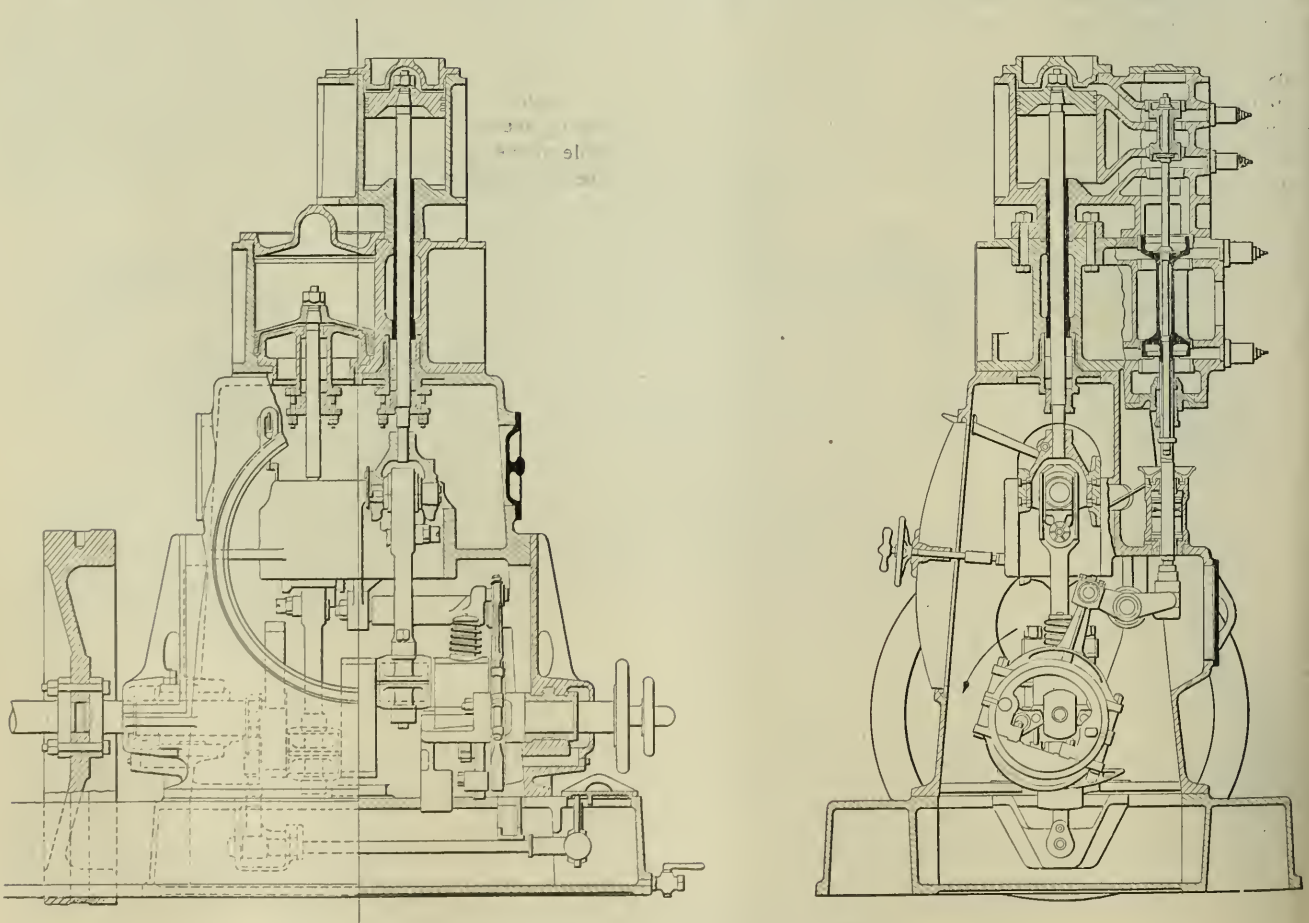


FIG. 27. SISSIN TWO-CYLINDER COMPOUND

large number of these engines were built and it will be remembered that it was only in the year 1885 that the late Mr. Willans patented his renowned central-valve engine, so Peter Brotherhood was the first to recognize in a practical way the need of a high-speed engine. This firm has manufactured a large number of inclosed forced-lubrication steam engines, and quite recently has put down a new works of much larger capacity at Peterborough. These works are fully equipped with modern machinery and are suitable for dealing with engines of the largest size.

The standard design of two-crank compound engine, as built by this firm, is illustrated in section in Fig. 25. It is built in sizes varying from 30 to 700 brake horsepower, and to run at speeds of from 550 in the case of the smallest size to 250 revolutions per minute in the largest sizes. The engines are stiffly built, and the bearing surfaces are of generous proportions. Separate piston valves are fitted to each cylinder, and the arrangement is clearly shown in the sectional elevation. This firm makes a practice of fitting [illegible] straps of bronze, the rods being of forged steel. The pistons are made of forged steel, shaped to facilitate the drainage of water, and are carefully adjusted so as to obtain a perfect balance of the moving parts of the engine.

Special attention is also given to the lubricating arrangements. Two pumps of the valveless type are fitted, except in the case of the smallest engines, and arrangements are made so that either of the strainers may be removed while the engine is running. The other [illegible] giving oil to the gauge [illegible].

Accurate governing is obtained by means of a powerful centrifugal governor acting directly on the throttle valve. The following results of governing may be of interest. Engine No. [illegible] was coupled to a Welsh coal mine, while No. [illegible] is an engine installed in one of the British Government buildings:

	Engine No. [illegible]	Engine No. [illegible]
Steady speed at full load	[illegible]	[illegible]
Momentary [illegible] speed when full load was suddenly removed	[illegible]	[illegible]
Steady speed at no load	[illegible]	[illegible]
Momentary [illegible] speed when full load was applied	[illegible]	[illegible]
Steady speed at full load	[illegible]	[illegible]
Steady speed at ¾ load	[illegible]	[illegible]
Steady speed at ½ load	[illegible]	[illegible]
Steady speed at ¼ load	[illegible]	[illegible]
Steady speed at no load	[illegible]	[illegible]
Steady speed at 50 per cent. overload	[illegible]	[illegible]
Normal full load, kw.	[illegible]	[illegible]
Steam pressure, lb. per sq. in.	[illegible]	[illegible]

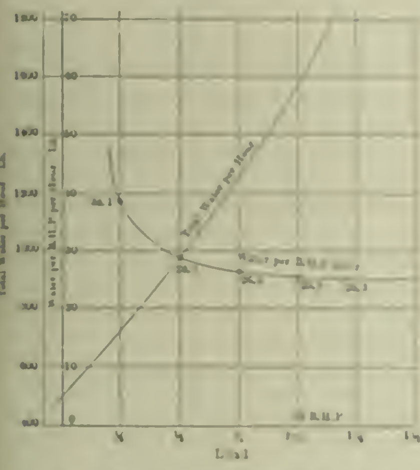


FIG. 28. WATER CONSUMPTION OF SISSON ENGINE

TABLE 1. TEST OF 100-KILOWATT SET, CONDENSING

	Steam Press. Lb. Per Sq. In.	Vacuum (Inches of Mercury)	Speed R.P.M.	Amps.	Volts	Kw.	I.H.P.	Steam Per I.H.P. Hour	Steam Per Kw. Hour	Combined Efficiency, Per Cent.
Over-load test	149	25½	444	218.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Full-load test	147	25½	446	188	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
¾-load test	149	25½	448	149	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
½-load test	151	26	[illegible]	100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE 2. TEST OF 120-KILOWATT SET, NONCONDENSING

	Steam Press. Lb. Per Sq. In.	Vacuum Inches	Speed R.P.M.	Amps.	Volts	Kw.	I.H.P.	Steam Per I.H.P. Hour	Steam Per Kw. Hour	Combined Efficiency, Per Cent.
Over-load test	151		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Full-load test	150		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
¾-load test	148		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
½-load test	149		[illegible]	150.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

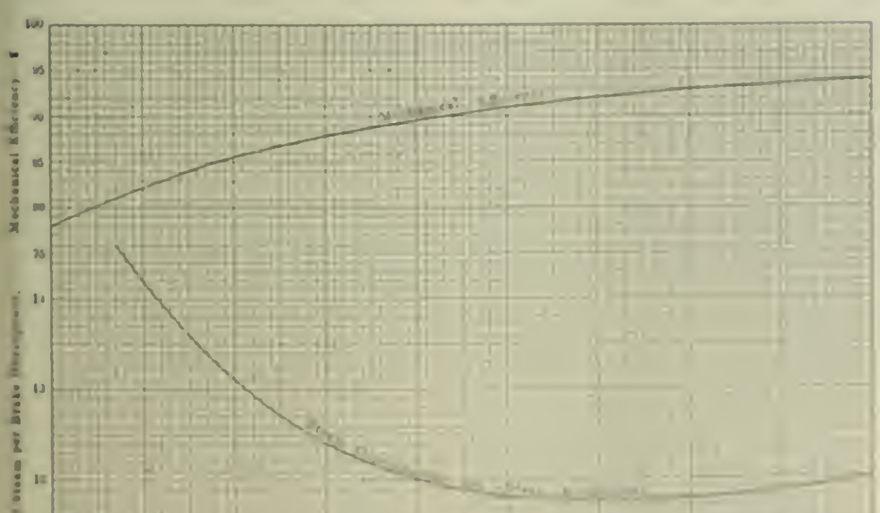


FIG. 29. STEAM CONSUMPTION AND EFFICIENCY OF BRITISH HIGH-SPEED ENGINES

No hunting or irregular working under any condition of load, speed or steam pressure.

The exterior appearance of the engine is shown in Fig. 26, which is a photograph of a Brotherhood engine coupled to a Crompton 400-kilowatt dynamo.

Sisson. An engine possessing both novel and efficient points in design is that manufactured by W. Sisson & Co., Limited, of Gloucester. The engines are made in two types: single-cylinder and two-cylinder compound. The compound engine is illustrated in section in Fig. 27. The high-pressure cylinder is partly superposed, and by this arrangement the cranks are brought so close together that there is only sufficient room for a substantial web between them. The cranks are opposite, and owing to the close distance between their centers, they balance one another almost perfectly. The engine is specially suited for superheated steam, since the high-pressure piston and piston [illegible] through a long [illegible] trunk, so that the steam-heated portion of the rod does not travel into the packing space at all.

The engine is simple. It has only two main bearings, and the arrangement of valves, in all except the largest sizes, is such that there is only one valve spindle working free, and that is only subject to exhaust steam. Both valves are actuated through a rocking lever from a powerful crank-shaft governor. The valve [illegible] are fitted with separate liners of special nickel-iron alloy.

The framing is of ample strength. The lower part forms an oil trough and is fitted with an inspection door and drawoff cork. Large openings are arranged in the ends of the frame above the shaft, which are closed by flanges attached to the main bearing caps, and when these are removed the crank shaft can be readily withdrawn through the opening at either end, for the flywheel can be disconnected from the shaft and again fixed without any difficulty, as it is spigoted onto a solid-flange coupling.

The speed of the engine is controlled by altering the cutoff, although at light loads the governor has a throttling action on the steam. These engines are economical for their size, as will be noted from the two curves given in Fig. 28, which were plotted from data on a 10½x6-inch engine. Initial pressure 150 pounds and atmospheric exhaust.

To illustrate the best results obtainable as regards steam consumption and efficiency with British high-speed engines, when working under ordinary conditions, the curves in Fig. 29 are given, which clearly show the steam consumption and efficiency of a modern triple-expansion engine at all loads from no load up to 25 per cent. overload, when working with steam at a pressure of 175 pounds per square inch, superheated 100 degrees Fahrenheit and exhausting into a condenser with a vacuum of 26 inches.

American Society of Hungarian Engineers and Architects

A number of Hungarian engineers and architects pursuing their professions in this country have organized the American Society of Hungarian Engineers and Architects. The society has two objects: First, to bring in closer touch engineers and architects of Hungarian extraction, living in this country, and to give moral support and information to newcomers; second, to encourage the exchange of engineering, technical and industrial information between the technical men of Hungary and of the United States and to foster technical societies, sciences and industries.

The society will hold monthly meetings where papers will be read and discussed. The membership consists of mechanical, electrical and civil engineers, chemists, architects and craftsmen. Following are the officers of the new society: President, A. Henry Pikler, M. E., member of the American Institute of Electrical Engineers, engineer-in-charge of the transformer department, Crocker-Wheeler Company, Ampere, N. J.; vice-president, Karoly Z. Horvay, architect, chief draftsman, building bureau of the Board of Education, Brooklyn, N. Y.; secretary, Zoltan de Nemeth, M. E., New York Edison Company; treasurer, Sandor Oesterreicher, E. E., associate member of the American Institute of Electrical Engineers and of the American Society of Mechanical Engineers, New York Edison Company; assistant secretary, Ernest L. Mandel, B. S. C. E., Bureau of Commissioner of Public Works, New York City. The society's business address is P. O. box No. 1031, New York City.

Graphite as a Lubricant for Gas Engine Cylinders

By Walter N. Durant

Becoming interested in the above subject and having access to a new 6-horsepower horizontal engine, using city gas for fuel, I determined to make some experiments. Finding it impossible to mix graphite and oil and feed it through the ordinary lubricator, the experiments were confined to feeding the graphite dry through the air intake and continuing the use of cylinder oil through the lubricator. At first about an ounce of graphite was fed through the air intake at short intervals, but after each charge the engine would show increased internal friction; however, it would quickly pick up and then appear to run smoother than before. The quantity of graphite was reduced and it was soon found that the best results were obtained when the engine was not given more graphite than could be consumed in the cylinder, or about 1/12 to ⅛ ounce per horsepower in a 10-hour run. This amount should not be fed all at once, but distributed as evenly as possible throughout the 10 hours.

The experimenting extended over a period of four months, and during that time the engine was given some severe tests. The spark plug was always in good condition and never missed fire, or became carbonized or short-circuited. The cylinder and valves were frequently examined; the latter were in fine condition and the cylinder did not show a sign of a scratch, but had that smooth, dull appearance which indicates the absence of friction. Unfortunately it was impossible to determine the amount of fuel saved by the use of graphite, as the engine was under a constantly varying load.

Desiring to know what others thought of graphite as a cylinder lubricant, I wrote to 45 prominent gas-engine manufacturers, asking if they recommended its use in their engine cylinders. The majority of replies stated that the writers had none, or very little personal experience, and declined to express an opinion. The answers containing advice were interesting, but rather conflicting, and no information could be gained from a reply like this:

"It is not customary with us to use graphite in the engine cylinders, although we sometimes use a little."

The following is a little more explicit:

"The great trouble with graphite is to apply it properly, so as not to plug the rings and make them stick. If properly applied, however, graphite is indeed an ideal method of lubrication, but, of course, must be used with oil."

A prominent firm making high-grade auto engines writes:

"We would recommend the use of graphite once in a while in your crank case. Same will do no harm. It has a tendency to close the pores of your cylinder and polish same up so as to increase the compression. It is a good thing."

A large marine gasolene motor manufacturer also says:

"Smear the cylinder walls with it. Once a month is often enough to do this. Of course, in addition the regular amount of oil should be fed through the multiple oiler. Graphite will help to retain good compression."

Another well known gas-engine company writes:

"We use more or less graphite in connection with lubrication, and where properly used much better results can be secured than with lubricating oil alone. If the cylinder has been allowed to cut slightly because of lack of oil there is nothing that will put it in shape so quickly as the use of graphite. Where good flake graphite can be mixed with oil and fed to the cylinder good lubrication is certain."

The manager of a large company making gasolene marine engines writes:

"We consider graphite the best lubricant in the world for gas-engine cylinders. The trouble in using it is in getting it into the cylinder. So far no satisfactory means have been devised. We think so much of the lubricating qualities of graphite in cylinders that we make it a rule thoroughly to coat the inside of every cylinder with it before sending our engines out from the factory. If one of our customers should ask us the question we would tell him to use it by all means if he could get it into the cylinder."

A New York City builder says:

"We think graphite lubrication is very good provided you have the proper means for furnishing the graphite in the required and constant quantity so that it will reach the parts to be lubricated."

The objections to its use were: "Forms lumpy spots on valve seats. Has a tendency to carbonize spark plugs. The expense in using it would overcome the advantages."

Nearly all of the firms which did not recommend the use of graphite, pointed out the impossibility of mixing graphite and oil and the certainty of clogging the lubricator if fed in that way. Aside from this, the only objection I can see is in using too much at one time in small cylinders.

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

A Boiler as a Water Supply Tank

The mistakes and absurdities that inevitably blaze the path of the inexperienced technical graduate who launches out on his own hook in an advisory or supervisory capacity are exemplified in the device described herein in connection with the water supply in a hotel building.

The house pumps in this hotel are two electrically driven centrifugals, one of which is always held in reserve. The boiler plant consists of two 72-inch by 18-foot horizontal return-tubular boilers, cross-connected by a steam drum as shown in Fig. 1, and used alternately. The genius who performs the function of consulting engineer to the owners of the property in question, thought it would be a capital idea to utilize these boilers as pressure tanks on the house water-supply system, during their periods of temporary inactivity as steam generators, instead of placing a tank for this purpose in the attic.

Accordingly, acting on the inspiration, intending to connect the blowoff pipes from the boilers to the house water system, as shown in Fig. 2.

The purpose contemplated in the installation of this contrivance was to pump

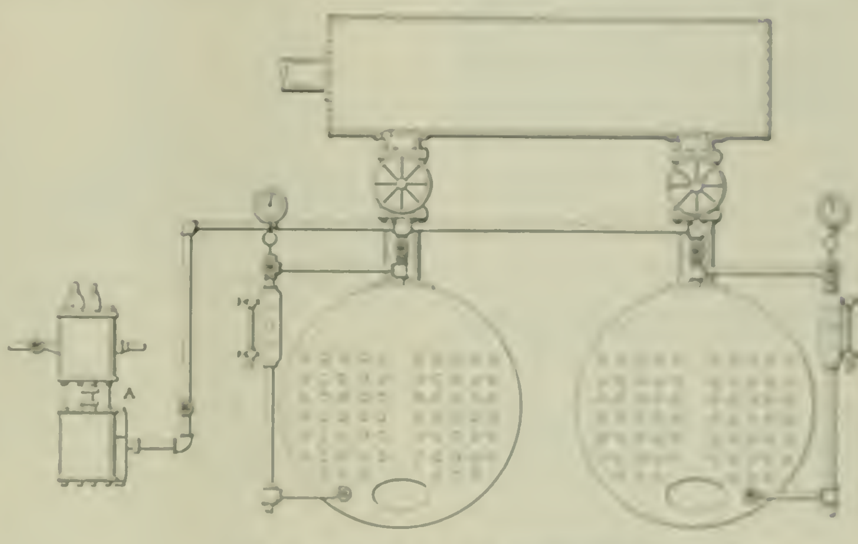


FIG. 1. SHOWING AIR-PUMP CONNECTIONS

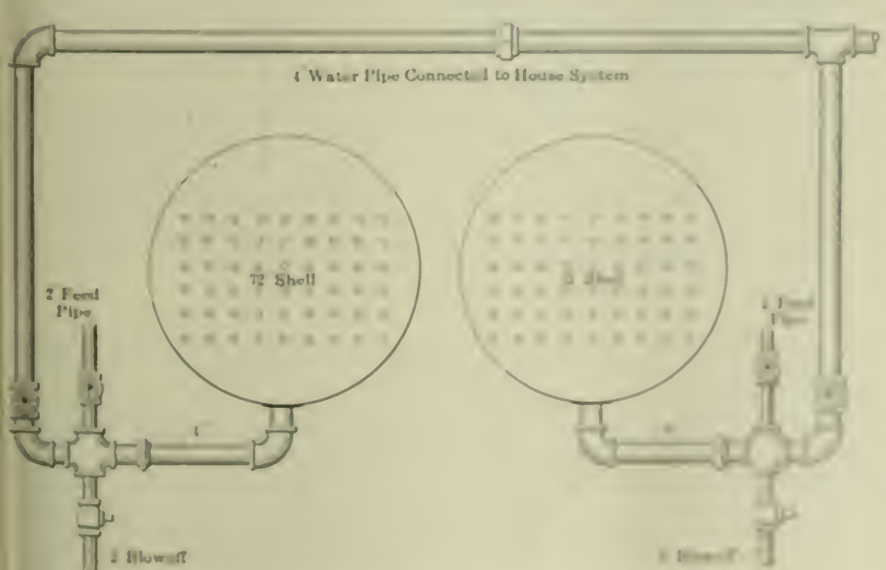


FIG. 2. SHOWING [illegible] CONNECTIONS

he had a discarded 8-inch Westinghouse air pump, of the locomotive type, rigged up as shown at *A*, with the discharge pipe coupled to the water column connection to the steam space in each boiler, further

an 80-pound air pressure on the water in the boiler out of steam service and then to cut the boiler in on the house system and permit the expansive force of the air to send the water through the pipes until the pressure would drop to 60 pounds, the house pump being cut out in the meantime by an automatic switch in the motor circuit set to open at 80 pounds, and which would again operate to close the motor circuit at 60 pounds, and thus set the pump in motion again until the 80-pound air pressure was reestablished, when the same cycle of events would be repeated. The ultimate object of the whole thing was to economize on the power expended in driving the centrifugal pump, that power being supplied from an outside source.

The job was begun some months ago, but at the time of this writing it has progressed no farther than the air connections to the water-column pipes. Whether the deviser of the apparatus got a tip from the boiler inspector, or was called off from some other source, or dropped it of his own accord, or is only holding it in abeyance, to be completed later on, is not known.

Leaving out of consideration the fact that the safety valves on these boilers are set at 80 pounds and that the air [illegible] is a [illegible] point of [illegible] without [illegible], and would probably be doing [illegible] well to give a [illegible] of the [illegible], it would be interesting to know what "practical" men think of the project on general principles.

A. T. [illegible]

Chicago, Ill.

Babbitting a Pinion

Some time ago a loose pinion, 18 inches long, required babbitting. As I was unable to babbitt it on the shaft, it was removed and a wooden roller dressed down, supposedly the same diameter as the shaft. When I tried to replace the pinion on the shaft, I found that I had dressed the roller down too much, making the babbitted hole too small for the shaft.

I had another old shaft of the same diameter with a long keyseat at one end, the edge of which was a trifle higher than the rest of the shaft. The end of the old shaft was put in the babbitted hole of the pinion, and taking a half hitch with a chain around the shaft, with the aid of two men to turn the shaft, the weight caused the shaft to work down through the babbitt as it revolved, the high side of the keyway acting as a cutting tool, making a nice fit in the pinion to the shaft.

P. C. Forgard.

St. Paul, Minn.

Friction Clutch Trouble Remedied

For the benefit of those who are having trouble with friction clutches, I will cite an experience that ended my clutch troubles. One clutch in particular gave considerable trouble. Four arms holding the shoes broke one evening, and were replaced. After a few weeks one of the arms on the spider cracked, necessitating a new spider. In a few weeks more another arm on the spider broke. We replaced the old spider with the new, and proceeded to line it up. After lining up we threw the clutch in and tightened the shoes. That was as far as I had ever seen any lining done by anyone, and leaving off at this point was where we had been making our error. After tightening the shoes the clutch was released and thrown in again, and as I was watching it closely I saw the spider move a little to one side. This was where the trouble was. In tightening the shoes we had not got an even strain on all of them and on closing the clutch the tightest shoe would crowd everything out of line, there being a small amount of lost motion in the journal. We equalized the strain on all the shoes until we could throw the clutch in at any position and have it remain true.

In lining clutches on quills, the opposite end of the quill should be carefully lined. If one side is pushed out it shows that the opposite shoe is too tight. Either release it, or tighten the side that is out. A good fit is all that is necessary to do the work.

Remoh Lenoie.

Keene, N. H.

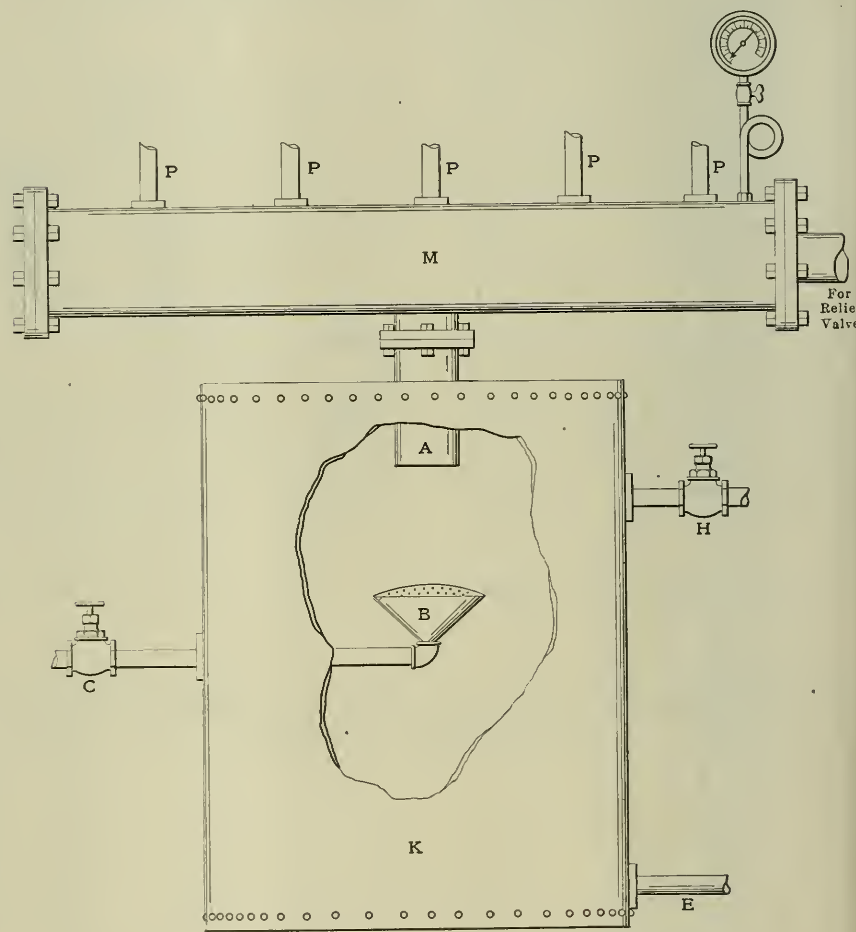
A Homemade Condenser

In the December 29 number M. D. Casper asks for a description of a homemade condenser for exhaust-steam heating. There are steam plants run on the vacuum system giving perfect satisfaction, where no condenser is used; simply a receiver tank which collects the air and water in the system; these in turn are pumped out by a vacuum pump which maintains a constant vacuum of any desired degree in the returns. In the sketch *K* is a square or cylindrical vessel, *M* is the receiver main and *P P*, etc., are the returns. The receiver main is connected to *K* by the pipe *A*. Valve *C* is for the injection water. At *B* is a perforated rose which scatters the water over the entering steam. At *H* is an auxiliary water pipe connected to a pump or city main. It is to be used should the condenser get too hot through shortage of injection water, etc. The pipe *E* is to be connected to the air pump; a check valve is shown on the end of it.

The form of a common jet condenser is immaterial, but care should be taken that the mains cannot be flooded to such extent that the water will reach the engine. A suitable relief valve attached to the condenser tank would be advisable.

J. S. Noble.

Toronto, Can.



HOMEMADE CONDENSER SUGGESTED BY MR. NOBLE

Kerosene in Steam Boilers

I have noticed for years first one letter and then another dealing with the use of kerosene for removing scale in steam boilers, also the devices for feeding it. While the arrangements for using kerosene show much thought and no small amount of ingenuity, the same amount of thought on the natural philosophy of the thing would convince anyone that using kerosene in a steam boiler with steam over 212 degrees Fahrenheit is time wasted.

I have tried kerosene in boilers under pressure and used it in boilers with no pressure, and the only time I have found it of any use as a scale remover is when a boiler may stand idle and empty and the kerosene put in, then slowly feed water to the boiler until full. Then, after about one hour, let the water out, so as to allow the oil to cover the tubes, heads and shell and allow the boiler to stand as long as possible. A good dose of rainwater in a steam boiler is the best scale remover I have found yet.

Regarding kerosene in boilers under steam pressure, I have noticed that a long time before I could hook the boiler to the others, the engine and boiler room were full of kerosene fumes. As I only have about 20 pounds steam pressure, how much kerosene will be left when I connect it to the other boilers?

The boiling point of fresh water is 212 degrees Fahrenheit, at sea level. I have often noticed on a barrel of the best illuminating oil the figures 150 degrees, and have assumed this was the point it would vaporize at. Now there is some difference between 150 degrees and the temperature of steam at 100 pounds pressure, and I have come to the conclusion that the kerosene in a boiler has passed off in the form of vapor long before any steam is used from it.

I am afraid a good many engineers are under the impression that kerosene can be pumped in a boiler under steam pressure and help remove scale, but it will not do the work.

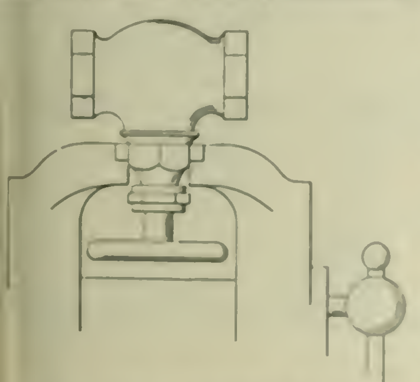
JAMES C. MELLEN.

Brooklyn, N. Y.

Globe Valves

Many practical hints were given in Mr. Wakeman's article on globe valves, published in the January 5 number. In regard to valve disks, the flat spots referred to certainly form an effective locking device, as in nine cases out of ten it is useless to try to remove the nut with a monkey wrench after the disk has been in use some time. If the disk is first split in two or three places, and a piece taken out, the rest will generally turn easily enough without doing any damage to the nut.

This operation is more simple than filing down the flat sides, as recommended



HOW TO TAKE THE BONNET OF A GLOBE VALVE OFF

by Mr. Wakeman, and as the nut is apt to work loose, due to vibration in the steam pipes, I think the locking arrangement preferable.

It is a good idea to take off the bonnet of a valve before it is put to use, but these bonnets are often screwed up so tightly before leaving the shop that a monkey wrench will not loosen them without slipping and rounding the corners.

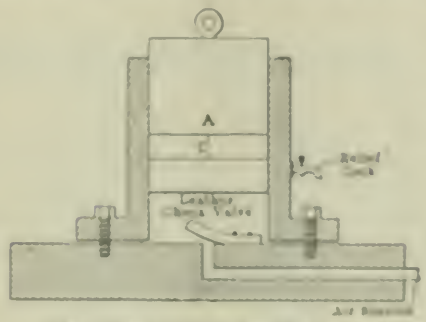
The safest way under any circumstances is to put the valve in a vise, as shown in the sketch herewith, with a piece of tin bent over the jaws to prevent marring the hexagon surface. Then screw a piece of pipe in one of the openings, or in both if the bonnet is very tight, and it is bound to come loose with the least possible chance of springing or twisting the body of the valve out of shape.

R. CEDERBLOM.

Gary, Ind.

Badly Worn Dashpots

A short time ago a young engineer was called upon to set up a large engine. The engine in question was an old-fashioned



REPAIRING A BADLY WORN DASHPOT

Corliss, and the worn dashpots gave considerable trouble. As he could not induce the firm to put in new ones, he had to devise some method of repair.

The dashpots were of the old-fashioned type, with a solid plunger, the valves being closed by a dead weight. The dashpot plunger, when new, was turned up to an easy fit in the dashpot, at the bottom of which was a leather check valve to control the air. The dashpot stood on a cast-iron base plate having a hole drilled in it from the side and connecting with a vertical hole in the center of the dashpot underneath the leather check valve. When the plunger of the dashpot was raised it created a vacuum, causing the leather check valve to be raised, thereby admitting air to the dashpot. When the valve was released and the plunger fell, thus closing the valve, the leather check valve closed, retaining a portion of the air in the dashpot and creating a cushion which prevented the plunger from striking the bottom. At the side of the dashpot was a cock to regulate the amount of air, as required. These plungers were so badly worn that the air leaked out, allowing them to pound on the bottom of the dashpot each time they seated. The regulating cocks were of no use whatever, as they were entirely closed.

As there was a small lathe on the premises, run by another engine, the engineer took out the plungers and turned a groove in them at the center, then to take [illegible] two pump packing rings with a good working fit, as at A. The rings were peened so that they were a trifle larger than the inside of the dashpot, thus causing them to be slightly pressed together when in place. When the engineer got the dashpots adjusted again he found that they worked nicely and he has had no further trouble.

FRANK L. [illegible]

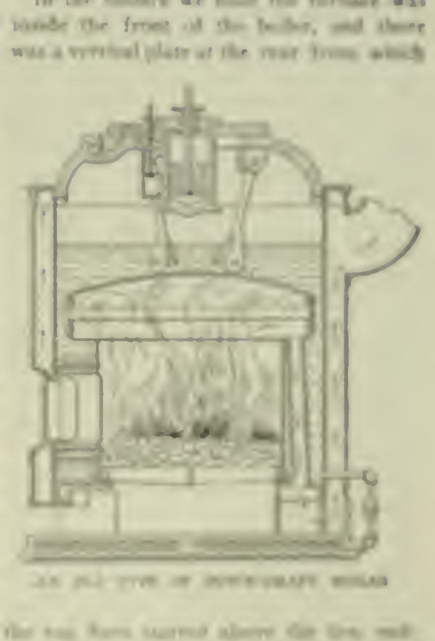
Adams, Mass.

Down Draft Furnaces

The first "down-draft" furnace was patented in England in [illegible] by Lord Dundonald, a draftsman who amused himself with engine and boiler experiments. The patent expired in [illegible]; in [illegible] they began to be made in New York City and other places and were approved by leading engineers, for two reasons: First, the hottest fire was under the thinnest and most solid body of water in the boiler; second, the priming, foaming and spitting due to the up-draft furnace were not nearly as bad with the down-draft furnace.

The plans were different from ours, as the fire was under the boiler at one end and the hottest gases under the other end, whereby if there were any unequal expansion, it developed about the space of the wall dividing the two horizontal planes and gas chambers, and the solids in the water were found over that wall at the bottom of the boiler.

In the boilers we built the furnace was inside the front of the boiler, and there was a vertical plate at the rear from which



AN OLD TYPE OF DOWN-DRAFT BOILER

the top flues started above the fire, leading to a back connection surrounded with water inside the boiler shell. Another row of flues or tubes passed below the first row, from the back connection to a front one; another row below the second passed the front one to a [illegible] in the rear end of the upper side of which [illegible] the smokepipe. These three connections were [illegible] by [illegible] inches of water in the boiler, so that wherever there was heating surface the water got some benefit.

In the [illegible] boiler the rear gases [illegible] the whole end of the boiler, but did no good, because heat will not move downward, unless it is forced, and there was not heat enough at that point to raise any perceptible heat above that due to the steam already there.

There was another boiler with down draft, built for a Mr. Baxter, a sketch of which is shown herewith. It is the true Dukdonald boiler, but the engine in the top was the invention and patent of William Murdock, a Scotchman, in the year 1770. So it may be seen that Solomon was not such a fool when he said: "The thing that hath been is the thing that shall be;" and "there is no new thing under the sun." Though I quote him, I demur thereto; for if there had not been an original somewhere, there could not be copiers.

Peter Van Brock.

Jefferson, Ia.

A Remodeled Steam Plant

During the fall of 1907, when the writer came on the scene, the plant belonging to the Hoopeston Gas and Electric Company consisted of a 150-horsepower Stirling boiler, two 100-horsepower tubular boilers, one 14x14-inch Ideal and one 11x24-inch Corliss engines, three 1100-volt single-phase 125-cycle alternators and two 500-volt direct-current generators. The electrical machines were belted to the engines in such a way that one engine could carry the day load, which was comparatively light, and the other the heavy evening load until midnight. The day load consisted of a few 500-volt motors scattered around and a number of flatirons. The night peak load was occasionally as high as 80 kilowatts, and the street lighting consisted of five arcs and 128 thirty-two-candlepower incandescent lamps on a midnight moonlight schedule.

The equipment was of ample capacity for the existing load, but any considerable increase could not be handled without further additions to both prime movers and the present single-phase system, or a complete remodeling. Steam leaks were manifold and multiform. Secondary wires were of small cross-section and of great length. All lines were in bad shape, and it was no uncommon occurrence, on wet, windy nights, for the circuit-breaker to show signs of great activity.

With the advent of a new enterprise an aggressive power campaign was decided upon, and a 85-kilowatt generator was purchased and belted to the Corliss engine. Shortly after, the question arose as to new prime movers and a twin cylinder, single-acting, 280-horsepower gas engine was decided upon. Anthracite suction-gas producers were also purchased, and a 200-kilowatt generator was bought and belt-connected to the engine. Preparations for the immediate installation of the new equipment were at once made and the existing apparatus was crowded to the rear of the building. Part of the front wall was removed, one stack taken down and two tubular boilers skidded to the exterior so that foundations for the producer equipment could be constructed.

For a period of some seven months the Corliss engine struggled along under the heavy load imposed upon it, occasionally developing as high as 120 horsepower. The main-bearing pillow block was reënforced and a support placed under the guides, hoping to delay the inevitable, which finally came at 4 a.m. one morning, in the shape of a broken pillow block and cap, which allowed the shaft to drop down and forward, twisting the valve rods, breaking one steam arm and throwing one exhaust valve under. No one knew how it happened, but it was generally ascribed to old age and heavy overloads. The generator was shifted over to the piston-valve engine and for two months this engine ran continuously with only an occasional stop for packing purposes.

The old wooden switchboard was dismantled and a new five-panel marble board installed, carrying oil switches and like apparatus in keeping with the rest of the equipment. A 30-horsepower 2000-volt motor was purchased and direct-coupled to one of the old 500-volt machines, which had hitherto been belt-driven. Owing to the fact that this machine was only of 56 kilowatt capacity and that it had 150 horsepower in small motors already on its mains, no more direct-current power was solicited, but three-phase 440-volt power was pushed and at the end of six months 85 horsepower in this type of motors were connected and at the end of another six months 135 horsepower.

An uptown office was established and the supplies were taken care of from thi[s] point. Our only competitor, who ran [a] plumbing shop in connection with th[e] electric-supply business, was bought ou[t] and the light company thereafter did a[ll] wiring and furnished all supplies. A[n] advertisement was run in each of the loca[l] daily papers and changed weekly.

Owing to the fact that the primary vol[t]age was doubled and inasmuch as th[e] lines were sadly in need of repair, co[n]siderable time was spent placing these i[n] first-class shape, some 20 transforme[rs] were thrown out and all meters were r[e]adjusted for the new frequency. A num[]ber of fan motors were changed and

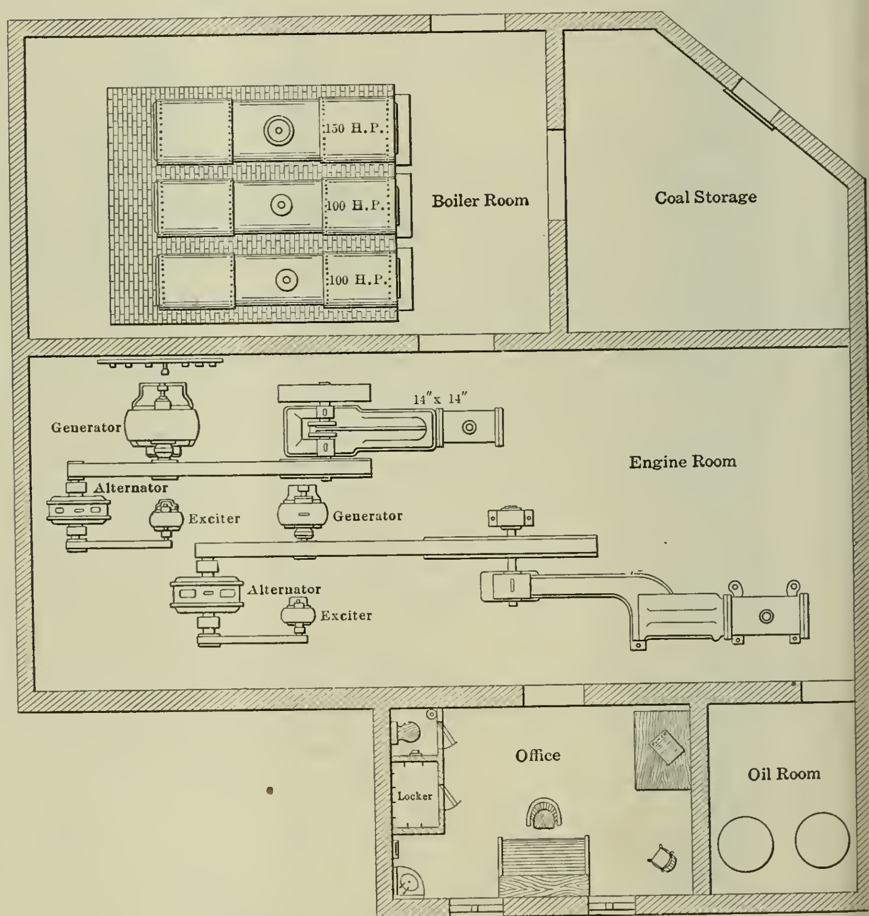


FIG. 1. THE OLD LAYOUT

[f]ew small single-phase motors were got rid of.

As is shown in Fig. 2, one boiler, engine and generator were left in complete repair so that this apparatus could be started up at once should the gas equipment be disabled. It has been found necessary to resort to this arrangement two or three times for a day or so at a time in order that minor adjustments might be made on the gas engine.

Seeing the need of means of hoisting the coal to the tops of the producers, a motor-driven chain hoist was added to the station equipment, and a power head the engine, owing to governor troubles and improper mixtures. All this was corrected as soon as we secured a practical gas man to take charge of the equipment. The engine is called upon to deliver about 125 horsepower during the day and upward of 250 horsepower at night until 11 p.m., when the load drops to 25 horsepower.

A marked difference was at once apparent in the coal consumption, notwithstanding the unfavorable conditions the plant operates under, running for one-third of the time at practically one-tenth load. The company is now figuring with

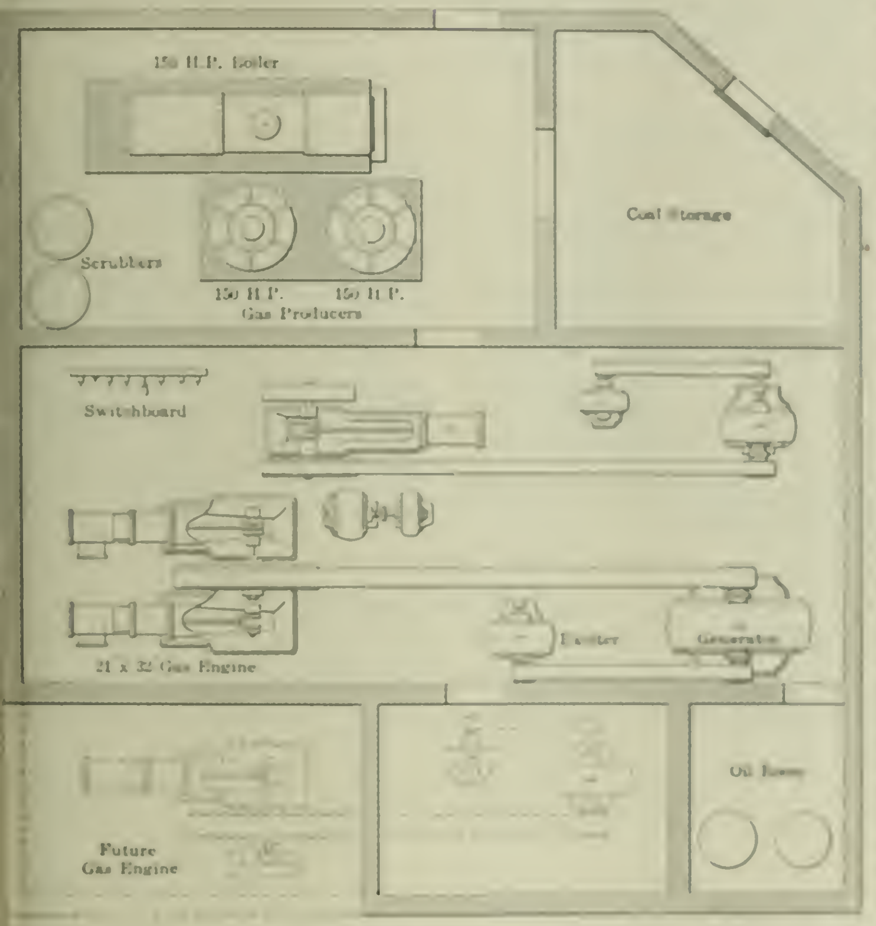


FIG. 2. THE NEW ARRANGEMENT

[d]riven by a 5-horsepower motor for the deep-well pump was put in. This latter proved a great saving, as the consumption of city water for the gas engine for cooling purposes and for the wet scrubber in the producer room was no inconsiderable item. All wires were taken from the ceiling and placed in conduits under the floor and the ceiling taken down. This additional head room afforded better light and ventilation and presented a more pleasing appearance.

In due time the new equipment arrived and was placed in position. For the first few months we were troubled somewhat by the slowing down and speeding up of the engine builders for a second engine of the same type, but of smaller size, and when this is installed and running during the lighter load periods, 1¼ pounds of coal per horsepower hour will doubtless be realized.

The dotted lines in Fig. 2 show the probable location of the next engine to which will be belted the 85-kilowatt generator. When this change is made the steam engine and remaining boiler will be removed, which will make room for one more producer of the same capacity as those now installed.

C. E. Benson.

Hoopeston, Ill.

Drum Motion Distortion

In the article on drum-motion distortion, published in the issue of January 26, I see that I made several statements which may lead to erroneous conclusions, and therefore think it well to give the following as additional to that article.

As has been previously pointed out, this cause of distortion in indicator diagrams may be analyzed by considering the variation in the force existing in the cord during a cycle of the drum motion. This force is the resultant of the spring tension and the force of acceleration of the drum, which act in the same line. Beginning at the head-end dead center, the spring tension is minimum, while the force of acceleration is negatively maximum (under the assumption of harmonic motion); that is, the drum acts as a drag. Thus, the force in the string is the numerical sum of these two forces. At the crank-end dead center, however, the force of acceleration is positively maximum; that is, the inertia of the drum here helps it onward; and therefore the active force in the cord is the numerical difference between the accelerating force and the spring tension at the crank-end dead center. If these forces in the cord are equal at the ends of the stroke (as they may be), and if the force of acceleration increases in the same way as the spring tension, there would be no deformation in the diagram. The latter condition, however, cannot ordinarily be fulfilled, as the spring tension increases uniformly throughout the stroke of the drum, while the force of acceleration increases according to another law, except under the condition of harmonic motion which is only approximately satisfied.

The following numerical example may make clear an interesting characteristic of drum-motion forces. Suppose the speed of the drum is such as to give an initial accelerating force of − 1 pound and, at the end of the stroke, a force of + 1 pound. If the corresponding spring tensions are + 2 pounds and + 4 pounds, the forces in the cord will be 2 + 1 = 3 pounds and 4 − 1 = 3 pounds, and, therefore (for harmonic motion), constant throughout the stroke. Now, if the speed is increased so that the accelerating forces are − 2 and + 2 pounds, we cannot again obtain a constant cord tension by varying that of the spring, because the range through which the two forces operate are equal only in the first case. For instance, if the spring is tightened so that the initial tension is 3 pounds, the final would be 5 pounds (the increase always being constant for the same extension of spring). The forces at the ends of the stroke would then be 3 + 2 = 5 pounds and 5 − 2 = 3 pounds. The conclusion is reached, therefore, that for any drum spring of given strength there is only one speed at which there is approximately no distortion of a diagram of a given length. At other speeds the best tension is obtained as previously described.

J. C. SMALLWOOD.

Philadelphia, Penn.

Verifying Motor Connections by a Diagram

I had just finished reading the "Catechism of Electricity" in the January 5 number, when the chief came in and asked me to reverse the rotation of a motor. We have about twenty motors and they are apparently all shunt-wound. But having the "Catechism" in mind, I looked into the motor and found it to be a compound-wound machine. I could not re-

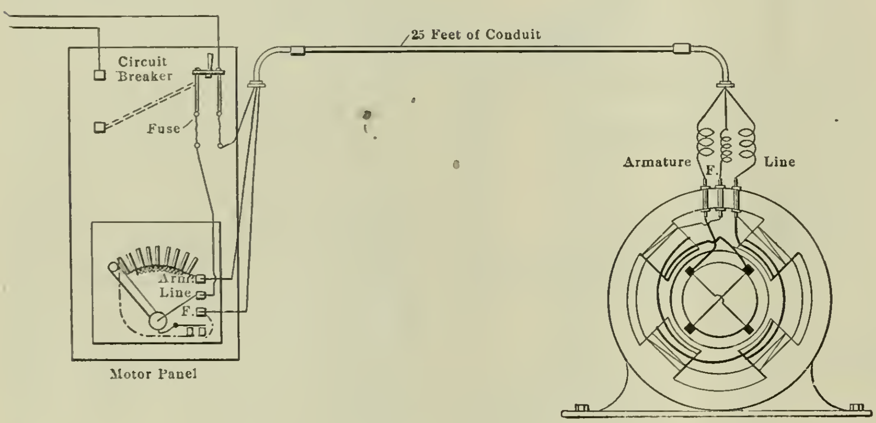


DIAGRAM FOR VERIFYING MOTOR CONNECTIONS

verse the shunt winding alone because that would make the motor differential, and the only way I could see was to reverse the current in the armature by exchanging the leads to the brushholders.

I started the motor up to find out which way it had been running and the starting lever touched the first contact on the faceplate of the starting box, and the motor started off at a furious rate; it seemed to me it turned up about 2000 revolutions per minute, when it should have run 450. I immediately pulled the switch and began looking for a break in the shunt-field circuit. Being unable to find any defect whatever in the circuit, I made a diagram of all of the connections of the motor, which is shown herewith. Owing to the conduit being so long, I had to use a test lamp to "prove" the diagram and in doing this I found that the main leads had been transposed at the motor. This showed me how the motor lost its shunt field. The shunt circuit from the starter to the field winding was all right, but the only return path was through the armature lead instead of the line lead; consequently the shunt winding was connected merely to the terminals of the starting resistance, and got practically no current.

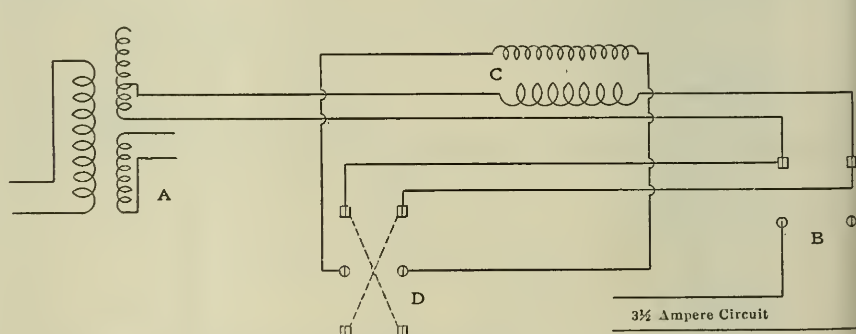
Changing the main leads back again straightened out the trouble and I then reversed the motor by transposing the brushholder cables. I found later that the wiremen had connected the motor up to try it and it had then been disconnected and moved away from its position. When put back it was turned around and the outside leads were connected up backward, as described.

R. E. OSBORN.

Toledo, O.

Puzzling Transformer Action

I submit herewith an electrical problem, hoping that some reader of POWER may be able to solve it. The accompanying diagram shows the wiring of one section of our switchboard which supplies current to a 3.5-ampere series incandescent



WIRING DIAGRAM OF ONE SECTION OF SWITCHBOARD

lamp circuit for street lighting. The constant-current transformer *A* has two secondary windings, one of which supplies this circuit, and the other, through an inductance regulator, supplies a 6.6-ampere circuit not shown; *B* is the circuit switch; *C* is a 20 to 1 constant-potential transformer which may be connected so as to raise or lower the voltage impressed on the line, a double-throw switch *D* being provided to control the primary current in the transformer or to cut it out altogether, as required. The idea was to produce closer regulation than that given by the steps of the transformer *A*, which are too far apart.

When the switch *D* is closed upward the voltage is boosted, but when closed downward, the transformer *C*, instead of lowering the voltage, boosts it 10 or 15 volts. The question is, why doesn't it buck?

I would esteem it a favor if some other reader would give me a correct explanation.

E. L. MASON.

Garnett, Kan.

Lifting Limitations of a Pump

In the reply to an inquiry in an issue of several months ago, it was stated that a pump will not raise water to the theoretical limit of 34 feet because of the "slippage" and the friction of the water against the pipe walls. This is correct and in the case of a pump designed as an ordinary single-action hand pump in which the bucket can be adjusted to work clear down to the valve, thus eliminating the clearance, your explanation is practically complete if the water is cool and the suction pipe air-tight.

In a pump made as a steam pump is ordinarily constructed there is another and greater reason for its failure to raise water to the theoretical hight, and that is its inability to create a perfect vacuum.

Take, for instance, a pump of such dimensions that the piston displacement is 1 cubic foot, and the cubic contents of the clearance between the piston and cylinder head and the space between the valve disks is 0.25 foot. Then when the piston is at one end of the cylinder and moves to the other the 0.25 cubic foot of air in the suction end would be expanded to 1.25 cubic feet at 3 pounds pressure if there were no suction pipe on the pump and the opening for it closed. Of course this would not be the condition in pumping, and air would be taken from the suction pipe as that in the cylinder is rarefied but under no circumstances could the air in the cylinder, and consequently in the suction pipe, become less than 3 pounds; therefore, the effective air pressure to raise the water would be but 15 — 3 = 12 pounds, enough to balance a head of about 27 feet, and the pump could not raise water by suction to exceed this distance even if all other conditions were as nearly perfect as it is possible to make them. We know 15 pounds is not exactly correct for the air pressure, but this does not affect the principle.

In many pumps the clearance is greater in proportion to the piston displacement than 1:4—the ratio we have considered here—with a consequent lowering of the pump's efficiency in raising water by suction.

Frank L. Wallis

Des Moines, Iowa.

[Mr. Wallis' argument would apply to a pump starting up with no water in the suction end of the system, but the condition on which it is based disappears when the pump is "primed," which is easily and commonly done.—Editors.]

The Surface Condenser

I noticed in your issue of February 16, page 351, an abstract of an article relating to condensing apparatus, which was published in the December 25, 1908, number of London *Engineering*. I submit herewith a copy of a letter which I have forwarded to the editor of *Engineering*, commenting upon the article in question, as follows:

"I was much astonished at the article which appeared in the issue of December 25, 1908, of London *Engineering*, in which the statements were made that the economy to be gained by the increase of vacuum from 24 inches to 28 inches was approximately 17 per cent. on steam turbines, and with the reciprocating engine the same increase of vacuum would result in a saving of only 2 per cent., and that, in order to utilize such a high vacuum, the low-pressure cylinder would have to be built rivaling Captain Ericsson's 14-foot hot-air engine cylinder, and the small economy gained by the increase in vacuum is given as an excuse why the average marine engineer regards low vacuum as justifiable. It appears to the writer that the statements made in this article are not in accordance with the facts and that the use of low vacua as mentioned in marine practice is an exception and, instead of being justified by economy, is only an excuse for badly designed condensing apparatus or a lax engineering department.

"In looking for data on existing practice regarding the best vacua to carry, I have made some investigations among the transatlantic liners, and the best ships with reciprocating engines are carrying from 26 to 28 and more inches of vacuum. Where the results are looked into, the engineers are required to keep the vacuum system tight and carry all the vacuum they can get, and while it is true that greater benefits can be derived from high vacua in a steam turbine than in a reciprocating engine, it is also true that, where primary heaters are not used, the higher the vacuum carried the greater is the [illegible] economy which can be obtained from the plant. The Allis-Chalmers Company, of Milwaukee, Wis., has built more pumping engines than any other firm in the United States and has earned large sums for producing results better than those guaranteed, and the higher vacua have played an important part in those results.

"While the writer was chief operating engineer of the Interborough Rapid Transit Company, New York City, we changed the motor-driven air pump and jet condenser for a barometric type of condenser and increased the vacuum on each of the 8000-horsepower Allis-Chalmers horizontal vertical engines at the Seventy-fourth street station from 26 inches to 28 inches, thereby increasing the power on each of the eight units approximately 272 horsepower, and the economy of the station was increased very nearly in the same ratio. This change was made about seven years ago and the plant is still operating with 28 inches of vacuum, the vacuum being measured with mercury columns connected to the exhaust pipe at a point just below the exhaust nozzle of the low-pressure cylinder.

"A careful test made on the Fifty-ninth street station of the Interborough company showed a decrease in steam consumption of 8 per cent. when the vacuum was raised from 25 to 28 inches. These engines drive 5000-kilowatt generators and the test was very carefully conducted. In view of the results obtained by the test just mentioned, the writer questions the statements made that an increase from 24 to 28 inches of vacuum results in the saving of only 2 per cent.

"The South Side Elevated Railway in South Chicago has 3000-horsepower units on which is carried 28 inches of vacuum and has been for the past three years, and we could give many other instances where high vacua are being carried on reciprocating engines with economical results, sufficient to justify the installation of the high-vacuum apparatus.

"It is true that eternal vigilance is required to keep air leaks out of the system, but the writer submits that it is cheaper to keep the system tight than it is to pump large quantities of air or, what is ordinarily done, run on low vacua.

"Operating on low vacua is due to one of three things: Either the condensing apparatus is not suitable for its work, a lax engineering department, or the policy on the part of the management which will not furnish help enough properly to maintain the plant in good operating condition.

"The remarks in the article relating to vacuum gages are unfortunately true and the writer has yet to find a vacuum gage that will stay correct for any great length of time, but in American practice in any well managed station, mercury columns are installed to check up the gages and the gages are used only as an approximate check on operating conditions. In the larger stations, mercury columns are attached to each unit so that a correct observation can be made at any time."

R. D. Tomlinson.

Milwaukee, Wis.

As to Increase of Salary

An engineer asked me not long ago if I thought it proper for him to ask his employers for an increase of salary. The question looked simple enough, but before giving him my answer I asked him why he thought he was worth more. He replied that the man they had before him received $200 per year more than they were paying him, and the "boss" took delight in telling of paying his old engineer $18 per week, although he was saving him $30 per week over the running expenses of the former engineer.

He said he always made it a point not to ask for an increase, but always tried to show his employers by his work that he was worth all they could afford to pay.

I should like to have the opinion of Power readers in regard to this question. Is it proper to ask for an increase of pay?

Charles W. [illegible]

Sharon, Penn.

The Cummer Engine

The very comprehensive articles on "Setting the Valves of the Cummer Engine," in the December, 1908, and January, 1909, numbers, by Messrs. Allen, Coffine and Francis I found very interesting. To my mind there never was placed on the market an automatic engine with better material, finish and capability of withstanding hard service with the least [illegible] and less [illegible] to keep up than the old Cummer, an engine that has won much praise from those who have known its performance. The only reason I can assign for its not being more prominently known and used is its having peculiar valves and governor.

I had charge of a 100-horsepower Cummer engine for nearly ten years and have often wondered how many hours of thinking, reasoning and experimenting the inventor had put in while designing the engine.

The articles referred to are so clear and concise that no one who ever ran a Cummer engine can doubt for a moment that the advice and instruction contained in those articles alone are worth more than a year's subscription to Power.

My old Cummer has been displaced by a Corliss engine in order to provide for an increased demand for more power.

[illegible]

[illegible], Penn.

Refrigerating Plant in Steel Works

Largest Plant in Existence for Drying Air Supply to Blowing Engines; Saves $1 a Ton in Making Pig Iron and Produces More Uniform Output

BY OSBORN MONNETT

It is but recently that the subject of water vapor held in the atmosphere has had any attention with reference to its effect on the operation of blast furnaces. While it has long been realized that all air in its natural state contains water vapor in varying quantities, depending on the temperature and the opportunity which the air has had for acquiring moisture, it was for a long time considered that this was one of the insurmountable difficulties and drawbacks in furnace operation, although all the other elements which go toward the making of steel have had careful consideration for many years.

Advantages of Using Dry Air

At the late meeting of the American Society of Refrigerating Engineers, held in New York City, Bruce Walter, who has been connected with developments in this line from the beginning, brought out many interesting facts based on experience with refrigerating outfits in several different plants. It appears that there are required approximately two tons of ore, one-half ton of limestone and one and one-half tons of coke, to make a ton of iron. In addition to this, five tons of atmospheric air is required to furnish the necessary oxygen. In this enormous quantity of air it can be readily seen that the moisture will be a great disturbing factor. Irregularity in moisture content of the atmosphere under different conditions not only changes the quantity of oxygen delivered from time to time according to the humidity, but each pound of the moisture requires something like 13,000 B.t.u. to decompose it into oxygen and hydrogen. This, of course, reduces the efficiency of the furnace, requires more coke and interferes with the regularity of the output.

In 1897 the Carnegie Steel Company began experimenting under the supervision of James Gayley, who is the inventor of the Gayley dry-blast process, with a view to determining the approximate cost of removing the moisture by means of refrigeration.

Subsequently at the Isabella plant of the United States Steel Corporation, located at Etna, Penn., a large outfit for removing moisture from the air was installed and the results have been highly satisfactory to steel men. The coke saving has been shown to be about 350 pounds per ton of iron, the daily output increased about 10 per cent., the iron produced is more regular in quality, and less air is required, due to the decreased temperature and consequent smaller volume. An

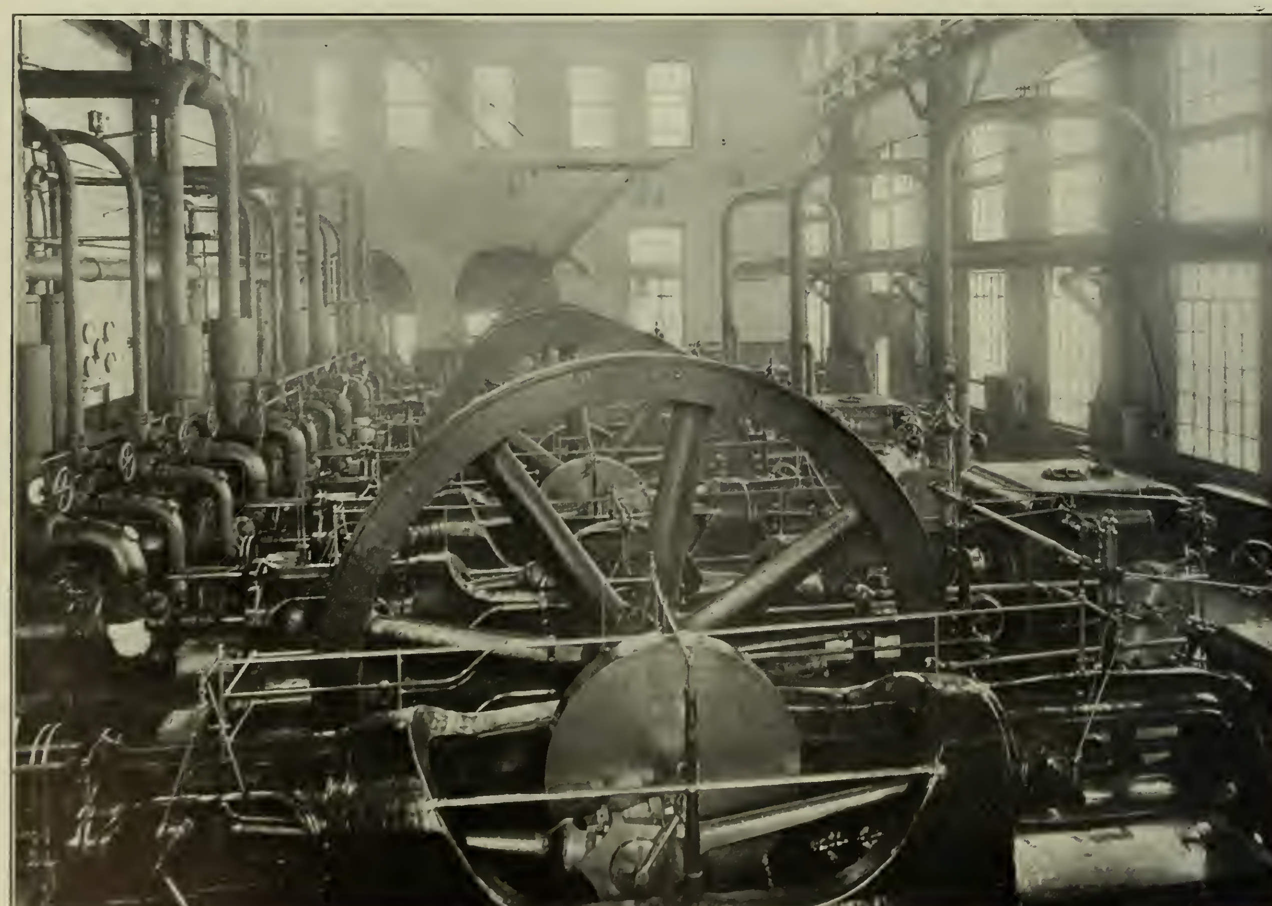


FIG. 1. GENERAL VIEW OF COMPRESSOR ROOM

interesting point in this connection is that the saving in steam used by the blowing engines has been found to exceed the amount of steam taken by the refrigerating equipment. Incidentally there is also a decrease in the quantity of limestone required owing to the fact that the reduction of the amount of coke reduces the ash, and less lime is required to take care of it.

Experience at the Isabella plant and elsewhere, both in this country and Europe, has determined that there is an average decrease of cost in the manufacture of pig iron of approximately $1 per ton, due to the application of dry air.

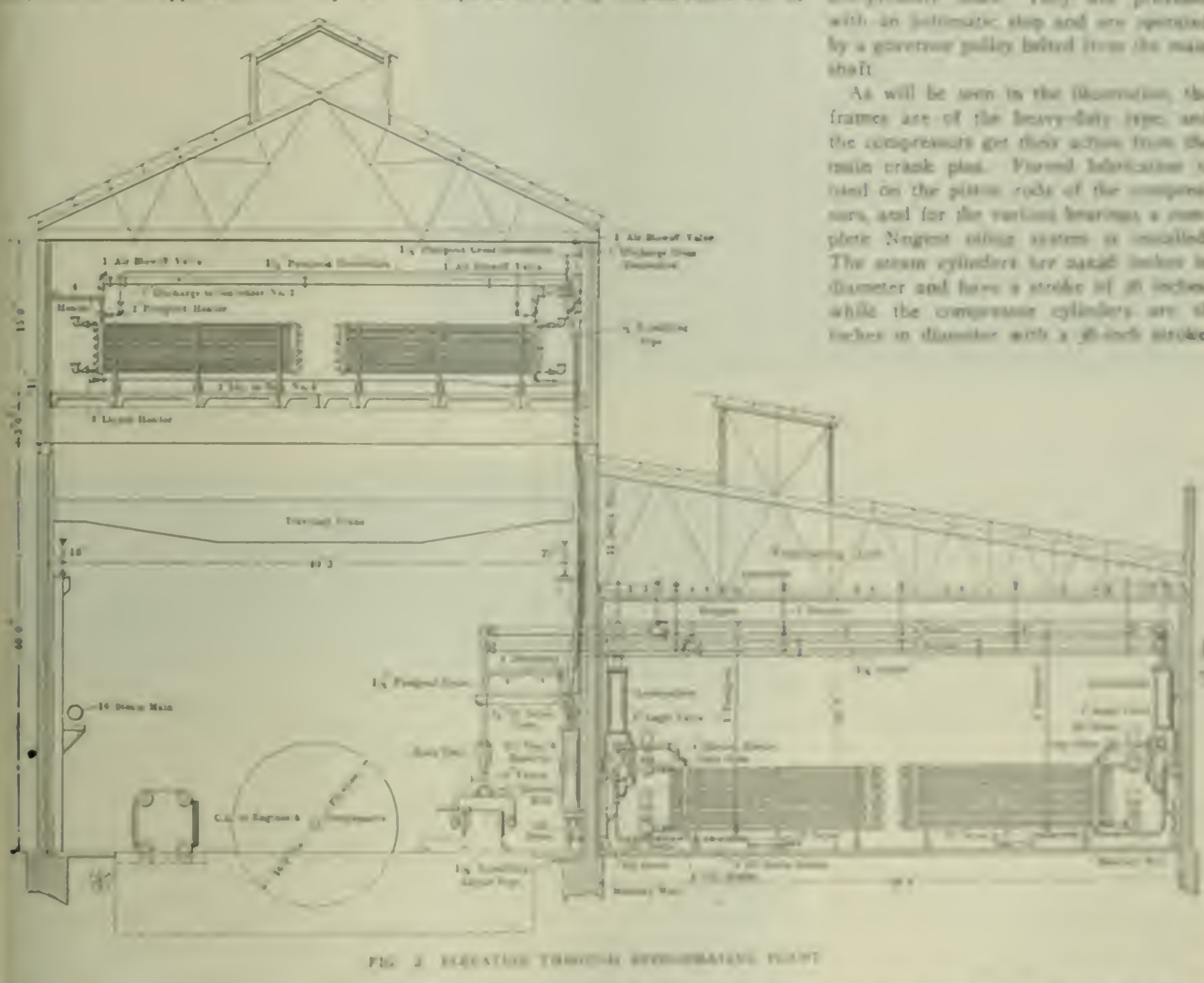


FIG. 2. ELEVATION THROUGH REFRIGERATING PLANT

Although this is a great advantage, a still greater one is the fact that the quality of the output can be depended upon to be more nearly uniform than when using natural air. The quantity of water removed from the air supplied to a blast furnace making 450 tons of iron per day is said to be 5000 or 6000 gallons in 24 hours, when the humidity is greatest.

As the amount of moisture in the air varies from 0.5 grain per cubic foot on a cold day in winter to 9.5 grains per cubic foot in mid-summer, it can be seen that the load on the refrigerating equipment will vary considerably, so that the average amount of steam required is much less than that called for by the full capacity rating of the machines. This explains why the saving in steam required by the blowing engines, which operate continuously with cold air of corresponding small volume, is more than sufficient to operate the ammonia compressors.

1200-TON REFRIGERATING PLANT

Recently there has been put in operation at the South Works of the Illinois Steel Company, at South Chicago, the large refrigerating plant shown in the accompanying illustrations. The plant which is capable of drying 122,000 cubic feet of air per minute, and is the largest that has so far been installed for this purpose, consists of four refrigerating machines of 300 tons capacity each, of the duplex horizontal type. Each machine consists of a cross-compound condensing Corliss engine and two ammonia compressors placed opposite the high- and low-pressure steam cylinders.

Fig. 1 shows a general view of the machines. They are located in a building 124 feet long and 92 feet wide, which is spanned by an electric traveling crane. A 16-inch steam main extends the length of the building at one side, resting on brackets and roller bearings to take care of expansion. From the top of this header a steam connection is made to each of the units through long-sweep bends. The compressors, together with the ammonia condensers, brine coolers and air coolers were supplied and installed by the Vilter Manufacturing Company, of Milwaukee, Wis. The steam ends of the machines consist of the Vilter standard Corliss-engine design, with a single eccentric actuating a wristplate from which the valve motion is derived. The governors, which are of the regular flyball pattern, control the cutoff on both the high- and low-pressure sides. They are provided with an automatic stop and are operated by a governor pulley belted from the main shaft.

As will be seen in the illustration, the frames are of the heavy-duty type, and the compressors get their action from the main crank pins. Forced lubrication is used on the piston rods of the compressors, and for the various bearings a complete Nugent oiling system is installed. The steam cylinders are 24 and 48 inches in diameter and have a stroke of 48 inches, while the compressor cylinders are 18 inches in diameter with a 48-inch stroke. The latter are provided with a set of two suction and two discharge valves. The compressor heads are bored to a true [illegible] and the pistons and valves [illegible] to the same [illegible], the construction [illegible] of large valve area and small clearance. Provision is made for preventing the suction valves from falling into the cylinders in case of the breaking of a valve stem. In the same [illegible] the cylinder barrels [illegible] [illegible] of [illegible] [illegible] pressed into the cylinder by hydraulic pressure and bored and finished at the same time as the [illegible] [illegible] [illegible] [illegible] the [illegible] between the cylinder jacket and cylinder proper forming the water jacket.

Double-pipe Condensing and Brine-cooling Systems

Discharging from the compressors, the gases pass through oil traps, of which one is provided for each machine, and enter the condensers, which are located on the second floor of the building, as shown in the elevation, Fig. 2. These condensers are of the double-pipe type, consisting of 2-inch pipes 18 feet long with 1¼-inch pipes passing through them for circulation of the cooling water. Twenty-five stands of such double-pipe condensers grouped 12 pipes high are provided for each machine, making in all 100 stands. Fig. 3 is a photograph of this part of the installation. Although each condenser ordinarily operates with its individual compressor, connections are so arranged as to permit the operation of two or more of them in combination on all or part of the condenser system.

Four receivers collect the liquefied gas and carry it through individual pipes to the cooling apparatus in which the liquid ammonia is expanded, thereby extracting the heat from the brine.

The double-pipe system is also used in cooling the brine and consists of four batteries of 20 stands each. Each stand has twelve 3-inch pipes with 2-inch pipes passing through them. This apparatus is installed in a building adjoining the compressor room and shown in Fig. 4, which is 68 feet 4 inches long by 58 feet 8 inches wide and 25 feet high. The floor, walls and ceiling are insulated with a double layer of 2-inch cork board. A saturated solution of calcium chloride is used as the cooling medium. This is forced through the inner pipes and transmits its heat to the liquid ammonia in the annular space on the interior of the 3-inch pipes.

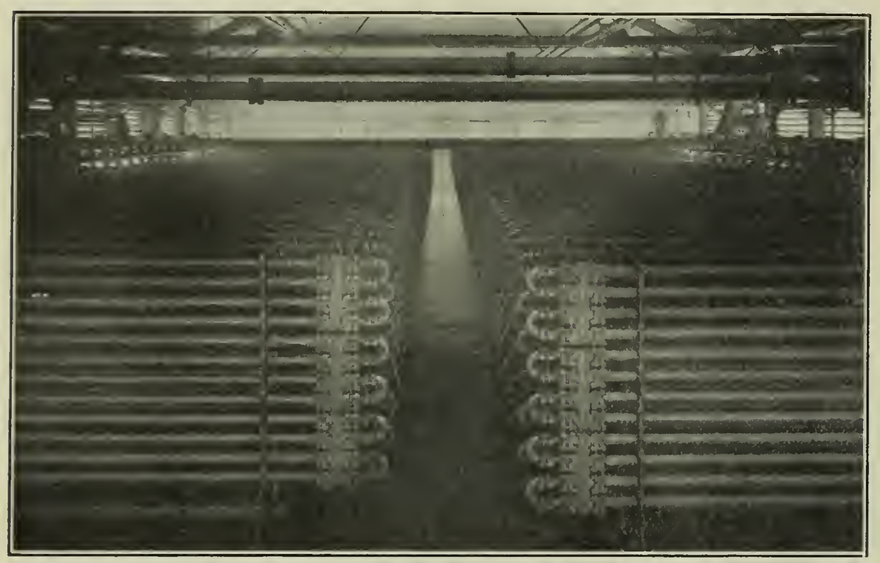


FIG. 3. AMMONIA CONDENSER ROOM

Novel Method of Introducing Refrigerant to Cooling Coils

One of the features of this part of the installation is that relating to the method by which the liquid refrigerant is introduced to the double-pipe cooling coils. In usual practice this is accomplished by needle valves or expansion cocks attached to the supply side of each double-pipe system, and the expansion is regulated as nearly as possible, so that each set of cooling stands receives its requisite amount of ammonia according to the demands on the system. Unless this regulation is very accurate, there will be some of the surface left ineffective for lack of liquid ammonia to which heat can be transmitted, or more or less of the ammonia will pass through the apparatus in a liquid state, thus materially decreasing the capacity.

In this installation there is an elevated receptacle called an accumulator for each battery of cooling coils. As shown in the drawing, Fig. 2, these accumulators are placed at such hight that liquid ammonia will flow through the cooling coils entirely by gravity. In the upper part of each accumulator is a coil through which circulates the liquid ammonia from the condensers. The cold expanded gas passes out through this part of the accumulator on its way to the compressors and cools the incoming ammonia.

After being cooled, the ammonia is liberated through a valve and allowed to run into the bottom part of the accumulator where it is subjected to suction pressure only. The success of the procedure depends upon relieving the liquid ammonia of its excess of sensible heat before it is allowed to pass to the accumulator. Therefore, there is no evaporation when the ammonia passes from the condensing pressure to that due to the suction pressure on the system.

After passing into the bottom of the accumulator the liquid ammonia flows by gravity to the double-pipe brine coolers, flooding them with liquid. The exchange of heat is then obtained by a boiling process rather than by instantaneous expansion as with other systems. As the liquid in the coils absorbs the heat from the warmer brine, it boils, the same as water would boil in a steam boiler, and the gaseous ammonia thereby formed makes its way to the outlet of the coil which, as shown in Fig. 2, connects with the accumulator at a point just above the level of the liquid. In case any liquid am-

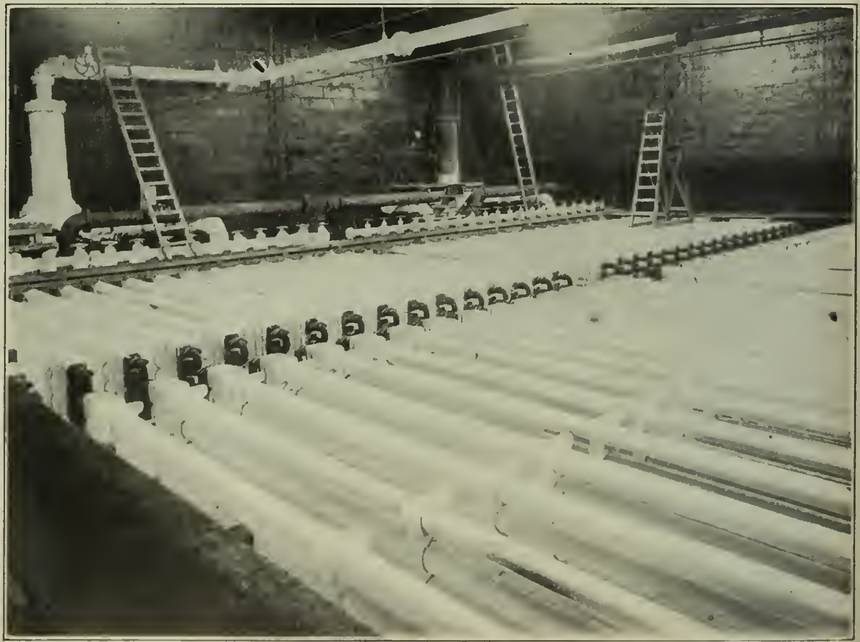


FIG. 4. DOUBLE-PIPE BRINE COOLERS

monia should pass through, it immediately drops into the bottom of the accumulator and is circulated again until it has absorbed its quota of heat and is expanded into gas. The gas then ascends into a large pipe header which terminates in a separator before returning to the compressor cylinders.

Cooling the Air

An important part of the work of this installation is circulating the cold brine through the coils where the air is cooled before going to the blowing engines. For this work there are three Prescott Corliss cross-compound, flywheel-type pumping engines installed. Each has a capacity of 1200 gallons per minute when operating with 120 pounds of steam. The pumps have steam cylinders 12½x24 inches in diameter and plungers 8¼ inches, all with a common stroke of 24 inches. These pumps were especially designed to take care of brine at the low temperature required in this plant, and particular care was taken to avoid shrinkage in the castings, considerable more metal being allowed in the pump sections than is ordinarily the case.

Each suction and discharge deck contains seven 4-inch valves with a total area of 70 square inches, which gives a velocity of 2.8 feet per second through the valve seats. A suction pressure of 15 pounds is carried on the system. The brine enters the air-cooling coils at about 16 degrees Fahrenheit and returns to the pump at 32 degrees.

A separate structure is provided in which to cool the air. This is a building 47 feet 10 inches by 66 feet 10 inches in ground plan and is divided by brick walls into seven compartments. In each compartment are numerous coils of 2-inch pipe, 40 feet long and 200 pipes high. The coils are staggered in order to bring the air into contact with all the cooling surface and are connected with brine headers on the top and bottom. Brine enters at the top and flows downward in the opposite direction to that of the air. Ducts on each side of the building in the basement distribute the air to the compartments, which are controlled by inlet gates. The air is blown into these ducts by two motor-driven fans, forced up through the cooling coils and out of the top of each compartment at a temperature of 32 degrees, where it is collected in an 8-foot conduit leading to the blowing engines.

As the moisture is removed from the air it collects on the coils in the form of frost, and it is arranged so that the compartments may be taken out of service one at a time for the purpose of thawing off this accumulation after it has reached a certain thickness. To do this the compartment is isolated by closing the top and bottom gates, the brine is drawn off into storage tanks and water is sprinkled on the coils until the frost is removed, when the compartment can again be put into service.

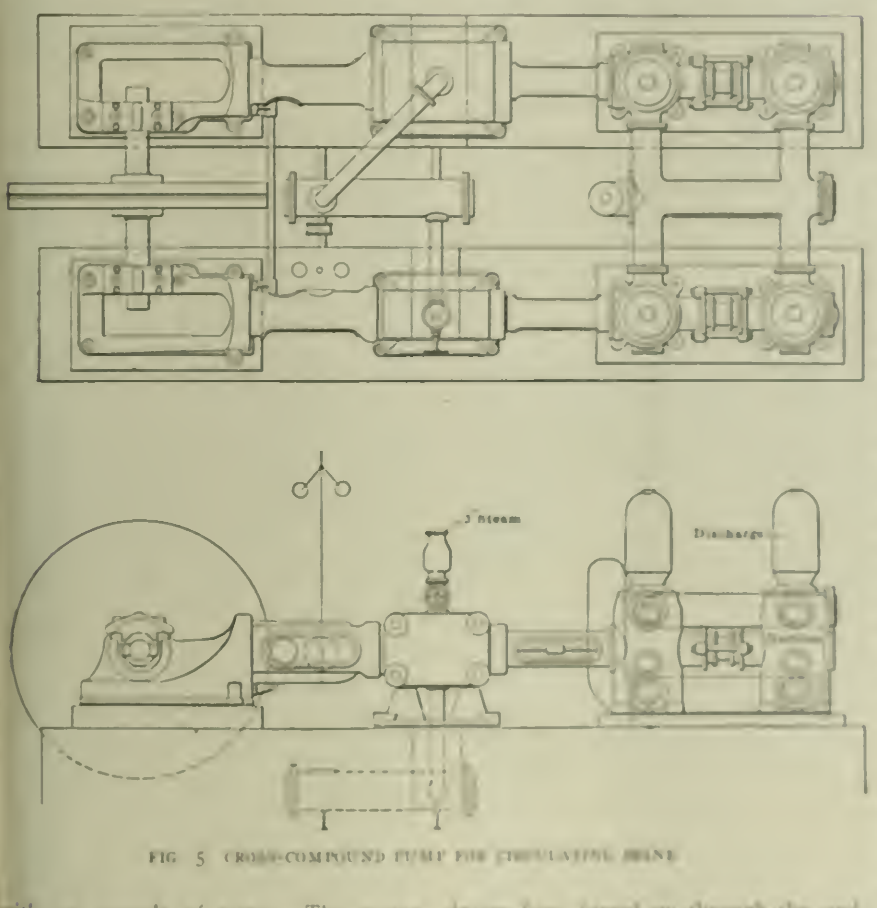


FIG. 5. CROSS-COMPOUND PUMP FOR CIRCULATING BRINE

Single- versus Four-valve Engines

Although many conditions may differ to affect the relative merits of single- and four-valve engines, the following conclusions, reached by F. W. Dean, mill engineer and architect, Boston, Mass., as the result of a series of comparative tests are certainly instructive as regards economy. The engines in the series were all simple, of the high-speed type, direct-connected to electric generators and ranging in size from 12x10 to 20x18. They had all been run under working conditions for a considerable period, with one exception, exceeding 2000 hours.

The most important conclusion reached is that the four-valve engines, which were built to be more economical than single-valve engines, utterly failed in their object. The results show that efforts to realize economy by duplication, or multiplication of parts, even if ports are shortened and clearances reduced, accomplish nothing. The duplication of valves used in the four-valve engines tested simply increased the opportunity for leakage. Mr. Dean asserts that it is doubtful if the four-valve type is tight even when new, and that it has no chance of ever being tight thereafter unless it is refitted, which is seldom done. This type of valve must take the whole responsibility of the extravagance of the four-valve engines. He does not hesitate to advise builders to abandon four valves on high-speed engines unless they are prepared to build a really high-class engine having four Corliss or gridiron valves made and fitted in the best manner. Even then it would be necessary for them to prove their case. Steam engines of whatever type should have valves that are not only tight originally, but that should become so by wear if they are not so originally. The wearing process should be a tightening process.

A bulletin has just been issued in the engineering series of the bulletins of the University of Wisconsin, under the title, "Current Practice in Steam Engine Design." The monograph was prepared under the direction of the late Storm Bull, professor of steam engineering, by O. N. Trostel. The book, which is intended for general distribution, contains forty-odd charts showing graphically the proportions, weights and dimensions of the essential parts of Corliss and high-speed automatic engines. It is the result of an investigation of considerable extent of recent practice of steam construction and covers the changes that have taken place in the last ten years. It enables comparisons to be made between plans and drawings submitted and the common averages, and maximum weights and proportions in current practice. The authors also furnish formulas for designing the essential parts of a steam engine.

Some Useful Lessons of Limewater

Practical Test for Hardness in Water; How to Soften Permanent-Hardness Water; Explanation of the Reaction in Water Softening

BY CHARLES S. PALMER

In last week's instalment we noted one test with barium solution for telling the difference between temporary-hardness water and permanent-hardness water. That is what would be called a chemical test, and it means a great deal, for it uses the insoluble white barium sulphate for finding sulphuric acid (or soluble salts of the acid, called sulphates). All that is good; but it is only an explanation of what you know already about the practical testing of hard water.

Practical Test for Hardness

You take a piece of soap to test for "hardness" in water. If the soap will not make a quick lather and, worse still, if the soap causes that greasy scum to form in and on the water, which you know is called "lime soap," then you know that the water is hard. That is the first step in testing hard water practically. The next step is to find out whether the water will become soft by simple heating and settling; if it will become soft by heating (and now you know that this is only changing the extra or bicarbonate of lime or calcium, which is soluble, to the insoluble plain carbonate), if the water does this on simple heating, then you know that the hardness is only temporary; it can be got rid of in ways that are comparatively easy. But, if the hardness of the water is not improved by heating and settling, if the soap still refuses to lather quickly, and if that greasy lime soap still comes in the water after the heating and settling, then you can be sure that you have "permanent" hardness.

This permanent hardness is harder to remove than the temporary hardness, and for several reasons. The chemical test that you gave the water at the end of the article in February 16 showed you that the permanent hardness is due to calcium sulphate, $CaSO_4$. Now the sulphates are all "salts" of sulphuric acid, oil of vitriol; and one quality of this sulphuric acid is that it is not easily volatile, as carbonic acid is; and another quality is that it is a strong and stable acid. In the case of the lime carbonate, we added extra carbonic acid from the breath; and we drove it off again by simple heating. But in the case of sulphuric acid you are dealing with a stronger, a more stable and a less volatile acid than carbonic acid; and that tells some of the reasons why temporary hardness, or "carbonate hardness," as it may be called, is so much easier to get rid of than permanent hardness, or "sulphate hardness." In both cases, you will have to do mainly with lime-like compounds for the basic part of the "hard" salts, although there are also salts of sodium, of magnesium and so on, in hard water; but the big difference between the temporary or carbonate hardness and the permanent or sulphate hardness will be found to lie in the difference between the instability of the carbonates and the stability of the sulphates. Let us get some experiments with this other kind of lime-like salts, the sulphates, which are found in permanent-hardness water.

The first thing to do is to make some of this permanent-hardness water. You can do this in several ways. One way is to shake up a little common plaster of paris in a tumbler of water, and after some minutes filter off the clear solution. Plaster of paris is nothing more than calcium sulphate (sulphate of lime), and it is thirsty for water. That is the reason why it is used for making all sorts of things where a quick-drying paste is wanted; and that is also why plaster of paris is called "anhydrous," which means "without water" but willing to unite with it. You will filter the solution of this plaster of paris to get a sample of artificial permanent-hardness water, or you can make it in another way.

Go back to that solution of plain limewater. Slip a strip of your litmus paper down the side of a tumbler and fill it half or two-thirds full of filtered limewater. You note that the litmus paper is blue; and that reminds you that the limewater is alkaline or strongly basic. Now take the bottle of sulphuric acid and carefully drop in a drop or two of sulphuric acid, not too much, stirring with a piece of the glass rod which came with your outfit. Bring the sulphuric acid and limewater to neutrality, so that it makes the litmus paper neither red by acid nor blue by the alkaline limewater, but neutral purple. You can get this point by several trials; and it is worth your while to get it and get it right. You may find that the sulphuric acid is too strong for the limewater, and that a few drops of the acid will more than neutralize a half tumbler of the limewater; in that case, your wits will tell you to pour out a few drops of the acid into another tumbler of water, and then to use this second tumbler of diluted acid to neutralize the limewater. But, when you do get the limewater and the sulphuric acid together, neutralized and filtered, you will have the same thing as the filtered solution of plaster of paris, and both will be nothing more than artificial permanent-hardness water. And if you don't believe that this kind of water is permanently hard, just try to get rid of that lime-like part quickly, easily and cheaply. It can be done, in some cases, and perhaps in all cases; but it is part of the object of these lessons to see what the difficulties are, or rather what the possibilities of help are. You know what the troubles are.

Softening Permanent-hardness Water

Well, here is your solution of permanent-hardness water, or sulphate water. Tease it with every test that you used with limewater and lime-carbonate water. You will probably get no precipitate with carbonic acid, whether taken from the breath, from the glowing coal, from the bottle of "fizz," or from the apparatus shown in the February 9 number, where you made carbonic acid from marble or soda and hydrochloric acid. The calcium sulphate which makes the scale, the hard scale, in permanent-hardness water is more soluble than the theoretically possible lime carbonate which might come down by blowing through some carbonic-acid gas; but the hard water does not give down its lime sulphate as easily as that. The reason why the carbonic-acid gas from the breath, or from any of the other sources that you used, does not throw down the lime as calcium sulphate seems to be that as the carbonic acid would take hold of the lime, the sulphuric acid would have to step out; but this same sulphuric acid would not remain free in any quantity but turn round and attack the lime carbonate formed somewhat; and so the possible reaction would work backward; at any rate it does not work to soften the water.

But this has given you an idea; if plain carbonic-acid gas will not throw down the lime from lime sulphate, why not put in something with the carbonic acid, something like a base, to take care of the sulphuric acid that will be set free? Why not try something like soda carbonate, soda ash, or the like? You will find that this will make an interesting experiment; and it will block out the way for some good thinking.

Make a pint or so of this filtered solution of plaster of paris, then add a pinch of soda ash; shake the water well, and let it settle. Do not filter this, but let it take its time to settle by itself. While the stuff is settling, you can study the following equation of the reaction:

Explanation of Reaction in Softening Water

You will notice that the "salt" lime (or calcium) sulphate has two parts, a basic part and an acid part, and a similar thing is true of the "salt" sodium carbonate, that you add to the hard water to soften it. You can straighten it out and remember it at the same time, in this way: Write out the names of the substances, underlining the base parts, and overlining the acid parts, thus:

$$\left.\begin{matrix}\underline{\textit{Calcium}}\ \overline{\textit{Sulphate}}\\ \textit{Soluble}\end{matrix}\right\} + \left\{\begin{matrix}\underline{\textit{Sodium}}\ \overline{\textit{Carbonate}}\\ \textit{Soluble}\end{matrix}\right.$$

equals

$$\left.\begin{matrix}\underline{\textit{Calcium}}\ \overline{\textit{Carbonate}}\\ \textit{Insoluble}\end{matrix}\right\} + \left\{\begin{matrix}\underline{\textit{Sodium}}\ \overline{\textit{Sulphate}}\\ \textit{Soluble}\end{matrix}\right.$$

You see that the exchange between the salts is much like dancing couples exchanging partners. Each "salt" has its acid part and its basic part, and the parts simply exchange places, with the selective affinity necessary to make one of the salts insoluble, that is, the lime carbonate. Thus you have driven the lime out of solution, and while you have done this, you have also left another soluble salt in the water, that is sodium sulphate. It is like driving out a plug by another plug; but still one plug stays in the log. But in the case of the temporary-hardness water, in changing the extra carbonate to the plain carbonate you drove out both plugs at the same time. Here, in the case of the permanent hardness, the plug which stays in the log is the soluble sodium sulphate.

But, you ask, what is the harm of leaving some of this sodium sulphate in the boiler water? Well, what is the harm of leaving such a soluble thing as sulphate of soda, which you know already as Glauber's salt, in the boiler water? Because, as you well know, such salts may cause priming, not to mention the possibility of their helping in the corrosion of the metal of the boiler and its connecting pipes. So there you are, and you begin to see what are some of the annoying problems connected with this general subject of water softeners.

Now this lime (or calcium) sulphate is soluble in water, one part to some four or five hundred parts of water, if the solution is loaded to the limit. Soda, which is sodium carbonate, is very soluble; and if you add this water softener in the comparatively cheap form of soda ash, you will still need a settling tank for the lime carbonate to settle out clear. Also, the boiling water will have to be blown off frequently, to say nothing of looking out for the foaming and priming that wait on the poor boiler man to give him his full share of trouble.

Carefulness in Experiments

There is one thing that should be mentioned here regarding the action of chemicals on each other, that is, that any description of the actual happening is and can be only approximate to what does actually happen. If you alter any of the conditions, as the quantity of the water or other solvent used, or if you change the temperature, or the quantity or purity of the chemicals used, naturally the results will vary slightly. This does not mean that nothing definite will happen, but it does mean that little things will vary the general results, and each experimenter will have to keep his own eyes open to see just what does actually happen in the case of the chemicals he is using in his laboratory. Do not misunderstand me. There is no uncertainty as to conditions or results; but there may be the greatest variety in the conditions and results, and things that one may call little or of slight importance may make things appear to change greatly. But, remember this: When you and I may differ as to what does happen, nothing is easier than for each of us to try it for himself; then we will find out without depending on the books to see for us.

Explanation of Slacking Quicklime

We have found out some interesting things about this substance, lime; and yet, there is so much to examine and to discuss that we have had to overlook many things that are both interesting and practical. One of these is the "slacking" of "quicklime." You have often seen masons getting their mortar ready, and you have seen the white, muddy mass fairly boil with heat as the lime is mixed with water. Indeed, this heat of slacking lime is so strong that, as you well know, fires may be easily caused by leaving barrels of quicklime in exposed places in or near wooden buildings; and the question comes up right here: What is the slacking of lime? What is the difference between quicklime and slacked lime?

Practically, the difference is due to the action of water. Water consists of hydrogen, two parts, and oxygen, one part; and we tell this long story in the short and curious way implied in the formula, H_2O, which is read thus: "H two O;" that is, there are two chemical units of the element hydrogen and only one part or chemical unit of the element oxygen. So you learn the formula of water as H_2O. Now you already know that quicklime is the rust of the metal calcium, and that is told in the form CaO, which is read: "C-a-O," Ca standing for the chemical unit of calcium and O standing for the chemical unit of oxygen. You can write the action of water on quicklime this way:

Quicklime and Water [illegible]

or you can write the same story with symbols in this way:

$$\left.\begin{matrix}CaO\\ \text{Calcium}\\ \text{Oxide}\end{matrix}\right\} + \left\{\begin{matrix}H_2O\\ \\ \text{Water}\end{matrix}\right\} = \left\{\begin{matrix}Ca(OH)_2\\ \text{Calcium}\\ \text{Hydroxide}\end{matrix}\right\} + \text{Heat}$$

As you look at these, there does not seem to be much difference between quicklime and slacked lime; but as you remember that the difference is enough to set a house on fire, evidently it is worth considering. The difference practically is evidently the adding of water to quicklime; but the quicklime is what is called "a base anhydride," that is, it is a base minus water; and in some curious way this takes on water, splits it into several parts, rearranges these parts with the calcium and oxygen and forms the quiet base, calcium hydroxide (or calcium hydrate) $Ca(OH)_2$. It is apparently an important difference, this between the base anhydride as quicklime and the base proper, calcium hydroxide; and you will find this same difference between some of other bases and their anhydrides. But it is interesting to know that this common quicklime is the only common, available and active base anhydride. When you dissolve some quicklime in water, it first takes on water forming the base proper, slacked lime (calcium hydroxide or hydrate), and then this dissolves in the water; so that probably it is not possible to have a solution of quicklime as such, CaO; but you will get rather a solution of the real base, slacked lime, $Ca(OH)_2$. In much the same way, you will find that some acids have the two forms, the anhydride alone on the one hand, and on the other hand the anhydride with the ingredients of water, making the real acid. This is true of sulphuric acid, of nitric acid, of phosphoric acid (which gives one a chance to get an acid anhydride as active in its way as quicklime is a base anhydride in its way) and, especially, silicic acid.

The story of silicic acid starts from common sand, which is the acid anhydride of silicic acid. You would hardly guess that clean white sand is a heavy acid anhydride from the indifference it shows to water and everything else ordinarily; and this is found out by some ingenious ways. But just think of what you have actually seen of the common brick furnace, the common laundry supply, or even your own furnace, with its [illegible] "salts" of the silicic acid [illegible] combined with such bases as [illegible] lime or [illegible], and so on. You can [illegible] a good [illegible] with this kind of sand [illegible] your boiler [illegible]. Use a big lump of lime in one corner of your [illegible]. If [illegible] it will stay there; it is [illegible]. Get a shovel of clean sand and put it in another corner of your [illegible]; it will stay there, for it is [illegible]. But [illegible] the base anhydride quicklime and the [illegible] acid anhydride, sand, and pretty soon you will see the fire fuse the two together, making a clean melt in the liquid molten slag, which is a lime or calcium silicate.

You see this tendency toward the making of slag in every shovelful of your cinder; and now you begin to see that there are several fields of chemical action: there is the water field, sometimes called the field of "wet" chemistry; and there is the field of hot molten fusion, sometimes called the field of "dry" chemistry. Most elements have special relations with both fields, and this is particularly true of the substance lime. In the first place, it is made by burning limestone, driving off the volatile carbonic acid and leaving the base anhydride, quicklime. Then you dissolved this quicklime in water forming the true base, slacked lime, in limewater, or calcium hydroxide (the word "hydroxide" means that it has some of both hydrogen and oxygen). Then by blowing in carbonic-acid gas, you drove this calcium hydroxide, or limewater, to the plain insoluble carbonate, the same thing as limestone. Then by more carbonic-acid gas you forced this plain insoluble calcium carbonate over to the soluble extra or bicarbonate of calcium. Then you drove it back to the insoluble plain carbonate, by heating and settling. You also brought back the soluble bicarbonate of calcium to the insoluble plain carbonate, by mixing it with some of the base limewater emulsion, the two averaging up as the plain carbonate of calcium, the result of water softening by Clark's process.

You also begin to get a glimpse of the permanent hardness of sulphate of calcium waters; and you found out that you can throw down the lime by the alkaline salt, common washing soda, or soda ash. By the way, you will be interested to learn that common cooking soda is the extra or bicarbonate salt of soda; and that can be changed to the plain carbonate (soda ash or washing soda) by heating dry for an hour or two at a heat considerably higher than boiling water, roughly about that of molten solder. You can do this in a saucer on your kitchen stove at home, or in the front part of your furnace. It is interesting to know that the extra or bicarbonate of sodium can be changed to the plain carbonate only by heating it in the dry way, while the similar lime bicarbonate salt can be changed to the plain carbonate by heating in the wet way, another curious illustration of the relations and differences pertaining to the fields of "dry" and "wet" chemistry.

Thus far we have had to do mainly with lime or calcium compounds in our study of hard water, although we have frequently referred to the fact that there are other substances which come in to complicate things. One of the other things which is important in hard water is the salts of magnesium, for this element is almost a chemical cousin of calcium.

There is also one other thing to which you may want to give some attention, and that is the collecting of samples of actual boiler scale from various boilers and from various waters. You will find that the scales from some of the waters can be entirely cut or dissolved in the hydrochloric (muriatic) acid; these are mostly the temporary-hardness waters; while some of the scale will not easily or completely dissolve in any of the acids which you have, these are mostly the scales of permanent-hardness waters; and this kind of testing is closely related to the test given at the close of the third paper of these lessons, in the February 16 number. And so we are gradually accumulating the familiarity with limewater that will carry us on to the clearer understanding of what hard water is and how it may be treated.

Catechism of Electricity

937. *If the thermometer readings in 936 were taken on Fahrenheit thermometers instead of on Centigrade thermometers, would the results be affected?*

They would. If, however, the Fahrenheit readings be converted into Centigrade by substitution in the formula $C° = 5 \div 9\ (F° - 32°)$, in which $C°$ represents degrees Centigrade and $F°$ denotes degrees Fahrenheit, and these new figures in the calculations, the results will be the same as before.

938. *How long does it require a motor working under full-load conditions to attain maximum temperatures in its various parts?*

Small motors attain their maximum temperatures sooner than larger motors. Ordinarily, about four hours is sufficient for small motors and from six to eight hours for large ones.

939. *Is it possible to detect abnormal heating in a motor by any method not yet mentioned?*

Yes, by the sense of smell. When the heating has reached this stage of development, the limit of safety has been far exceeded. Trouble asserting itself in this manner may usually be located in the field or armature coils as the insulation on these windings when subjected to undue heat gives forth a very pungent odor not easily mistaken. If the machine is not shut down at once, the trouble is liable to increase until smoke is visible and the damage irreparable.

940. *What are the general causes of abnormal heating at the commutator?*

Those defects which have previously been mentioned as causing sparking at the commutator will also raise its temperature. They constitute the general causes of abnormal heating at the commutator.

941. *How should these general causes of abnormal heating be removed?*

By removing the source of the sparking as previously explained.

942. *Does not the appearance of the commutator serve as a guide to the direct cause of the heating?*

It does if the trouble is with the commutator. For example, if there are burnt spots on the surface of the commutator, there is probably dirt or foreign matter on it which should be removed. If, when the current is applied, small sparks can be detected in the insulation between the commutator bars, there is either foreign matter between the bars or the insulation itself has become defective. In the former case the troublesome particles should be removed and in the latter case a new commutator will probably be necessary.

943. *Is a hot commutator sometimes caused by trouble in other parts of the motor?*

Yes.

944. *What usually causes the brushes to become abnormally heated?*

Loose connections in the brush holders or between the brush holders and the brush-holder cables, decomposition of the brushes at their contact surfaces, or carbon brushes of too high resistance.

945. *What should be done in case the brushes are of too high resistance?*

Some improvement may be noticed if the brush holders are set lower so as to make that portion of the carbon through which the current passes as short as possible. Other methods of correcting this trouble consist in providing brushes of larger cross-section, in using a greater number of brushes and brush holders on each stud, and in increasing the conductivity of the carbon brushes by using copper in one form or another in connection with them.

In case one of the carbon brushes is found to heat more than the others, a comparison between its resistance and that of one of the others will show at once if the difficulty lies in its conductivity. If its relative resistance is found to be high, advantage may be taken of any of the remedies just given for decreasing its resistance.

946. *To what cause can abnormal heating of the field coils usually be traced?*

To the passage through them of a larger current than they are designed to carry.

947. *What would be the heating effect if one of the field coils was short circuited?*

The short-circuited coil would be cooler than the others, and its pole piece would be weaker magnetically.

948. *Is there a more accurate method*

of locating a short-circuited field coil than that mentioned in 947?

Yes. To make absolutely sure whether a field coil is short-circuited, measure the resistance of each one by the drop method. This consists in passing a direct current, maintained constant by means of a rheostat and ammeter, through the field coils connected in series and measuring by aid of a voltmeter the drop in pressure across the terminals of the individual coils. If there is a variation of more than 5 or 10 per cent. between the voltmeter readings, there need be no doubt but that the coil showing the low reading is short-circuited.

949. *How may a short-circuited coil be remedied?*

If the trouble lies at the terminals of the coil it is usually easy to bend or insulate them without removing the coil from the pole piece; otherwise, it should be taken off and rewound.

950. *What are the causes for high temperature in the pole pieces?*

Either heat conveyed to them from other parts of the machine which have reached a high temperature or eddy currents in the pole pieces.

951. *Describe how eddy currents are developed.*

Changes in the magnetic condition of the pole pieces due to a variation in the field current through the magnet coil are responsible for the development of eddy currents. The eddy currents travel at right angles to the lines of force of the field. They penetrate into the interior of the pole pieces, although not to a great depth, and heat the iron cores.

952. *What harm is done if the pole pieces reach a high temperature?*

They raise the temperature of the field coils and so increase their resistance.

953. *How is it possible to tell whether hot field coils are caused by eddy currents in the pole pieces or by too large a field current?*

If eddy currents are causing the trouble, the temperature of the pole pieces will be higher than that of the field coils. A comparison of the respective temperatures of pole pieces and field coils may approximately be obtained by the sense of feeling, if due allowance is made for the difference in conductivity between the iron of the former and the insulation of the latter. A more accurate comparison of temperatures can, of course, be made by means of thermometers properly applied.

954. *What can be done to eliminate eddy currents from the pole pieces?*

The reconstruction of the pole pieces is the only practical remedy. They should be laminated by building them up of plates or disks stamped from soft sheet iron, instead of forming each core of one solid mass of iron. The plates are enameled or painted on both sides, and when dry are bolted tightly together and cast in with the frame. The enamel on the plates acts as a resistance to the eddy currents and checks their formation. It does not, however, impede the flow of the lines of magnetic force through the pole pieces, because these lines pass lengthwise along the plane of the plates.

955. *Are eddy currents ever responsible for unduly raising the temperature of the armature?*

Yes, especially when they form in the armature core. In this case there is no noticeable sparking, but there is a higher temperature in the core than in the surrounding coils. The machine also requires more than the usual amount of current to run it at no load. As in the similar case with the pole pieces relief can be obtained only by laminating the iron core.

If the motor is of large capacity, carrying heavy armature conductors, eddy currents may also develop in them. This trouble may be distinguished from that just mentioned by a higher temperature in the conductors than in the core. It will be necessary to subdivide the conductors into strands or strips, twist them about each other, and sink them into slots in the armature core in order to overcome the difficulty.

More Water Needed at Colliersville

By Thomas Wilson

That a water power plant should be designed, erected and be in actual operation for some time before it was discovered that there was not sufficient water to run it the year round even to the capacity of the smallest unit installed, would appear to be incredible. Such a plant was designed, however, and put into commission about a year ago on the Susquehanna river near Colliersville, Otsego county, N. Y. The plant was intended to furnish power for the 61-mile line of the Oneonta and Mohawk Valley railroad, also power and lighting to the adjacent towns and villages. The railroad company also has a steam plant at Hartwick, N. Y., about [illegible] miles distant, from which current was formerly supplied. It is now the intention to use it as an auxiliary to supply any deficiency in current from the water plant at Colliersville. From all indications it would appear that the steam plant must be called into service quite frequently, and during the dry summer months be depended upon entirely.

The equipment is divided into two units of 1000-kilowatt Westinghouse generators direct-connected to Holyoke horizontal turbines of [illegible] horsepower each. The Stevens-Hewitt Engineering Company, of New York, designed the plant, and in June, 1906, construction was begun by the designers acting as contractors on a percentage basis. Before the work had progressed very far, it became evident that the cost would overrun the estimate. A new contract was consequently executed by the same parties and the firm of William Barclay Parsons was appointed by the owners, Henry W. Ross and associates, as engineers to supervise the completion of the work and the testing of the machinery. This work was completed under the direction of P. S. Tunner, representing the Stevens-Hewitt Engineering Company, and tests were conducted by H. M. Brinckerhoff, mechanical and electrical associate of William Barclay Parsons.

From all available information it would appear that the capacity of the plant and the subdivision into units was based on the average minimum rather than the lowest flow of water, and that the data for this flow was taken from incomplete reports of the Geological Survey and from observations of the designing engineers which extended over a period of only two years' duration. That these observations did not extend over a long enough period even to check the accuracy of the figures obtained by the Geological Survey was evidenced last summer during the worst drought of many seasons. Ordinarily the average low flow of the Susquehanna river at this point is approximately [illegible] feet per second, but during the dry months of August and September of last year the flow dropped to [illegible] cubic feet. As a consequence the plant was entirely shut down during these months. During a normal summer it would be possible to obtain from [illegible] to [illegible] horsepower during the two dry months for at least a few hours per day. With 1000-kilowatt units this power could not be secured with efficiency, so that the installation really involves [illegible] plant averaging from [illegible] to [illegible] horsepower, the water power being readily obtained from the minimum flow which is found [illegible] per second.

For the average power during a year's operation data are wanting, but it is perfectly evident that the plant [illegible]. With the [illegible] units it is impossible to take full advantage of the low flow, and just why some smaller units, such as [illegible], were not installed in preference to one of the 1000-kilowatt machines, is a question that should be answered by the designing engineers.

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Contents

Is Water Power Cheaper than Steam?

The answer to such a question depends largely upon the size of the plant in relation to the minimum flow, its flexibility, or the power to utilize efficiently all available flow, and the nature of the load to be carried. In many instances the capacity of a plant is based upon the normal June flow, which is considered a fair average, although it is known that the amount of water available during the three dry months following will be away below this figure, and sometimes, if the flow is based on erroneous figures, or if there is an unusual drought similar to that experienced last summer, the supply of water will dwindle to such an extent that it may be necessary to shut the plant down entirely. This condition was realized at the Colliersville, N. Y., plant, as told elsewhere in this number, there being no small units to take advantage of the small supply actually available—nothing but two 1000-kilowatt machines to utilize a flow hardly sufficient to develop 250 horsepower. Fortunately, a steam plant was available to carry the load, and from all appearances it should have been allowed to carry it the year round. Of course, the extraordinarily low water of the last dry season was altogether unusual, and many other water-power installations had their troubles, but with a plant so unwieldy as that at Colliersville, a repetition of last summer's difficulties is almost sure to occur during the dry seasons of succeeding years. Imagine the economy of maintaining two plants to supply a given power: one a water plant operating ten months in the year, and then not always at full capacity; the other a steam plant kept in constant repair and readiness to supply any deficiency in current from the water power. The fixed charges on such an arrangement would be very considerable, and the aggregate cost per unit of output from the combination would in all probability be more than that from an average steam plant designed for the load.

Basing the capacity of a water plant on the minimum flow also has its objections, for during nine months in the year a large amount of water would be overflowing the dam, and there would be enough water available to develop power far in excess of the rating of the plant. Much depends on the nature of the load. A lighting load adjusts itself to some extent with the seasons, that is, it is lighter during the three dry months and heavier during the remainder of the year, when there is usually plenty of water. A motor load requires a constant supply of current with but little variation from month to month, and in such a case it is either necessary to rate the plant on the minimum flow and provide a reservoir for storage, or depend upon costly steam reserves to supply the deficit of power. In either case it is important to know accurately the real minimum as well as the average minimum flow, and no chances should be taken or guesses made as to the actual quantity of water that will be available after the plant is installed.

The Flywheel as an Element of Danger

Seven years of experience of the Fidelity and Casualty Company has shown that the loss ratio in flywheel insurance is twice as great as in boiler insurance; that is to say, the proportion of the money received as premiums to that paid out for losses is twice as great in the case of flywheels as in the case of boilers. For the year just passed it has been three times as great. Another statement warranted by the experience of the same company is that about thirty per cent. more of the flywheels in use explode than of the boilers in use.

In the regulation of speed fluctuation, the capacity of a flywheel depends upon its weight and the speed at which it is run. In a wheel of any diameter, if the speed of rotation be doubled, only one-half the weight is required, and as the cost of flywheels depends directly upon their weight, it is customary, in order to save cost, to make them as light as possible and to run them at the highest possible speed consistent with safety.

The forces tending to rupture a flywheel are in many respects similar to those which tend to bring about boiler explosions. In the boiler the steam pressure exerts a radial force on the shell tending to tear the sheet along longitudinal lines, and when this force exceeds the strength of the material of which the shell is made an explosion takes place. In the flywheel, also, the force tending to tear it apart is radial and dependent upon the speed. In the boiler the force increases directly with the pressure, while in the flywheel the force to be reckoned with increases as the square of the speed. Doubling the boiler pressure simply doubles the stress on the seam, while doubling the speed of the wheel quadruples the force acting on the rim.

In the boiler the strength may be increased by thicker sheets. If the thickness of the sheets be doubled, the boiler is twice as strong as before, but doubling the thickness of the rim of the flywheel, although it doubles its strength, also doubles its weight and the force tending to rupture it, for as the weight is increased so is the centrifugal force, and the rim is no stronger than before, however much it may appear to be so.

The point that is desired to be brought out is this: The flywheel is certainly an element of danger in power-plant operation, if placed in the hands of ignorant or incompetent men, and it is just as important that the engineer should be as familiar with formulas relating to centrifugal force as with those bearing upon the efficiency of riveted joints.

Draft and Boiler Capacity

Not many years ago an evaporation of two pounds of water per square foot of heating surface was considered good practice. This has been increased to two and one-half pounds for horizontal tubular, and in the case of the water-tube boiler to three pounds for the normal rating. Modern tendencies are to greatly increase this evaporation by burning more coal per square foot of grate area and necessarily increasing the supply of air, which in some cases has practically doubled the capacity of the boiler with but a slight drop in the efficiency. It is now proposed by the Technologic Branch of the United States Geological Survey to double or treble the capacity of a boiler by passing two or three times the usual quantity of air through the fuel bed and boiler. Numerous experiments along this line have been made by passing measured weights of air through two beds of lead shot, one always remaining the same to represent the boiler, while the other is varied as to size of shot and depth to represent the fuel bed. From the data obtained with the shot numerous charts have been plotted and a number of laws deduced bearing on the relative amounts of power required to force air through fuel beds of various thicknesses, composed of various sizes of coal, and through boilers of various lengths and areas of gas passages.

As a result of these experiments it may be possible to increase the rate of working the boiler-heating surface to three or possibly four times the present value. Such an increase would undoubtedly mean new designs of grate, stoker, furnace and boiler, especially fitted for high rates of working.

No attempt should be made to force more air through existing boilers by running the fans at a much faster rate, as the power consumed for this purpose would increase out of all proportion. New fans and engines must usually be installed, which will supply the greater volume of air at as high or even greater efficiency. Data are now being obtained as to the power required by pressure and exhausting fans to produce the desired pressure and volume of air.

One way of reducing the work required from a fan working under the new conditions is to increase the grate area, thus avoiding a high pressure drop through the fuel and insuring better combustion of the fine particles of coal. The pressure drop through the boiler would be increased materially, creating a high velocity where it is desired.

Further experimentation along this line is to be desired, and especially with hot fuel beds and boilers in actual operation. It is the intention of the Geological Survey to perform such experiments in the near future, and the results of their work, to be published in a bulletin on "Drafts," should be of exceptional interest.

Competent Engineers are Not Mere Machines

When an engineer is intrusted with the care and operation of a steam plant it would seem that if he really is competent his judgment should, to some extent, be relied upon in matters involving the spending of money for supplies and repairs.

This thought was brought to mind by the experience of an engineer who has a particularly alert mind and a fertility in resource rarely equaled.

One of the side walls of a boiler furnace needed renewal. On being informed of the need, the proprietor said:

"Get a mason and the necessary material and do the work, but do not allow the expense to run above ten dollars."

Mason and material were secured and the work started. After the wall had been stripped and the new brickwork started, the engineer said to the mason:

"You know just how much firebrick and clay are worth and you know, too, just what you charge an hour for your time. Now keep track of the time, fire-clay and brick and when these items together amount to ten dollars, stop work and come out of the furnace."

With about twenty-five more brick to lay, the mason came out and was sent home. Then the engineer notified the owner that the appropriation had been exhausted and the work was not complete. There was nothing to be done except to send for the mason to return and finish the work.

"Why did you let him go away before the work was done?" asked the employer.

"When I came here," said the engineer, "you told me that you wanted to know where every dollar that was spent on this plant went, and you have set the price on a great many things that you did not know anything at all about, thereby costing yourself a lot of money by not allowing the man you hired for what he knew about engines and boilers to use his knowledge. I have grown to be ashamed of some of the things that you have made me do and have called a halt. If I stay with you, I am going to be the engineer.

"I shall operate the plant as well as I know how and make all the repairs I can for you, but I will not be handicapped any longer by such petty restrictions as you have heretofore imposed on me. I wish to say what repairs are really necessary and where I shall buy [illegible] and firebrick and how thoroughly repair work on the apparatus under my care shall be done, with due regard for the safe and successful operation of the appliances for which I am responsible."

The owner was somewhat surprised at this and said so, adding:

"I think I can put myself in your place and see the situation from your point of view. I have always looked upon an engineer as a sort of necessary expense accompanying the engines and in need of the same supervision as other labor. I see that in this instance, at least, the engineer is a real factor in economical power production, and a factor to be reckoned with. In the future we will try to see what can be accomplished by intelligent cooperation, that is, as nearly as we may be able to arrive at it."

In this instance it was readily accomplished and today the engineer of the plant is the head of the department to which he belongs. He treats the plant as though it belonged personally to himself and he is determined that it shall be the best of its kind. He insisted that he be given an opportunity to prove his worth, and when given it he "made good."

Polytechnic Institute Student Section of the A. S. M. E.

This organization has just been formed as an adjunct to the department of mechanical engineering of the Polytechnic Institute of Brooklyn, in charge of Prof. William D. Ennis. The section is intended mainly for the undergraduates, but the movement is being enthusiastically supported by the alumni and other prominent engineers of Brooklyn, many of whom have authorized the committee on admission to present their names for membership. At present about [illegible] are enrolled and it was expected that fully a hundred would be on hand for the February meeting.

The activities of the section will take the shape of addresses by men eminent in the various branches of mechanical engineering, visits of inspection to nearby establishments and the reading and discussion of members' papers.

Regular meetings will be held on the first Saturday of each month during the college year, excepting October, usually in the evening, in the auditorium of the College of Engineering, Livingston and Court streets, adjacent to the Brooklyn City Hall.

An unusual invention for the [illegible] was recently demonstrated at the [illegible] in which a [illegible] The [illegible] that the [illegible] may be [illegible].

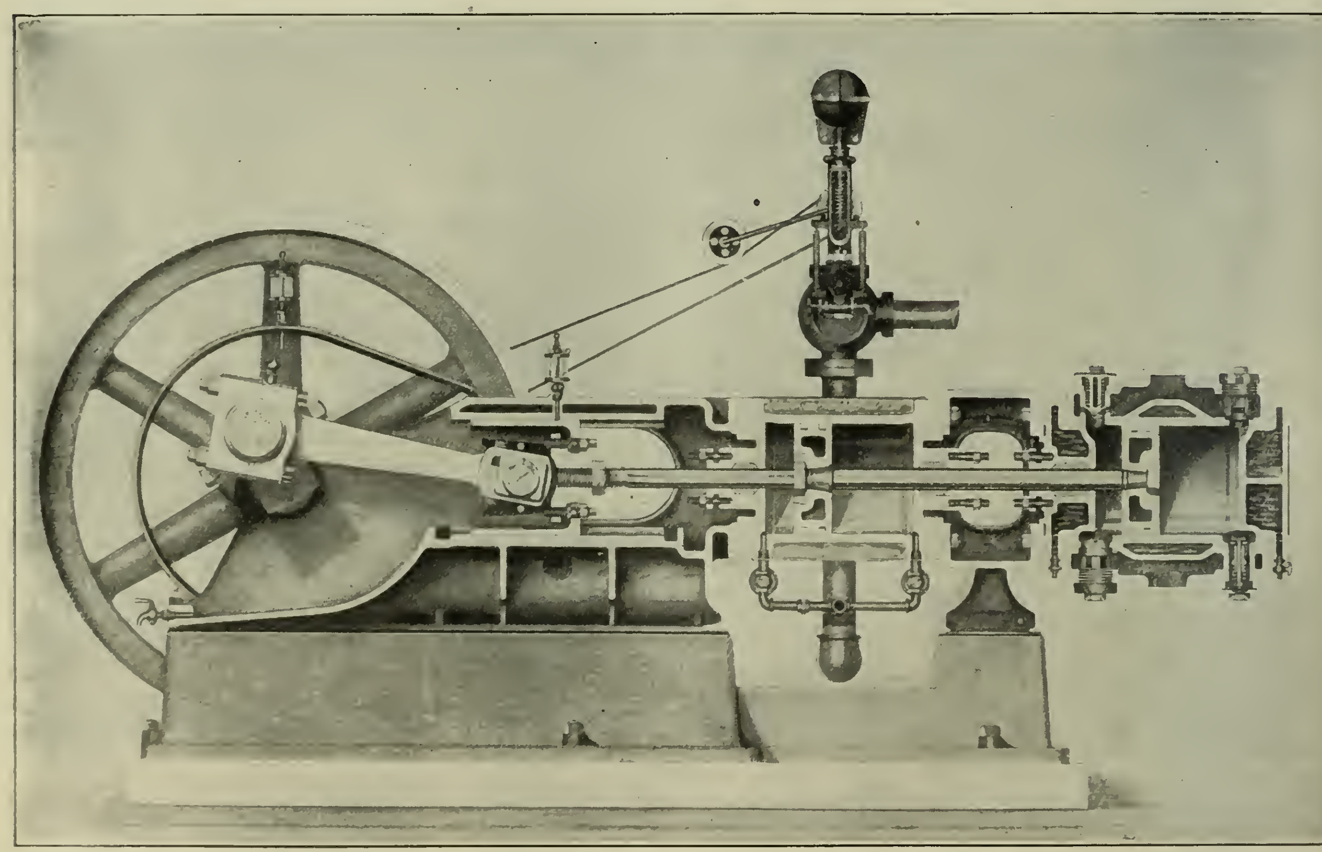
Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

Dallett Air Compressor

The air compressor shown in sectional view herewith is built by the Thomas H. Dallett Company, York and Twenty-third streets, Philadelphia, Penn. This compressor incorporates the essential features of having all parts requiring adjustment or renewals readily accessible, and employing a liberal amount of metal, so placed as to insure rigidity in operation.



SECTIONAL VIEW OF THE DALLETT STEAM-DRIVEN AIR COMPRESSOR

The frame is of the open-fork center-crank type, designed to obtain on each size of compressor a greater range of capacity by substituting, when desired, a cylinder of the next larger size than the standard to operate at 100 pounds pressure.

The main bearings are lined with babbitt metal, which is thoroughly peened in to obviate shrinkage, and then bored and scraped to fit the crankshaft. The duplex-belt, duplex-steam and single-steam machines are supported on deep, rigid subbases, thus making the entire machine self-contained.

The steam cylinder and valve gear of the steam-driven machines are designed to give high efficiency. All steam ports are short and direct, and the clearance has been reduced to a minimum. A plain D balanced slide valve is used on the small and medium-sized machines and the Meyer balanced adjustable cutoff valve on the larger machines. To provide efficient heat insulation, all steam cylinders are lagged with mineral wool and jacketed with sheet steel.

The governor of the steam-driven machine is equipped with a safety-stop device. The governor pulley is situated on the end of the shaft outside of the flywheel on the single-steam machine, thus bringing the flywheel as close to the bearing as possible. Formerly, in the case of duplex compressors with compound steam cylinders, if the machine stopped with the high-pressure side on the dead center, it would not start automatically, due to the fact that the high-pressure side takes steam from the line. This trouble has been overcome by using a reducing valve which reduces the live-steam pressure for use in the low-pressure cylinder. The air and steam cylinders are tied together and held in position by means of an internally flanged tie or distance piece.

Mechanically operated inlet valves are supplied on any size of compressor if desired. These valves are ground to gage and the valve holes lapped to size.

The air-intake and discharge valves are special features of these compressors. The intake valve is of the automatic poppet type, contained in a malleable-iron cage. The cage is one piece, and combines both seat for the valve and guide for the valve stem. The cage is threaded and screws into the wall of the air-intake chamber only, and is simply seated in a recess on the main cylinder wall, using thin corrugated-copper gaskets to secure a tight joint. A hexagonal recess has been cast in all cages to accommodate a special cast-steel wrench for use in removing and replacing valve cages.

The valve-cage cap acts as a locknut for holding the cage in place after it has been screwed down on its seat in the cylinder. It is provided with a hexagonal projection, and the same wrench can be used here as on the valve cage. In the case of compound machines corrugated-copper gaskets are placed under the valve-cage caps on the high-pressure cylinder to insure against leakage, as the discharge pressure from the low-pressure cylinder is constantly at these joints.

The valve proper is of a special alloy hardened steel, with seat and stem ground to gage. The valve spring is of phosphor bronze and of the right proportion to give the valve an easy opening and a quick closure.

The spring holder on the valve comprises a split taper ring set in a recess on the valve stem and held tight to the stem by means of a solid taper ring slipping down over it. The hammering of the valve on its seat tends to tighten the spring holder on the stem instead of driving it off, due to the action of the taper.

The discharge valve is of the automatic poppet type contained in a valve cage of malleable iron. The method of seating in the cylinder and locking in its seat is identical with that of the intake valve. A projection or boss has been provided on the valve cap which acts as a positive stop for the valve when it has reached a lift giving a full-opening area and does away with fluttering. This same projection on the cap also acts as a spring guide for the valve spring.

Both inlet and discharge valves are simple and compact, and each valve requires not over a minute's time for complete removal.

The intercooler has a large cooling area, employing the return-flow type of water circulation, and using baffle plates to deflect the flow of air and aid in its effectual contact with the cooling tubes, which may be removed intact from the intercooler box without disturbing any of the piping, as unions are supplied to obviate this feature. The intercooler is supplied with a pop safety valve, a pressure gage and a drain valve.

Each belt-driven machine is provided with an unloading device which automatically unloads the air cylinder. When a certain determined pressure is reached in the air receiver, one or more inlet valves at both ends of the air cylinder are held open and the load is taken off the compressor, allowing it to run light until the pressure drops in the receiver, upon which the valves are released and air compression is resumed.

On the steam machines, a combined speed and pressure governor is used. This governor unloads the air cylinder exactly as on a belt-driven machine, and at the same time it controls the speed, allowing a single-steam machine to turn just over when unloaded, and bringing a duplex or compound machine to a dead stop. By this means a great saving in steam is effected and the wear and tear on the working parts, as in the case of continuous running machines, is reduced.

These compressors are built from 8-inch stroke up to and including 18-inch stroke and with a capacity range of from 79 cubic feet of free air per minute to 1200 cubic feet.

Inquiries

Questions are not answered unless they are of general interest and are accompanied by the name and address of the inquirer.

Refrigeration Troubles

I wish to make a few changes in the 10-ton ice plant (can system) I run and would like to have your advice about it. The engine is an old-style compound with 12x16-inch cylinders running at from 90 to 100 revolutions per minute and exhausting into a condenser with a relief valve set at 15 pounds. When we are running more than half the exhaust blows out at the relief. The circulating water for the condenser is the overflow from the ammonia condenser flowing through by gravity. Now what I wish to do is to take the old piston out of the engine and get a new one, throw the old condenser away and put in a surface condenser, and put an oil filter between the condenser and the reboiler.

I think we can cut the coal bill enough to pay for making the changes in one season. The boiler is a horizontal tubular, 66 inches in diameter by 18 feet long, with 58 four-inch tubes, carrying 95 pounds pressure. We burn from 100 to 125 tons of coal a month. I think we burn too much coal for the amount of ice we make and the only way to cut expenses is to cut down the amount of steam the engine uses. And another thing, when we are running we cannot blow the whistle or let the safety valve blow for fear of knocking the cylinder head out. The main steam pipe and safety valve are connected to the highest point on the boiler. The engine lifts the water so you cannot tell how much you have in the boiler. If you are running with two gages in the glass and shut down, from three out of four the water will disappear from the glass. Please let me know what you think about it.

W. M. J.

From your description of the conditions existing in your plant we think that your equipment must be suffering from a complication of diseases.

We assume in consideration of what you say that the whole of the 100 to 125 tons of coal consumed per month is burned for generating steam for the ice plant only. If so, it is too much. A 10-ton plant producing 400 tons of ice per month should certainly not require over 75 tons of good coal at the outside and not over 100 tons of poor coal.

If you have steam blowing away through the back-pressure valve it certainly indicates that more water is being evaporated than is required for the ice plant. But safety and back-pressure valves are very deceptive pieces of mechanism, however, and it is almost impossible to gain any idea of the amount of steam escaping by observation alone. Try slowing down your engine until no steam passes the back-pressure valve, keeping the other conditions as nearly constant as possible. This will give you an idea of the amount of steam going to waste, since the total steam will be proportional to the original speed in revolutions per minute and the steam that the condenser will take after will be proportional to the number of revolutions per minute made by the machine after slowing down. The difference in speed in revolutions per minute divided by the original revolutions per minute will give the per cent. decrease in speed which will also be the per cent. of the total steam generated which is being lost through the back-pressure valve.

There would be no advantage in using an engine of so high an efficiency that the steam used would not supply the ice cans with water, and we do not think that it would pay to run a 10-ton plant condensing. If, however, you can improve the efficiency of your steam-consuming apparatus to such a point that it will supply only enough steam to supply the required amount of distilled water without running condensing, it should be done.

We think there is a possibility that your boiler is not evaporating as much water as it should per pound of coal. There must be reasons for your trouble with boilers other than that of the large amount of steam required.

Make sure that the tubes are not getting scaled badly. If that is not the case we would be inclined to think that there is insufficient draft or deficiency of air space through the grates. You should carefully inspect the settings and see that they are as nearly air-tight as they can be made. See that there is no short-circuit which allows the fire gases to pass directly from the combustion chamber to the stack without coming in contact with all of the boiler-heating surface.

It would be interesting to test the strength of your draft by means of a homemade gage made up out of two pieces of glass pipe and a rubber tube. It would also be interesting to determine the combustion conditions at the boiler. [illegible] per pound of coal.

Hoboken N. A. S. E. Entertainment

The seventh annual entertainment and reception of Hoboken Association No. 5, N. A. S. E., Hoboken, N. J., took place at Odd Fellows' hall on Tuesday evening, February 9. The attendance was larger than ever before. A top-notch entertainment was given, after which the floor was cleared for dancing, and in spite of the crowded condition of the hall, an enjoyable time was had. The committee of arrangements comprised W. J. Reynolds, James J. Dustin, Adolph Comens, John Platt and Henry Downes.

Newark Association Entertainment

The twenty-fourth annual entertainment and reception of Newark Association No. 3, N. A. S. E., Newark, N. J., was held on Friday evening, February 12, at the New Auditorium. The occasion attracted a large attendance, there being more than 1200 persons present, including many prominent supplymen and engineers. An entertainment of unusual excellence was followed by dancing. The address of welcome was made by A. B. Penny. Great credit is due the hustling committee.

On Saturday evening, February 6, at the Waverly hotel, Lowell, Mass., the Southwick Textile Club of the Lowell Textile School held its eighth annual meeting, at which Charles B. Burleigh gave an address on the equipment of textile mills with electric drives and the use of the steam turbine in connection therewith. The address was one of the best ever delivered before the club and Mr. Burleigh was given a vote of thanks.

Business Items

Orders received during January for "Swartwout" steam specialties made by the Ohio Blower Company, Cleveland, Ohio, include 9 steam separators, 2 oil separators and 10 cast-iron exhaust heads.

The Russell Engine Company, of Massillon, Ohio, is installing a 450-horsepower four-valve semi-Corliss engine for Samuel Bacon's Sons Company, Laurel, Del. Also a 300-horsepower tandem compound four-valve semi-Corliss engine for the Laurel Electric Light and Power Company, Laurel, Del.

A free sample of Ames alloy high-pressure sheet packing is being sent to engineers who apply for it by the U. S. Indestructible Gasket Company, 16 South William street, New York. This packing is made of a special composition and has been tested up to 6000 pounds, making it suitable for the highest pressure and for hydraulic work.

The Hoopeston Gas and Electric Company, Hoopeston, Ill., has placed an order with the Minneapolis Steel and Machinery Company for a 100-horsepower Muenzel producer-gas engine. They already have a 280-horsepower Muenzel producer plant and the small engine will be run on the light loads. In this way they will be able to run the entire plant more economically.

B. M. Knobel, who recently severed his connection with the Crandall Packing Company, has organized the Triumph Engineering and Supply Company, with headquarters at 253 La Salle street, Chicago. Here will be carried a complete line of rubber goods, packings, mats, etc. Also the "Cassco" bar metallic packing. Mr. Knobel has been prominent in steam-engineering circles in Chicago and throughout the middle West.

The G. M. Davis Regulator Company reports a recent shipment to the General Fire Extinguisher Company, of Providence, R. I., of a 30-inch pressure reducing valve to reduce pressure of 75 pounds down to 30 pounds. This valve is designed to pass twenty million gallons of water per day. The shipment weighed three tons and it is considered to be the largest pressure-reducing valve ever constructed in this country. The company also reports the receipt of an order for a 30-inch combination atmospheric relief and back-pressure valve to be used on a 5000-kilowatt Curtis turbine being installed in the 59th street station of the Interborough Rapid Transit Company, New York City. This company has nineteen 30-inch Davis relief valves installed in this plant.

New Equipment

The city of Anadarko, Okla., has voted $14,000 bonds for improvements to electric plant.

H. J. Kunkle, Wataga, Ill., has been granted franchise to construct an electric-light plant.

The Roosevelt (L. I.) Water, Light and Power Company has bought site for a pumping station.

An addition will be built to the power house of the municipal electric-light plant at Nashville, Tenn.

A municipal heating and lighting plant is to be erected in Albion, Neb. R. T. Flotres is city clerk.

The Gloucester (Mass.) Cold Storage and Warehouse Company will erect an additional cold storage warehouse.

The town council, Faundsale, Ala., contemplates installing water-works and electric lights. S. Stollenwerck, town clerk.

It is reported that about $35,000 will be spent in improvements at the water-works and electric-light plant at Opelousas, La.

The Carthage (Tex.) Ice and Electric Company has been incorporated with $20,000 capital by J. C. Whitney, M. E. Pittman and J. G. Woolworth.

The Syracuse (N. Y.) Cold Storage Company will erect a seven-story warehouse, an ice factory and five refrigerating stores at a cost of about $275,000.

The Peoples Ice Company, Wichita Falls, Tex., recently incorporated, will establish ice plant of 45 tons daily capacity. P. Marcus, president.

The Toronto (Ont.) asylum will install four new hot-water boilers, feed-water heaters, pipe, etc. W. D. Medcalf, inspector of boilers, should be addressed.

The Metropolitan Electric Company, Reading, Penn., will erect a new power house and transmission and distribution system at a cost of about $1,500,000.

It is stated that improvements will be made at the water works at Alton, Ill., including the installation of a new pump with a daily capacity of 6,000,000 gallons.

The Ft. Wayne & Wabash Valley Traction Company will remodel its power house at Lafayette, Ind. It is said between $100,000 and $200,000 will be expended.

The Board of Public Service, Cincinnati, Ohio, has been requested to have plans prepared for a new electric-light plant and a refrigerating plant for the city infirmary.

The Great Western Power Company has taken out a permit for the construction of a $50,000 building at Oakland, Cal., to be used as an auxiliary electric generating plant.

The Electric Generating Company, Fredericksburg, Va., has been incorporated with $100,000 capital. Will erect plant. R. M. Vandom, Exchange hotel, Fredericksburg, is engineer in charge.

New Catalogs

Locke Regulator Company, Salem, Mass. Catalog R. Locke engine-stop and speed limit system. Illustrated, 46 pages, 6x9 inches.

Philadelphia Lubricator and Manufacturing Company, The Bourse, Philadelphia, Penn. Pamphlet. The Lubrication of Machinery Bearings. 16 pages, 5½x8 inches.

Alberger Condenser Company, 95 Liberty street, New York. Catalog No. 11. Wainwright expansion joints, anchors and guides, heaters. Illustrated, 12 pages, 6x9 inches.

D'Olier Engineering Company, 119 South Eleventh street, Philadelphia, Penn. Leaflet No. 10. Steam turbines. Illustrated, 4 pages, 6x9 inches. Bulletin, Series T. No. 9. Horizontal centrifugal pumps. Illustrated, 8 pages, 6½x10 inches.

The Snee Wave Motor and Its Possibilities

A New and Apparently Overestimated Turbine Construction Designed to Utilize the Energy of Ocean Waves and Currents to Develop Power

BY FRANKLIN VAN WINKLE

Windmills and water wheels were undoubtedly the first forms of prime mover devised for the development of inanimate power, and it is not surprising that the restlessness of the seas should have suggested to ambitious inventors the possibilities of developing vast amounts of energy from the motion of the currents and waves of the ocean.

The appearance of ocean waves and the havoc wrought by their incessant action in time of storm give rise to distorted impressions of their motions and local development of energy. When the eye follows the crest of a wave as it moves over the surface of a body of water, the impression is created that the whole body of water is in rapid horizontal motion. In reality there is little more than progressive vertical displacement which is almost exclusively confined to a local rising and falling of the general surface. Floating objects, unless driven by action of winds or currents, are carried up and down nearly vertically over the same spot excepting for a small oscillation backward and forward, which occurs as the wave is passing.

FIG. 1. SNEE WAVE MOTOR BEING INSTALLED AT [illegible]

The action of surf in breaking over a beach leads many observers to believe that waves consist of an actual flow of the sea shoreward, when in fact the curling and breaking of surf are caused by the final falling down of the unsupported crest of a wave, which in falling and spreading out is rolled over and thrown up as surf by the return of waters from preceding waves that have been spread out on the beach.

Very few of the projects for utilization of wave power have attained importance beyond the experimental stage, because it has soon become apparent to experimenters that, in order to concentrate any considerable amount of energy from power of waves, extensive mechanical installations are necessary, to say nothing of difficulties attending construction and maintenance, and the uncertainty of source of energy and great cost of installation for a given output, as compared with that required for other methods of generating power.

Most of the schemes proposed for utilization of wave power were designed to take advantage of energy created only by the rise and fall of the waves, in which respect they appear to be rational. Some others have been proposed for utilizing the energy of [illegible] currents, oscillations and vertical movements of water, which according to [illegible] are supposed to be [illegible] through [illegible] of wave motion, and very few of the [illegible] of wave motors of this kind appear from their designs to take into account the fact that in order to gather energy from the movements of water, it is necessary both to arrest the motion of the water, and for continuous development of energy, the water so confined must be got out of the way of succeeding volumes of water.

A new form of wave motor has been widely advertised of late by the Snee Universal Wave Motor Company [illegible] that company. It is claimed for this motor that it will utilize the energy of ocean waves or currents, as well as that of channel and river currents, and "will revolutionize the power development of the world."

Atlantic City Plant

Two wave motors of the company are being installed at Young's new million-dollar pier, Atlantic City, N. J., for the alleged purpose of generating electric current for supplying light, heat and power. As shown in Fig. 1, the plant is being located adjacent to the pier and about 1150 feet seaward from the boardwalk. One of the motors is shown in Fig. 2. It is 14 feet high, 11 feet in diameter over all and weighs 61 tons, the inside revolving section weighing 16½ tons.

From its general appearance the motor might be taken for an elongated turbine. The main working parts of each motor consist of a vertical-shaft water wheel or runner revolving within a circular framework or cage, the latter formed of vertical parallel guide blades, a feature common to all types of inward-flow pressure turbine.

Fig. 3, which is a photograph taken of a small model exhibited at the Snee company's office, 1278 Broadway, New York City, shows the runner or wheel proper, partly removed from the cage or casing of guide blades. In Fig. 2 it will be noticed that the wheels under construction at Atlantic City have their exterior casings supported by two 24-inch I-beams, to which are bolted six steel heads, each 2½ inches in thickness and weighing 4700 pounds. Between these the outside guide blades or deflectors, made of 9/16-inch steel plate, are riveted in tiers, the hight of blade being 30 inches in each tier. The interior revolving part or wheel is to be mounted on a hollow steel shaft and hung from roller bearings, with the bottom of the shaft retained by a compartment filled with oil which is expected to rise in the hollow shaft to a hight sufficient to counterbalance the head of water on the outside. It is proposed to cover the two upright I-beam supports with concrete, and to secure the motors to a foundation resting on nine concrete piles, each containing 1050 barrels of cement and reinforced with steel rails. In addition to this piling, three steel reinforced concrete floors, weighing more than 100 tons each are introduced, making the structure a rigid mass of concrete and steel weighing over 500 tons. Constructed in this manner, it is expected that the action of salt water will not affect the supports of the motors.

Fig. 4, a top view of the motor, shows a brake wheel, by means of which it is expected to shut down on the motor when occasion demands. It is proposed to gear electric generators directly to the shafts of each wheel and operate a storage battery in conjunction with the generating plant, the battery to carry the load between the periods of power supply by the wave motors. It is reported that the exact arrangement and connection of the generators have not been definitely determined.

It is also proposed to install on the top of the foundation wind-driven wheels of the same design as the water wheels and measuring 28 feet in diameter by 50 feet high. This, of course, will increase the cost of the plant, but it is expected that by placing reliance on both wind and wave both motors will not be idle together for any considerable length of time.

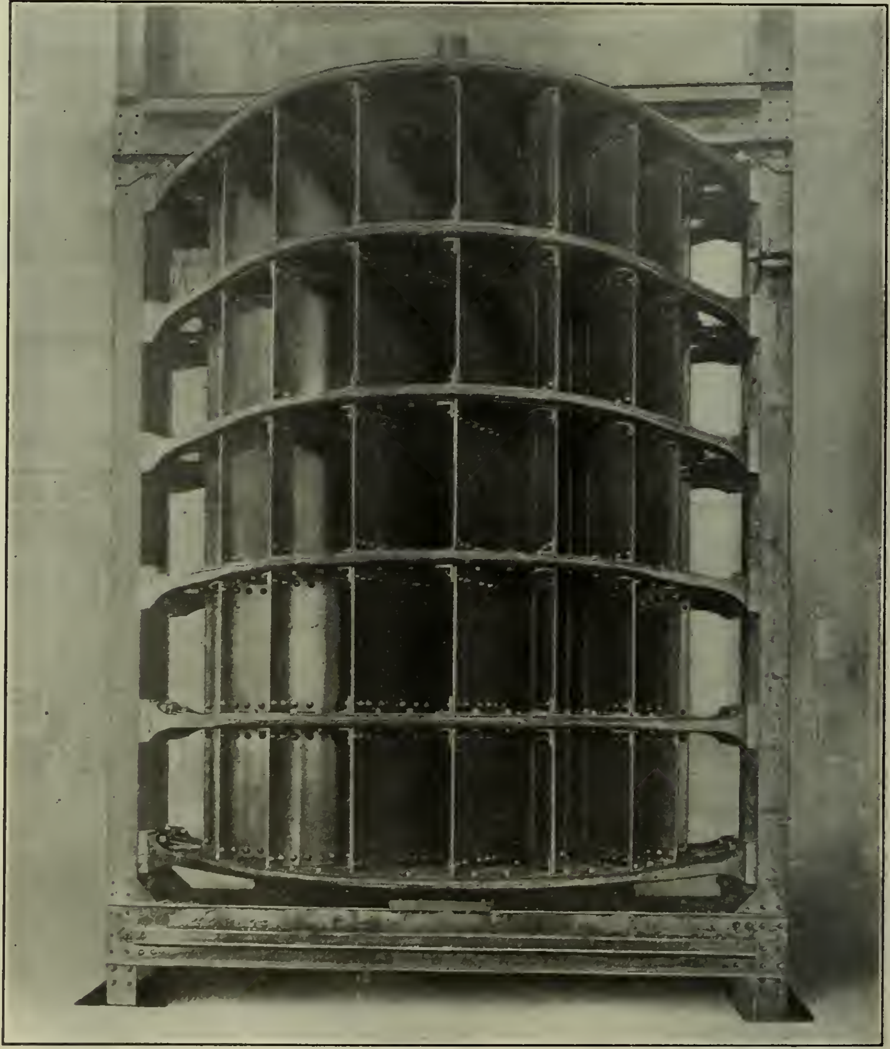


FIG. 2. SUPPORTING STRUCTURE AND ARRANGEMENT OF GUIDE VANES

No very definite data are available on the rating of these motors, only that with a current of 30 miles an hour, or 44 feet per second, each motor is expected to develop 2000 horsepower. The cost of the motors and foundation is placed at $100,000, or when figured at the rating given, $25 per horsepower. An average velocity of ocean waves at Atlantic City of 30 miles an hour is, of course far above normal, and even assuming that the whole body of water partakes of the same velocity as the movement of crests of the waves, the power for usual conditions could be only a small fraction of the rating claimed, and would undoubtedly raise the cost of installation per horsepower to such an enormous figure as to limit the use of the motors to their exhibition as novel attractions rather than as efficient and practical machines.

Operation of Motor Analyzed

That a motor of this design, if acted upon by swift currents of air or water, may be capable of developing some power is not to be doubted, for models made of galvanized sheet iron exhibited by the company demonstrate that fact. But the effective energy which motors of a given size and cost may be capable of developing will control their practical usefulness and commercial value. The installation proposed for Atlantic City has been extensively advertised by the projectors and the public is invited to purchase stock of the company upon claims of such extraordinary merit as to elicit an analysis of this wonderful invention.

Fig. 5 illustrates the general arrangement of the guide blades and the runner, shown in horizontal cross-section. In this diagram, A_1, A_2 A_3 A_4 represent the guide blades, *B* the curved buckets of the runner and *R* the radial vanes of the runner. The radial vanes and curved buckets of the runner are of the same general form as the flat, radial vanes and curved buckets of the ordinary horizontal-shaft water wheels, with the difference, however, that both kinds of float are used

FIG. 3. ARRANGEMENT OF BLADING SHOWN IN SMALL MODEL

FIG. 4. BRAKE WHEEL ON TOP OF MOTOR

for the runner of the Snee wheel. Flat radial vanes and semi-cylindrical buckets in pairs, as shown in the diagram, extend the full depth of the runner with parallel edges devoid of forward or backward curvature. The motor is in fact a current wheel intended to operate successfully with the vanes submerged during complete rotation of the wheel.

A striking feature in operation of the models of this motor is the uniformity of the direction of rotation, regardless of the direction of flow of the propelling current, and it is therefore proposed that this motor will be especially valuable for deriving power from waves and tidal currents as well as from river currents which are constant in direction of flow.

It is to be observed that in operation the Snee motor differs from that of the inward-flow turbine in one important particular, viz., that inward-flow vertical-shaft turbines are constructed for discharging the propelling fluid downward through the runner, while for operating the Snee motor the propelling current must enter through guide passages in one side of the motor, engage the buckets as it passes across the guide case and be discharged through other submerged guide passages on the down-stream side of the motor.

Placed in an open current sweeping across the motor, it would appear, as indicated by the arrow-head flow lines of Fig. 5, that not more than one-fourth of the guide passages can possibly be construed as effective in delivering water to the blades of the runner, because entrance through any more of the guide passages would only result in choking off free admission by those passages which are most effective in discharging water upon the runner. Rotation of the runner being in the direction indicated by the arrow *R*, it is to be noted that when the propelling current approaches the motor from the side *T* the effectiveness of water entering a guide passage like *A* will be seriously interfered with in the transfer of its energy to the vanes and buckets which have arrived at *D*, because there is no outlet for discharge of deflected water except by cutting across the path of other vanes, thereby causing a churning action and a breaking up of the solidity of masses of water which are in the wake of such vanes. The energy required to effect this displacement must be reserved out of the initial energy of current which may be presented to the runner, to say nothing of the effect of the breaking up of the solidity of water between vanes which have passed around to positions beyond useful effect from jets or streams impinged upon the runner.

The churning action referred to is somewhat lessened by the backward curvature of the outer ends of the series of curved buckets, but this feature cannot possibly compensate for energy lost in the formation of swirls and eddies between the vanes. While it may be said that energy rejected by the first vane or bucket will then be gathered by vanes on the opposite side, it is readily seen that a very large portion of such residual energy is not thus available for that purpose, and besides, as any energy which may be so available is to be derived only from irregular streams of water flowing at irregular velocities, the gathering of this residual energy is evidently incompatible with a well established principle of turbine water-wheel practice, viz., that in order to realize the best effect, either by impingement or pressure on a vane, there must be a fixed ratio between the velocity of the water and that of the vane. Analysis of this motor under principles of turbine water-wheel practice would, therefore, appear to be entirely out of place.

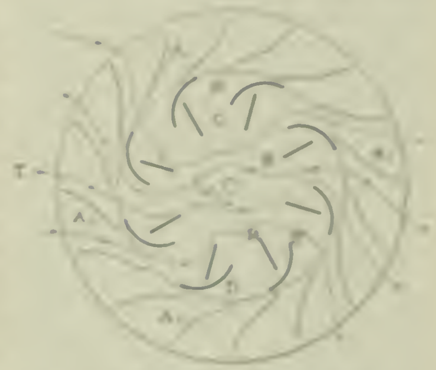


FIG. 5. INSTANTANEOUS FLOW IN THE MOTOR

Assuming the course of the current across the wheel to be constant in direction and velocity, the effective energy transmissible to the vanes and buckets of the runner cannot be construed as equal to the energy derivable from direct action of the main current, because there is counter action of deflected currents. The efficiency of vanes receiving direct and uninterrupted action of currents has been clearly established by Smeaton and other experimenters, and more particularly by Poncelet in testing the efficiency of ordinary current wheels.

In nearly all countries, and for many centuries, crude float wheels, with horizontal axes and driven directly by swift currents of rivers or tides, have been in use for raising water and for other mechanical purposes. Water wheels of that kind were undoubtedly the earliest form of rotary hydraulic motors, see Figs. 6 and 7. Carried on boats moored in a rapid current, they have been quite ex-

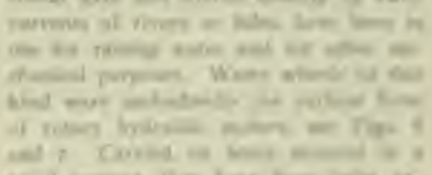


FIG. 6. VERTICAL SECTION [illegible]

tensively used in European countries in driving pumps for small flouring grist mills.

These water wheels are usually provided with flat radial vanes or floats placed around the periphery of the wheel like those of an ordinary steamboat paddle wheel, the floats or paddles being placed apart a distance equal to their radial length, which is usually about one-fourth the greatest radius of the wheel.

It has been demonstrated that for the best effect from these wheels, only so much of the wheel should be lowered down into the water as to insure complete submergence of each float as it passes under the axis of rotation of the wheel. The vanes dip into the unconfined current and receive motion from the passing water, accompanied by a heading-up of the impeded current. Much of the main body of the current passes to either side of the wheel, and in order to receive any energy from that portion of the current which does present itself to the floats, the floats must have less velocity than the current. These wheels cannot, therefore, be made to utilize more than a small proportion of the total energy of a current, and Poncelet found that they could develop only 40 per cent. of the energy of that portion of the current which had cross-sectional area equal to the projected area of one vane.

The maximum energy that can be imparted by a jet to a flat vane, normal to an unimpeded jet or stream of water which is free to glide from the vane, is one-half of the energy of the jet. But in operation of current wheels, such portion of volume of the jet or stream acting on the vanes as may be in excess of the quantity which can follow the vane in its path is impeded in its escape by a surrounding body of water which offers more resistance than if the excess discharged itself into the atmosphere.

Where any considerable amount of power is required, the employment of water wheels of this kind is usually prohibitive on account of the extensiveness of installation necessary for a given capacity, and also their great cost as compared with installation of other forms of prime mover.

The old horizontal float wheels possess the advantage over the Snee motor of retaining the dead water between the floats undisturbed by discharge from the surface of the vanes, and it would therefore seem physically impossible for the Snee motor to realize equal benefit from a given amount of energy of current from the time of its induction upon the runner to the time of its exit from the guide case, even though the directions of discharge chanced in all instances to be favorable to forward propulsion of the runner.

In the Snee motor retarding resistance will be offered by sweeping water between the vanes around the side *C*, Fig. 5, whether the water is thus carried as dead water or is made up of water deflected from vanes, and the proportion of back-water effect thus introduced will be considerably in excess of the proportion of total energy wasted in back-water effect by the old horizontal wheels with flat radial floats, as back-water resistance in the latter is only such as may be due to lifting the vanes gradually out of dead water moving with nearly the same direction and velocity.

The backward curvature of the curved buckets and "ventilation" afforded by the arrangement of curved buckets; as combined in pairs with radial vanes, have the effect of attracting outflow to the side *C*. Though the direction of such outflow may

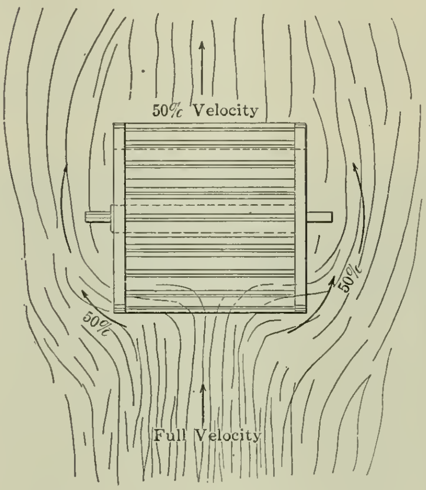


FIG. 7. PLAN OF CRUDE CURRENT WHEEL

chance to be favorable to the direction of rotation of the runner, there must be a sweeping around of dead water immediately in advance of the vanes on the side *C* with the final presentation of a solid body of water to all guide passages at which admission occurs. Neglecting any centrifugal tendency, and assuming that the dead water describes a circular path with half the velocity of current striving for entrance from tangential guide passages, the current cannot enter the space occupied by the runner without being checked in its velocity by the presence of dead water accompanied by a heading up of current which will fall to waste in passing to both sides of the motor. Any water which may enter and pass across the inner compartment has its velocity further reduced by the presence of dead

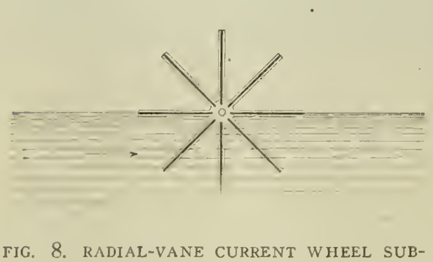


FIG. 8. RADIAL-VANE CURRENT WHEEL SUBMERGED FULL DEPTH

water and is constantly hindered in transfer of energy to the vanes or buckets of the runner by interception of dead water in its course and is halted in its velocity by the increasing presence of dead water. Whether or not it is so intercepted by all the dead water, a considerable amount of the energy so developed under such conditions is absorbed in sweeping dead water around the interior of the guide case.

It would therefore appear that the motor would operate more efficiently if turned on its side, with the axis of rotation horizontal, and were to be charged only with energy of current having a cross-sectional area equal to the projected area of a vane.

The tangential arrangement of guide blades can be considered of advantage only in better directing the current on the vanes of the runner. Their employment results, if anything, in a waste of initial energy of current by changing its direction. The greatest advantage that can be claimed for them is that the gradual reduction of the guide passages results in the reduction of waste of head incidental to changing the direction of current tangential to the path described by the vanes. However, no more energy is recoverable than the tangential deflection is responsible for, and it is extremely doubtful whether the presence of rivet heads and other sources of roughness of the surface of the guide blades can be compensated for in this manner, either when the passages are considered as only mouthpieces for admission of water to the runner or as gradually enlarged ajutages for final discharge of water from the space occupied by the runner.

Probable Efficiency

Whether or not the disadvantages pointed out do attend induction of initial current upon the blades of the runner, the total energy and effectiveness must be materially less than though the wheel were composed only of straight radial vanes extending from the center to the periphery as though the impingement of current were directed upon one-half of the wheel, employed as a horizontal-current wheel, as shown in Fig. 8. In such a case, the energy of current chargeable to the motor would be that portion of the current whose sectional area would be equal to the radius of the wheel, multiplied by its length, and the center of effective pressure would be at the center of the area of the vane. As, for best results, the velocity of the center of the vane should be one-half the velocity of the current, the velocity of the periphery of the runner would have to be equal to the velocity of the current, receiving no energy from the water. The total effective energy would be only one-half as great as though directed on the periphery with appropriate velocity of periphery.

The arrangement of guide passages of the Snee motor can hardly be construed as effecting direct delivery of current on more than one-half the full radial size of the runner wheel, and an estimate of capacity and efficiency based upon that of a current wheel receiving an area of current equal to one-fourth the projected area of the runner wheel and acting on radial vanes of the same area and in the same manner as in crude float wheels would accord to this motor as high power and efficiency as it is capable of developing, if not higher.

Speed of current, diameter, length and weight of runner, depth of submergence, velocity of runner and form and roughness of guide passages, buckets and vanes will all have material influence on the effectiveness of the wheel, but the assumption of maximum capacity and efficiency as given are based on all of these conditions being in most favorable combination.

Possible Power Development

The motors proposed for installation at Atlantic City have runners about 14 feet long and the diameter of the runners would appear from Fig. 4 to be something under 5 feet. Assuming these dimensions for the runners and the effective current area chargeable to the motors to be one-fourth the projected area of the space occupied by the runner, then the sectional area of initial water current operating on one of these motors would be one-fourth of 70, or 17.5 square feet.

Calling f the gross energy capable of being exerted by a current of water expressed in foot pounds per second, then

$$f = A\,v \times W \times \frac{v^2}{2g}, \qquad (1)$$

in which

A = Cross-sectional area of current in square feet,

v = Velocity of current in feet per second,

W = 62½ pounds, being the weight of 1 cubic foot of water, and

g = 32.2, the acceleration of gravity.

Substituting these values equation (1) may be written

$$f = 0.97\,A\,v^3. \qquad (2)$$

From equation (2) it is to be observed that the foot-pounds per second vary directly as the cube of the velocity of current. Substituting for A, equation (2), the quantity 17.5 square feet, the cross-sectional area of effective current assumed for one of the Snee motors gives

$$f = 0.97 \times 17.5 \times v^3 = 16.975\,v^3$$

foot-pounds per second. The gross horsepower of current acting on the motor would be

$$\frac{16.975 \times v^3}{550} = 0.03086 \times v^3$$

gross horsepower in the water.

For reasons which have been pointed out, it would appear impossible for the Snee motor to realize as high per cent. of efficiency as Poncelet found for crude current wheels which, as stated, was found by him to be 40 per cent. The interference and cross-currents encountered by the water in passing through the runner of the Snee motor cannot but detract from the transfer of its energy to the vanes of the runner, and the retarding effect must necessarily place its efficiency below that of the crude current wheels, varying with the velocity of the current presented and the speed of rotation of the runner. But for purposes of commercial comparison of this motor with other methods of generating power, if the same percentage of efficiency is accorded to these motors as ordinary current wheels, viz., 40 per cent., then the net horsepower of one of these motors would be

$$0.40 \times 0.03086 \times v^3 = 0.01234 \times v^3.$$

One of the principal claims for these motors is that they have certainty in developing power from ocean waves. This must be on the assumption that wave motion is accompanied by horizontal flow, i.e., current sweeping through the motor. Should a wave dash upon and spill over the motor it could only result in spasmodic bursts of energy, only momentary in effect and so weak as to be worthless of storage from the time of one wave to another. The horizontal velocity of current incident to wave motion is practically nothing, except in the case of surf waves, and then there is velocity only by the wave falling down and spreading out. If a place can be found for setting up one of these motors where surf waves fall down at all stages of the tide, then the current or spilling-over action of surf waves might be availed of. When it is considered that two surf waves rarely break in the same spot, the impracticability of dependence upon the action of surf waves can be understood.

It is a fact, however, that ocean currents exist and that surface currents are augmented by the travel of crests of waves in the same direction, but there are few, if any, ocean currents which ever attain a velocity of 5 miles per hour, and tidal currents of channels and rivers which empty into the ocean rarely attain that velocity. A velocity of 5 miles per hour would be equal to 7.33 feet per second. If such an ocean current could be found for installation of one of these motors, then its development of power, if accorded 40 per cent. efficiency would be

$$0.01234 \times (7.33)^3 = 4.86 \text{ horsepower.}$$

The U. S. Coast Survey reports the average flood-tide velocity through Hell Gate channel as 4.7 knots per hour and average ebb tide as 4.8 knots per hour. The average of these, 4.75 knots per hour, would be equal to 8.02 feet per second. This channel is about the swiftest tidal water in the vicinity of New York City. If one of the Snee motors of the size of those being installed at Atlantic City were to be placed in Hell Gate channel, then, on the same assumption of 40 per cent. efficiency of current, its power would be

$$0.01234 \times (8.02)^3 = 6.36 \text{ horsepower.}$$

The results to be attained by placing these motors on a beach like that at Atlantic City are hard to conjecture, but the power obtainable can scarcely be assumed as equal to that obtainable in the swift channel of Hell Gate, and this amount certainly would not warrant a very serious investment.

Placing the annual value of a horsepower at $40 and regarding this value per horsepower as worthy of capitalization on a basis of 5 per cent., each horsepower might be regarded as worthy of an investment of $800. Taking for granted that the cost of installation per motor would be only $25,000, i.e., only half as much as quoted for the installation of those at Atlantic City, it can be seen that in order to make a paying investment on the assumed basis of horsepower values, the $25,000 motor plant would have to be capable of developing 31¼ horsepower at $800 per horsepower. In order to develop 31¼ horsepower, the motor would have to be employed in a current of sufficient velocity to fulfil the equation

$$0.01234 \times v^3 = 31\tfrac{1}{4} \text{ horsepower,}$$

i.e., v^3 must equal 2,532.4, showing that a velocity of initial current of 13.6 feet per second would be required. This would be in a current having a speed of from 9 to 10 miles per hour.

Even though such an ocean current were to be found the difficulties of installation would undoubtedly increase the cost far beyond the assumed figure, $25,000. There may be a few isolated locations where river currents attain the maximum velocity of 9 to 10 miles per hour, but the difficulties due to choking up the motor from silt and debris would unquestionably make such installation [illegible] impracticable.

As for the Atlantic City experiment, it will be surprising to learn that it has accomplished anything worthy of consideration [illegible] exhibitional purposes.

Civil Service Examination

The United States Civil Service Commission announces an examination on March 17 at the usual places to secure eligibles to fill a vacancy in the position of mechanical and electrical engineer, $[illegible] per annum, Quartermaster's Department at Large, Fort Bayard, N. M., and similar vacancies as they may occur in any branch of the service.

Applicants who have not had at least two years' practical experience in mechanical and electrical engineering will not be admitted to this examination. Graduates in mechanical or electrical engineering will be considered as equivalent to [illegible] of this period. Applicants should at once apply to the United States Civil Service Commission, Washington, D. C., for application form [illegible].

Central Heating Plant for Lebanon, Ind.

By Byron T. Gifford

The Central Station Engineering Company, of Chicago, Ill., has just completed a central-station hot-water heating system for the Lebanon Heating Company, of Lebanon, Ind. The system covers the best residence district, as well as the business district of the city. Nearly all the mains are located in alleys, which are used wherever practical. In the initial installation, that is, the mains which were laid last year, there are approximately three miles of pipe lines, ranging in size from 12 to 3 inches. The sizes of these mains and laterals were determined by making a careful survey of the territory to be served, and ample capacity has been reserved for future extensions from the original installation.

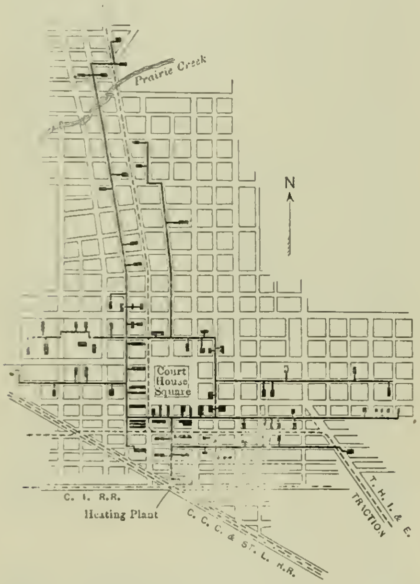


FIG. 2. INITIAL INSTALLATION OF STREET MAINS

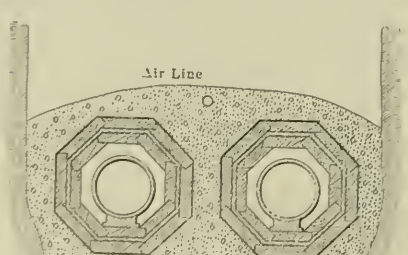


FIG. 3. CROSS-SECTION OF CONDUIT FOR WATER LINE

The pipe line leaving the station is 12 inches in diameter, and continues that size up to the first alley south of the public square; there the line branches two ways with 8-inch pipe which circles the square in the alleys and ties together on the north side, forming a belt which acts as a center of distribution and equalizes the pressure on the lateral lines. Gate valves are placed on all laterals, and also on both sides of the branches in the belt line, in order that any part of the distributing system may be closed off at any time without interfering with the service on the balance of the system.

The system is arranged on the two-pipe pressure-differential plan, and the pipe sizes are based upon a maximum velocity of 5 feet per second. The amount of water to be handled is determined by the number of square feet of radiation to be served, nine pounds per square foot of radiation per hour being the maximum amount used during the coldest weather. The insulation used around the mains is Wyckoff patent steam-pipe covering, which was put in place after the pipes had been tested and made tight under 80 pounds cold-water pressure. After the covering was in place and the joints thoroughly waterproofed with asphaltum, the entire covering was surrounded with from 2 to 3 inches of concrete of 1-2-5 mixture. This was applied comparatively wet and was thoroughly tamped so as to fill completely all spaces around the covering. The concrete envelop acts as a physical protection to the covering, as well as a foundation for the pipe line, and is not considered an insulator.

FIG. 1. STATION OF LEBANON HEATING COMPANY

The air line, which is used as a conductor of compressed air for the operation of the temperature-controlling devices placed on each job, is also embedded in the concrete, as shown in Fig. 3. The expansion joints, shown in Fig. 4, are of the slip-joint type with a brass sleeve sliding into a cast-iron body. These joints have extra-large packing boxes and are of the removable-gland pattern to insure easy access to the joint for the purpose of repacking.

The pipe rests on rollers which travel in metal guide plates, placed approximately 6 feet apart. The anchors, used to hold the pipe in place securely and control their expansion and contraction, are of the beaver-tail type, as shown in Fig. 5. These anchors are placed around the pipe at a coupling in the line, and are embedded there in an enlargement of the concrete envelop. Large roomy double-lidded manholes are built around each set of expansion joints and valves, the extra lid serving as a dirt catcher. The entire line is buried at least 3 feet under the surface of the ground. Detail of the entire line, showing all possible conditions between two anchor points, is shown in Fig. 6. Water leaving the heating station at 200 degrees Fahrenheit will reach a consumer 7/8 of a mile away from the station at 197 degrees Fahrenheit.

Boiler Installation

The station is located at a junction of the Big Four railroad and the Central Indiana railroad, the latter being the direct road from the Indiana coalfields. Coal is unloaded directly in front of the boilers from a side track connecting both of the above-mentioned railroads. The coal goes into a large bin, which is made as nearly dustproof as possible, being lined with paper and built of matched lumber. The boilers in the initial installation are four in number, viz., two 80-horsepower return-tubular boilers, and two 347-horsepower circulating boilers. The steam boilers are used to generate steam for the circulating pumps and other steam-driven apparatus in the station. The circulating boilers, built by the Rust Boiler Company, of Pittsburg, Penn., are composed of three banks of tubes connected to six drums, three at the top and three at the bottom. The circulating water enters the top drum at the rear of the boiler, passing down a bank of tubes to the lower rear drum, then over to the lower middle drum through a row of tubes, rising to the middle drum at the

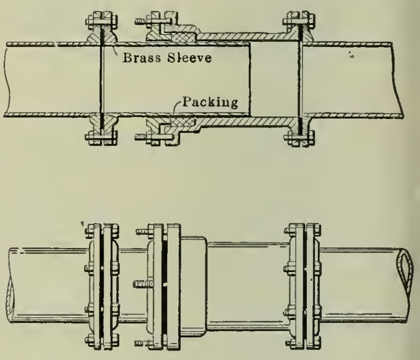


FIG. 4. TYPE OF EXPANSION JOINT IN USE

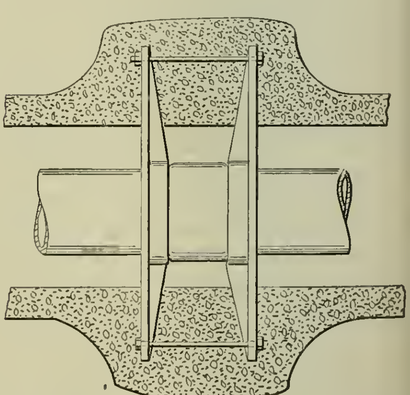


FIG. 5. BEAVER-TAIL ANCHOR

top and passing over to the front drum at the top, then down to the lower drum at the front and from there into the flow main and out into the pipe line. The gases in these boilers pass from the lower front drum to the upper front, down the middle bank of tubes and up the rear bank. With this arrangement the hottest gases come in contact with the hottest water, and the coldest gases with the coldest water. All four boilers are equipped with Green chain-grate stokers. Mechanical draft is used because of the low temperature of the gases under the circulating boilers, which would have necessitated a very high stack had natural draft been used.

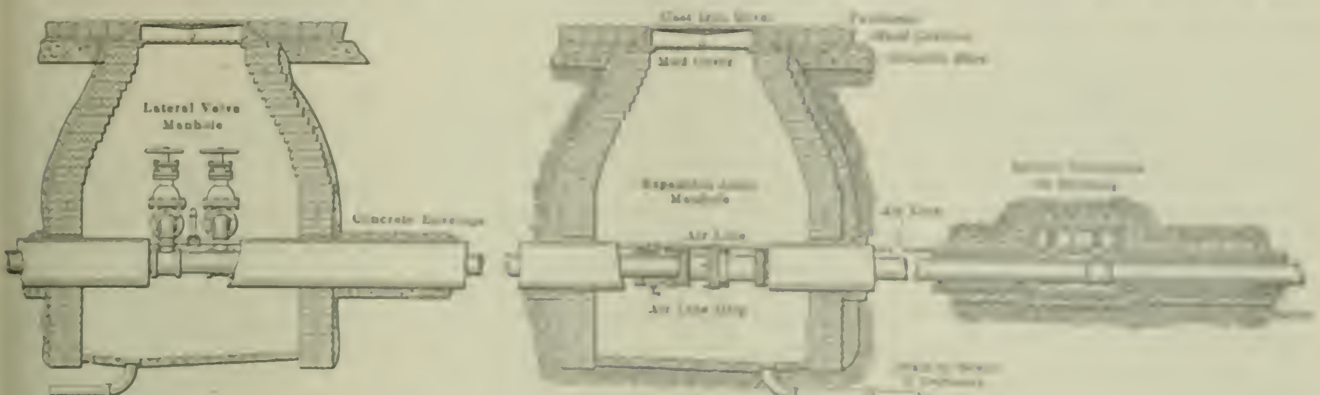


FIG. 6. COMPLETE SECTION OF PIPE LINE BETWEEN ANCHOR POINTS

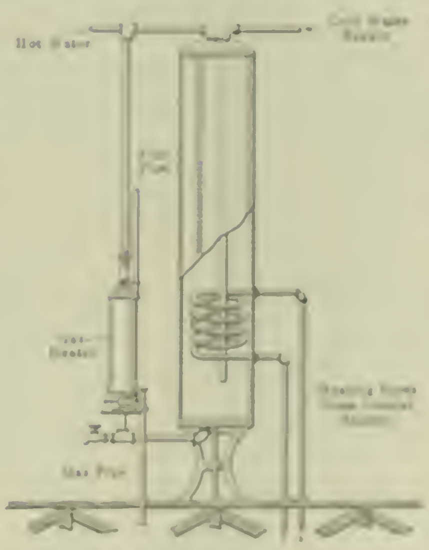


FIG. 7. HEATING WATER FOR DOMESTIC PURPOSES

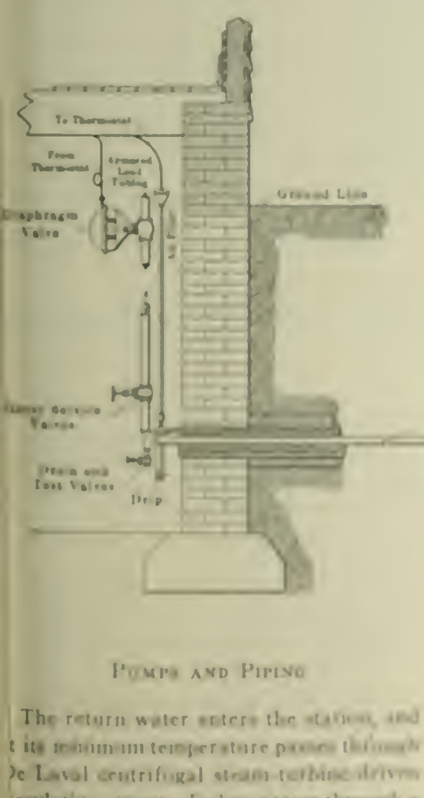



FIG. 8. TYPICAL SERVICE CONNECTION

Pumps and Piping

The return water enters the station, and at its minimum temperature passes through De Laval centrifugal steam-turbine-driven circulating pumps. It then passes through a surface condenser, in which is utilized all of the exhaust steam from the different pumps and other steam apparatus in the station, the condenser being so designed as to pull at least a 1-inch vacuum under all conditions. After the water leaves the condenser it goes to the circulating boilers, and there absorbs the amount of heat necessary to raise the temperature to the schedule then prevailing, before it is again sent around the heating mains. All the necessary auxiliaries, such as boiler feed pumps, low-pressure pumps, governors for the same, condensation pumps, duty well pumps, etc., are installed. A gage board equipped with thermometers, gages, etc., shows at all times just what the entire plant is doing.

At the present time the load connected to the plant is [illegible] square feet of radiation. Of this amount about [illegible] square feet consists of gravity equipment, which was installed in the different buildings before the central plant was built. The balance, or [illegible] square feet, is equipped for central-station heating, with no pipes smaller than 1 inch. The temperature of each building is controlled by a thermostat operated by compressed air supplied from a Westinghouse air compressor at the station. If desired, the company allows circulating water to pass through a coil in a range boiler, as shown in Fig. 7, in which water is heated for bath, lavatory, laundry or kitchen purposes, giving the consumer at all times hot water ranging from [illegible] to [illegible] degrees temperature.

Service Lines

The service lines running from the mains to the different buildings are installed in practically the same way as the mains. Where the service leaves the main, a swing joint is put in to take up the contraction and expansion. A curb box with shutoff valves is placed just inside the curb line or just outside of the property line on each service. The construction and other features are the same as in the mains. A longitudinal cross-section of this is shown in Fig. 8.

Duplicate apparatus consisting of pumps, boilers, [illegible], have been installed and space is provided for future installation in order that there may be no [illegible] of service by power-house equipment [illegible] an uninterrupted period.

Flanged Pipe Joints for High Pressure

Types of Screwed Joint, Peened, Shrunk and Riveted; Variations in the Van Stone or Lap Joint, and the Autogenous Welding of Flanges

BY WILLIAM F. FISCHER

One of the problems confronting the engineer in the installation of a system of high-pressure steam piping for the modern power station is the selection of a flanged pipe joint suitable to the work, pressure carried on the boilers and temperature of the steam if superheated. The failure of a flanged pipe joint, if properly made, is seldom attributed to the steam pressure alone, but can nearly always be traced to other causes such as careless erection, improper support of the piping, valves, fittings, separators, etc., or to the combined stresses caused by expansion, contraction, vibration and water hammer.

Screwed Joints

Although the old-fashioned screwed joint has proved entirely satisfactory in the majority of cases, when used in connection with saturated steam for pressures up to 160 pounds and in many cases even greater with a moderate degree of superheat, it is generally acknowledged, however, that the screwed, shrunk, shrunk and peened, or riveted joints are not altogether suitable for steam mains carrying the high steam pressures of today, or for highly superheated steam, due to the fact that these joints, when strained to any extent, have a tendency to develop a leak through the threads or between the pipe and the flange.

In many cases leakage or failure of a screwed joint when under pressure is due as much to imperfect and careless workmanship in the cutting of the threads and the fitting of the flanges, as to careless erection or poor design of the piping system. It is important that the threads be perfectly cut to standard sizes with tools of the best quality and in good condition. The pipe should be screwed completely through the flange to guard against leakage, and also to make the threads metal-tight against the oxidizing action of leaking steam and water. All grit, dirt, iron chips, etc., should be thoroughly removed from the pipe and flange threads before screwing on the flange, otherwise the friction of the parts may be so great as to prevent the joint being made up steam-tight. Occasionally in the larger sizes the pipe to be threaded is not perfectly round, having been flattened in handling or during transportation, and the threads cut deeper on one side than on the other. In a case of this kind the steam is apt to leak through the threads, no matter how tight the flange.

Several methods have been devised for making screwed joints to guard against leakage through the threads. One method in use is to cut a calking recess in the hub of the flange, as shown at *A* in Fig. 1. The pipe is screwed into the flange steam-tight, and the recess *A* is filled with soft copper which is calked in firmly. All flanges fitted with this recess should be ½ inch higher on the hub than the regular flanges to give sufficient bearing for the threads. The dimensions of the recess, as given in the figure, were furnished by the Crane Company.

Screwed and Peened Joints

Another method is to peen or roll the end of the pipe into a peening recess at the face of the flange, after making the flange up tight on the pipe. Such a joint is shown in Fig. 2. The pipe and flange are carefully threaded, and the pipe is screwed completely through the flange, leaving the end projecting slightly beyond its face. The pipe is then pounded down around its inner circumference with a peening hammer, or is sometimes rolled by special machinery, until the end completely fills the recess *A*, making a steam-tight joint between the pipe and the flange. The pipe is then put into a lathe and the joint faced off true to insure the face of the flange being perpendicular to the axis of the pipe.

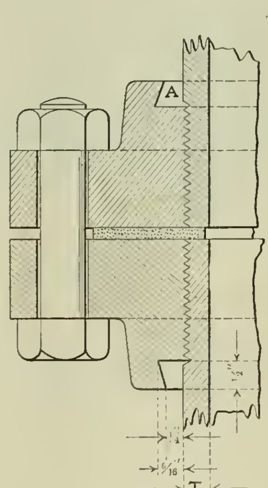


FIG. 1. SCREWED FLANGES WITH CALKING RECESS

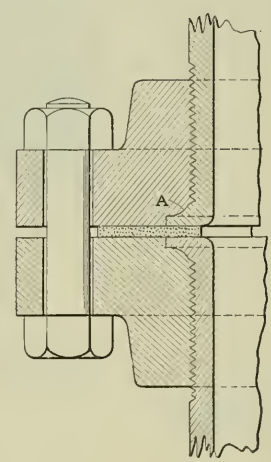


FIG. 2. SCREWED AND PEENED JOINT

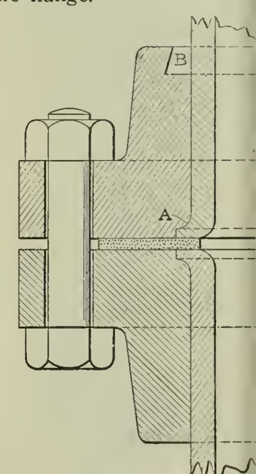


FIG. 3. SHRUNK AN PEENED JOINT

Shrunk, Peened and Riveted Joints

As pipe over 18 inches in diameter cannot be easily threaded, the flanges ar riveted, shrunk, shrunk and peene riveted and peened, or both shrunk an riveted on and then peened, all accordi to the judgment of the engineer. Th also applies to smaller pipe.

Shrunk Joints—In making the shrun joint the flange is accurately bored out t a diameter slightly less than the finishe outside diameter of the pipe. Whe heated to the proper temperature, th flange expands and is forced over the en of the pipe. In cooling, the flange co tracts and hugs the pipe all around i outer circumference with tremendo force. This, however, does not alwa insure a tight joint, and in most cases th outside of the pipe is turned true befo shrinking on the flange.

Shrunk and Peened Joints—An ord nary joint of this type is shown in Fig. The flange is shrunk on the pipe, as prev ously described, leaving a short length pipe projecting beyond the face of t flange. The end of the pipe is th peened or rolled into the recess *A* in manner similar to the screwed and peen joint. If so desired, the joint can also made with a calking recess in the hub the flange, as shown at *B*. Then shou a leak develop between the flange and t pipe, the recess *B* can be calked with so copper, as described for Fig. 1.

Riveted Joints—It is difficult to ma a plain riveted joint that will remain tig for any length of time after it is und pressure, especially where cast-iron flang e used. For work of this kind the nges should preferably be of rolled steel pressed steel. Riveted joints are more ten used for exhaust steam mains in the rger sizes than for high-pressure work. It was a custom among several of the ominent manufacturers, before welding

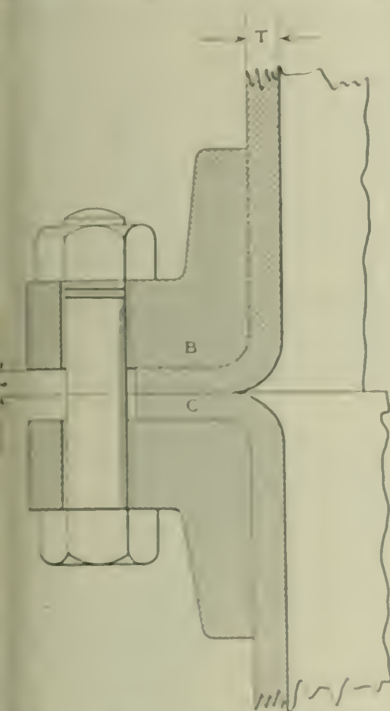


FIG. 4. ORIGINAL VAN STONE JOINT

There are many other joints in use, both in America and Europe, similar in many respects to the above, for which space is not available.

Van Stone or Lap Joints

Since the introduction of superheated steam more attention has been devoted to the details of piping systems. Valves have changed considerably. All cast-iron valves and fittings are rapidly being replaced by those made of cast steel, and in a like manner the joints previously described are being replaced by the Van Stone or lap joint.

Fig. 4 shows the Van Stone joint, of which the Lumsden & Van Stone Company, of Boston, Mass., was the originator. With joints of this type there is no possibility of a leak occurring between the pipe and the flange. In making this joint the flange is bored out to fit loosely over the pipe. The end of the pipe is then heated to the proper temperature and rolled or lapped over the face of the flange, as shown at *B*, the outer edge of the lapped portion coming just inside of the bolt holes. The faces of the laps at *C* are then turned off true in a lathe perpendicular to the axis of the pipe, and the joint is either made up metal to metal by grinding both faces of the lap, thus making a ground joint, or both faces are finished and a suitable gasket placed between them. Any good metallic or vulcanized gasket

finished lap is considerably less than that of the pipe itself. This is illustrated in Fig. 5, which shows a Van Stone joint before and after facing perpendicular to the axis of the pipe. The drawing is exaggerated for clearness. The original thickness of the pipe is shown at *T*, and

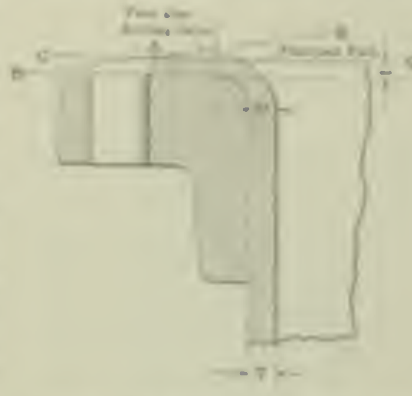


FIG. 5. VAN STONE JOINT BEFORE AND AFTER FACING

the thickness of the lap after facing front and back at *t*. Line *B B*, exaggerated also for clearness, shows the outward bevel of the face of the lap after rolling, due to the gradual thinning down of the metal, from the point *D* to the outer edge of the lap at *A*.

The method of constructing the joints

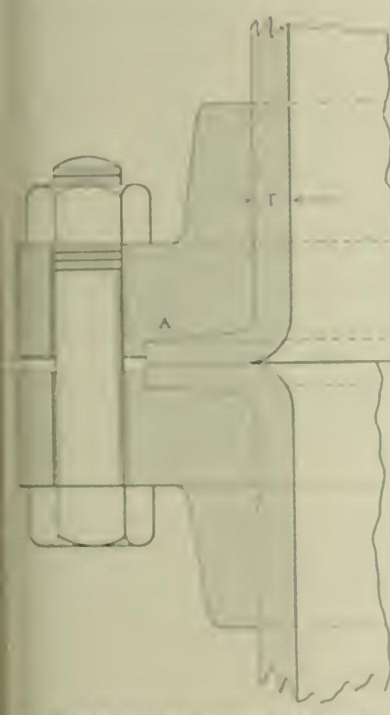


FIG. 6. IMPROVED [illegible] LAP JOINT

FIG. 7. LANGLAP JOINT

FIG. 8. IMPROVED LANGLAP JOINT

came as popular as it is today, to rivet nozzles to openings cut in the side of another pipe, making what is known as the riveted header. These nozzles in most cases are now welded on, making a more efficient joint in all respects for high-pressure work.

suitable for high-pressure superheated steam may be used.

By the ordinary method of flanging or lapping the pipe over the face of the flange the metal is thinned down considerably, so that when faced off front and back, *B* and *C*, the thickness of the

shown in Figs. 6, 7 and 8 is to bevel the face of the flange to the width of the lap to compensate for the difference in the thickness of the pipe between the inside and outside portions of the lap. The outward bevel of the face of the flange is shown at *A*. This brings the face of the joint almost true after rolling, only a light cut over the face being necessary in finishing.

Fig. 6 shows the improved recessed joint made by W. K. Mitchell & Co., of Philadelphia, Penn. The pipe is turned over on the face of the flange to within ¼ inch of the bolt holes. The flange is

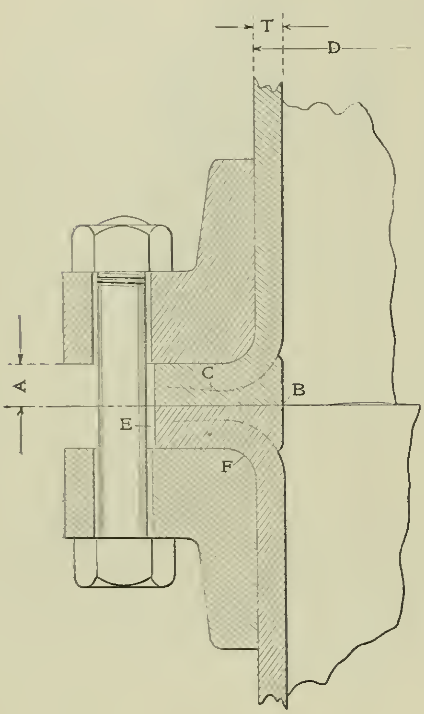


FIG. 9. THE WHITLOCK JOINT

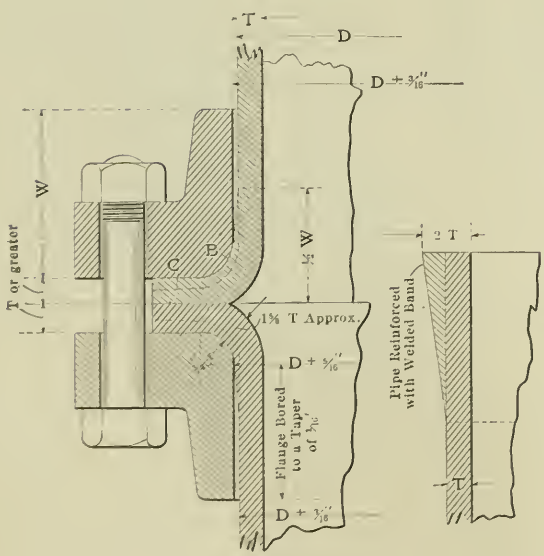


FIG. 10. IMPROVED VAN STONE JOINT

recessed on its face to receive the lapped-over portion of the pipe, but the lap is allowed to extend about 1/32 inch above the face of the flange to give a good bearing for the gasket.

Fig. 7 is the Cranelap joint, and Fig. 8 an improved type of this joint. The improvement consists in upsetting and rolling the joint flat and square at the inside edge, as shown at *B*, giving a much wider bearing for the gasket. These joints are made by the Crane Company, of Chicago.

Fig. 9 shows the Whitlock joint, made by the Whitlock Coil Pipe Company, of Hartford, Conn. This might be called a double-lap joint. In making it the end of the pipe is heated and doubled back on itself, as it were, when rolling or lapping the pipe over the face of the flange. This is shown by the dotted line *C*. The pipe is upset slightly at the inner edge *B* and outer edge *E* to square up the face of the joint before finishing. The joint is then faced off true in a lathe perpendicular to the axis of the pipe. The thickness *A* of the metal after facing is equal to, or greater than, the original thickness of the pipe *T*. This method also gives a wide bearing for the gasket, as shown at *B*, and the pipe is strengthened at the corner *F*, where the lap joins the main body of the pipe.

In Fig. 10 is shown the improved Van Stone joint made by the M. W. Kellogg Company, Jersey City, N. J. After facing, the flange is bored to a taper of 1/16 inch. In the drawing, *D* represents the outside diameter of the pipe, *T* the original thickness of the pipe, and *W* the hight of the flange from the face to the end of the hub. The flange fits loosely over the end of the pipe. In making the joint, the pipe is first reinforced by securely welding a wedge-shaped band on the end of the pipe all around the outer circumfer-

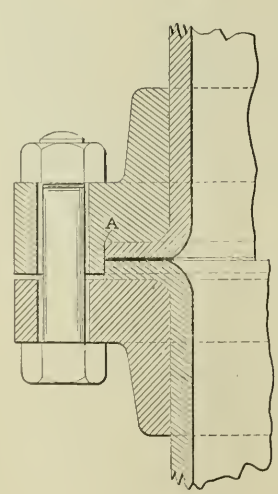


FIG. 11. VAN STONE HYDRAULIC JOINT

ence, doubling the thickness of the pipe at the extreme end. The dotted line *C* shows the position of the band after lapping or rolling the end of the pipe over the face of the flange, and finishing the joint on the front and back. The thickness of the pipe at *B*, where the lap joins the main body of the pipe, is approximately 1⅝ *T* or greater. The thicknes of the lap is equal to or greater than in all cases after finishing.

Fig. 11 shows a Van Stone hydrauli joint, also made by the Kellogg compan The upper flange is recessed at *A*, thu covering the edge of the joint to pr vent the gasket from blowing out at th

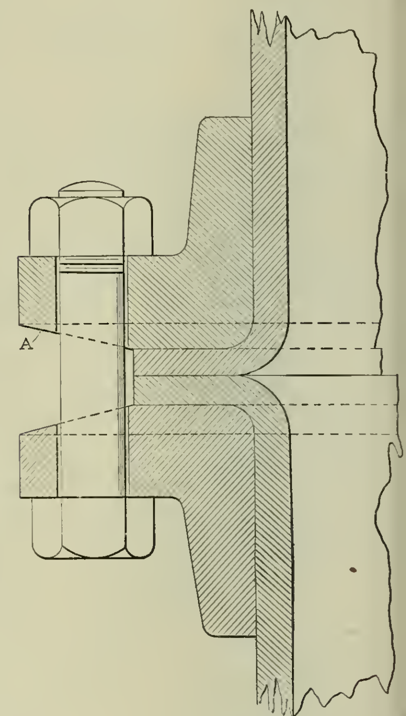


FIG. 12. VAN STONE JOINT WITH BEVEL FLANGES

higher pressures. This recessed flange also used in connection with the in proved Van Stone joint shown in Fig. 1 the joint being the same in all other r spects.

Fig. 12 shows a Van Stone or lapp joint sometimes used in connection wi a flange having the face beveled at making the gasket more accessible for r moving or renewing.

The flanges on the Van Stone join just described are loose and swivel, a fa appreciated by erecting engineers, as becomes necessary at times to change th position of the flanges to bring the bo holes into line when erecting. The flang can be revolved to the desired positio These flanges may be of cast iron, ca steel or rolled steel. The rolled-ste flange is to be preferred where the ext cost is not prohibitive.

Joints of the Van Stone type should faced off on the back of the lap, as we as on the front, in order to insure a tig joint, as scale is formed on the back whe the pipe is put through the process heating and flanging. This scale, unle removed, falls off in spots, leaving a r cess between the pipe and the flange ar allowing the flange to settle uneven against the turned-over portion of th pipe. Although the joint may be tig vhen first erected in the line, in time the cale is likely to crumble and fall away, llowing the flange to settle closer against he back of the lap, which will lessen the ension of the bolts and cause the joint o leak.

Another method has been tried for reinforcing the metal at the face of the ap. It consists in upsetting the end of he pipe before flanging. This does not give the increased thickness and strength t the place where most required; namely, t the corner where the lap joins the main ody of the pipe. It is also known that xcessive upsetting has a tendency to rystalize and consequently weaken the bers of the material.

Van Stone or lapped joints are made sizes from 4 inches up. For smaller izes, as a general rule, the screwed oint is used, and where properly made

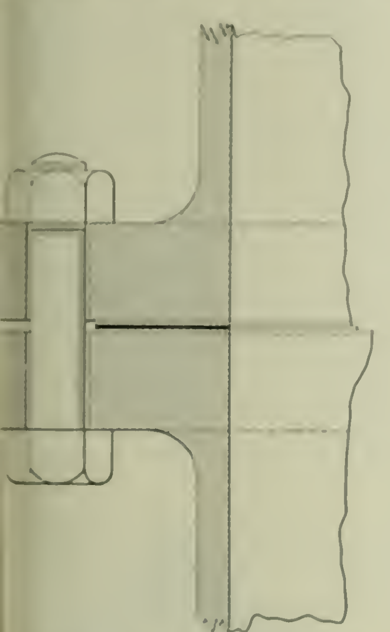


FIG. 13 FLANGE WELDED TO PIPE

ves excellent results. Or, if so desired, e flanges can be welded directly to the pe, both in the small and large sizes.

Welded Flanges

The practice of welding flanges to pipe by no means new, having been accomished satisfactorily in Europe for some years or more, especially in Germany d England. Many firms in America are w doing this work, to meet the ever ineasing demand for a metal-to-metal int of the welded type. The ordinary ethod of welding by mechanical means, ch as hammering or rolling, is not used extensively as in the past, due to the ct that the strength of a weld made in is manner is uncertain. There has retly come into use a system known as togenous welding, in which the metal self is raised to a temperature sufficiently gh to cause it to be its own joining material; that is, the parts to be welded are joined together by the fusion of their own substances without mechanical aid. By this method pipes are welded together, making any required length in one piece, and even separators and other steam appliances are welded up in the same manner, forming a homogeneous mass of uniform quality throughout.

A welded flanged joint is shown in Fig. 13. As will be noted, the flanges do not swivel on the pipe. For this reason the Van Stone joint is often preferred for erection purposes. Fig. 14 illustrates a type of welded joint much used on the Continent and to some extent in America. The flange *B* is either upset or welded to the pipe and beveled off at 45 degrees, as shown at *A*, to match the bevel on the loose-ring flange *C* directly above it. With this arrangement the bolt holes can

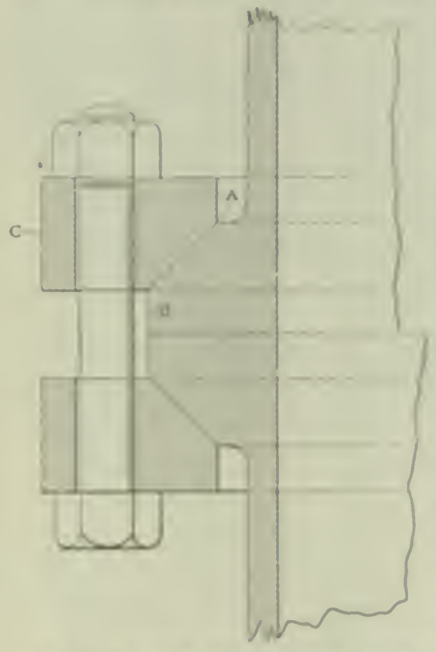


FIG. 14 WELDED OR UPSET ENDS WITH LOOSE TAPERED RING FLANGE

be brought into line when erecting by turning the flange C to the desired position. The welded flanged joint makes the most perfect and workmanlike joint in use at the present time if properly made.

In a number of tests recently made to determine the strength of welded joints, the metal showed an average loss in tensile strength of about 10 per cent. at the weld for equal areas. These welds were made by skilled workmen using modern methods. It is good practice to reinforce the metal at this point to insure the weld being as strong as or stronger than the pipe itself.

The Pennsylvania railroad commission recently issued a circular to every steam railroad company in the State of Pennsylvania which is being done to prevent [illegible] and other accidents to [illegible]

Electrolysis and Superheat

By Thomas Sawyer

I have seen a great deal in the technical press lately about the destruction of condenser tubes, but I have seen nothing at all, so far as I can remember, about the corrosion, erosion or electrolysis of pump cylinders. I was once employed for a long time in a power plant where the eating away of portions of pumps by what looked to me like electrolysis or galvanic action was a matter for serious consideration. Surface condensers with salt-water circulation were used, and every cylinder in which salt water was used suffered. In one cylinder it would be the back head, in another it would be the front head, and in still another it would be the valve deck or some part of the cylinder at or near the end of the brass cylinder lining.

The engineer always claimed that there was from some source an electric current passing into or through the pump to the water, and that where it left the pump for the water it took some of the iron along with it. He searched for "grounds" inside the plant and succeeded in getting all that could be found transferred outside of the system, but that did not appear to help matters much, so he settled down to the practice of keeping circulating-pump parts in stock, ready for instant use whenever a replacement was necessary. He got all sorts of advice from all sources and tried some of the remedies suggested.

One friend told him that the devouring element, whatever it was, was caused by acid in the water and that acid must have something to eat. It ate the cast-iron pump cylinder because that was [illegible] but zinc, being more easily dissolved in acid than iron, if it could be introduced into the water space of the pump, where it would be eaten instead of the higher-priced pump cylinder. This was tried with no change in the rate of decomposition of the pump cylinder that could be noted, and absolutely no effect on the zinc except to brighten the surface slightly where it rubbed on the iron.

There was one pump in the plant where the corrosion was confined to the valve deck, and in a few months the valve seats would become loose and drop out. It was decided to put in a brass cylinder in place of the cast-iron one, it being hoped that the current would not eat brass, and if there were no cast iron for the current to eat it would leave the pump for the water without doing any damage. The life of a cast-iron cylinder had been from a year to [illegible] months. The brass cylinder ran [illegible] three months, when the valve deck began to [illegible] at a rate [illegible] for the iron cylinder in its [illegible]

It seems that the electric current had [illegible] as effective on the brass valve [illegible] and stem that it would not leave for the water without taking along quite a bit of the material with which it had been associating. Here is a photograph (Fig. 1) of a valve stem and also a valve seat, which will give you some idea of how the wasting of the material is going on. It would seem that the outside of the valve stem is softened by the passage of the current, and in its soft state is rapidly worn away by the friction of the rubber valve. At one end there is quite a pit, about ¼ inch deep, and the pit has a copper-colored appearance, as though the zinc had been eaten out of the composition of which the stem is made, leaving the copper to be washed away by the water; from the photograph of the valve seat it can easily be seen how the wasting process has attacked both the face of the seat ring and the radial ribs. These radial ribs were originally about ¼ inch thick. Some of them are wasted away to a knife edge and considerably below the face of the valve seat. On the opposite side of the valve seat the face of the valve is depressed nearly ¼ inch where the rubber valve has worn the top surface material away.

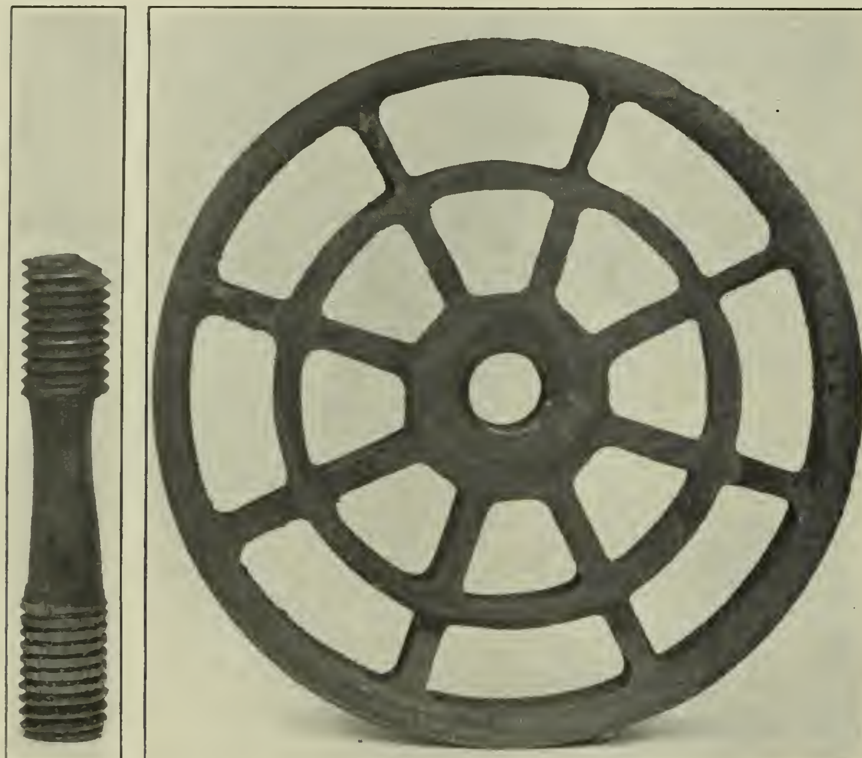


FIG. 1. VALVE STEM AND SEAT, SHOWING THE DEGREE OF WASTING AWAY

This matter is particularly interesting to me because in no other plant that I have visited have I seen the destruction of pump cylinders, valve decks, valve stems, valve seats, etc., carried on to such an extent, and I am at a loss to account for it. At certain portions of the day some sewage which possibly might contain nitrates is carried through the different pumps in the condensing system, but the greater part of the wasting away takes place entirely in this single pump cylinder.

The usual brass valve guards on the upper end of the valve stems are being replaced with cast-iron ones, in the hope that in the escape of the current from the pump to the water it will take iron along instead of brass. These small guards are cheap and if the action can be confined to them it will in a measure solve one engineer's problem. Of course, everyone knows that the proper way to cure any ill is to remove the cause, but in this case it seems that the cause is undiscoverable. It may come from the electric-car line half a mile away, or it may come from some cause in the plant itself. Anyway the problem is an interesting one and I shall watch developments with interest.

FIG. 2. WHAT WAS LEFT OF THE BRONZE VALVE SEAT

At this same plant a change was made from horizontal return-tubular boilers to water-tube boilers with superheaters, and no end of annoyance has followed the change. I know editors say that there is or need be no trouble in using superheated steam if the pipe and fittings used are o the right kind. That may be true as regards pipe and fittings, but we did no learn it soon enough. These boilers were installed under a guarantee to give 100 degrees superheat to the steam whe working at their rated horsepower, which guarantee I think was met, for I found 120 degrees superheat at a turbine throttle 120 feet from the boiler.

An amusing incident occurred one day when I started to take the temperature of the steam. We were using a steam pressure of 115 pounds and as I took the cover from the thermometer well, I looked around for something to clean out what dirt might have got in before the cover was put on. I saw what looked like a short piece of wire lying on a tool box nearby. I took the wire and, winding a little wad of waste around it to catch the dirt, pushed it down into the well. For an instant I thought the well had no bottom, for the wire went right along down When I pulled it out I had only about 2 inches left of what proved to be a piece of 30-ampere fuse wire. The well was nearly full of melted metal in which the thermometer was inserted when the temperature readings were wanted.

But I started to say something about superheat. The boilers and the new pipe line had all been equipped with special superheat valves which were all right until it was desired to close them. The first set was of the automatic nonreturn type. In less than six months they had all failed and were replaced by ordinary heavyweight valves. These answered a little better, but one day there came a glib-tongued salesman, with confidence in his goods written all over his face and showing in every word and action. He had the real superheat-proof valve. It had been discovered, he said, that all the trouble with valves in the use of superheated steam came from the difference of expansion between the cast-iron body and the bronze seats. So the company chemist had set himself the task of creating a bronze for valves and seats which should have the same coefficient of expansion as the cast iron from which the body of the valve was made, and he had succeeded.

And here was a guaranteed valve ready for use in which the bronze parts would always retain their proper relation to the iron body because the bronze parts would always expand and contract with the iron and to the same extent with the same temperature.

No argument nor "jollying" seemed to shake the confidence of this salesman in the quality of his wares and a set of stop valves for the boilers was ordered.

One day not long ago one of the valves was closed, but the closing of the valve did not shut the boiler off and other valves were shut one after another until the faulty valve, the valve with a guarantee of a live salesman and a responsible company behind it, the valve with a new coefficient of expansion, could be examined. It was found to be seatless. Here is a photograph (Fig. 2) of that part of the seat which could be found. The missing segment from the ring must have evaporated in the intense heat of the superheated steam, for no trace of it has been discovered. It will be noticed from the photograph that the seat must have become quite loose in the body of the valve and that it had danced about considerably, wearing away the threads which at first held it in position.

Annual Dinner of the A. I. E. E.

The annual dinner of the American Institute of Electrical Engineers will be held on March 11 at the Hotel Astor, New York City, and will celebrate the completion of the first quarter of a century of the institute's existence. The historical significance of the gathering is receiving special consideration by the committee of arrangements appointed by President Louis A. Ferguson, which consists of T. C. Martin, chairman; G. H. Guy, secretary; T. Beran, M. Coster, M. M. Davis, H. A. Foster, G. A. Hamilton, R. T. Lozier, W. McClellan, F. A. Muschenheim, H. W. Pope, C. W. Price, F. A. Scheffler, E. A. Sperry, A. Spies and A. Williams.

Steam and Electrical Equipment of the Ambrose Channel Lightship

By Warren O. Rogers

When an engineer passes a civil-service examination he is eligible for various engineering positions in the sundry departments of the United States Government. Among these is that of engineer and electrician on board a Government lightship. In order that a clear idea may be obtained as to what type of apparatus comprises the steam and electrical equipment of a modern lightship, a short description of the Ambrose Channel lightship, formerly known as the Sandy Hook lightship, off the entrance to New York harbor, is given herewith.

The new Ambrose channel lightship is equipped with two Scotch boilers having [illegible]

two [illegible] each, one boiler being shown in Fig. 1. These boilers generate steam for the different apparatus throughout the ship which are used for illuminating signal lights, etc. Steam is also used for blowing the huge fog whistle in thick and stormy weather. The coal bunkers are placed along the sides of the ship, and hold a supply sufficient to last from four to five months.

In Fig. 2 is shown a vertical compound engine, with cylinders of [illegible] and [illegible] inches in diameter and a stroke of [illegible] inches. It is direct-connected to a propeller shaft, the propeller being [illegible] feet [illegible] inches in diameter, with a [illegible] pitch. This engine [illegible] will enable the lightship to proceed [illegible] in case it should break away from its moorings [illegible]. The engine runs condensing, as do the auxiliary engines throughout the ship. [illegible] The condensing system is [illegible]

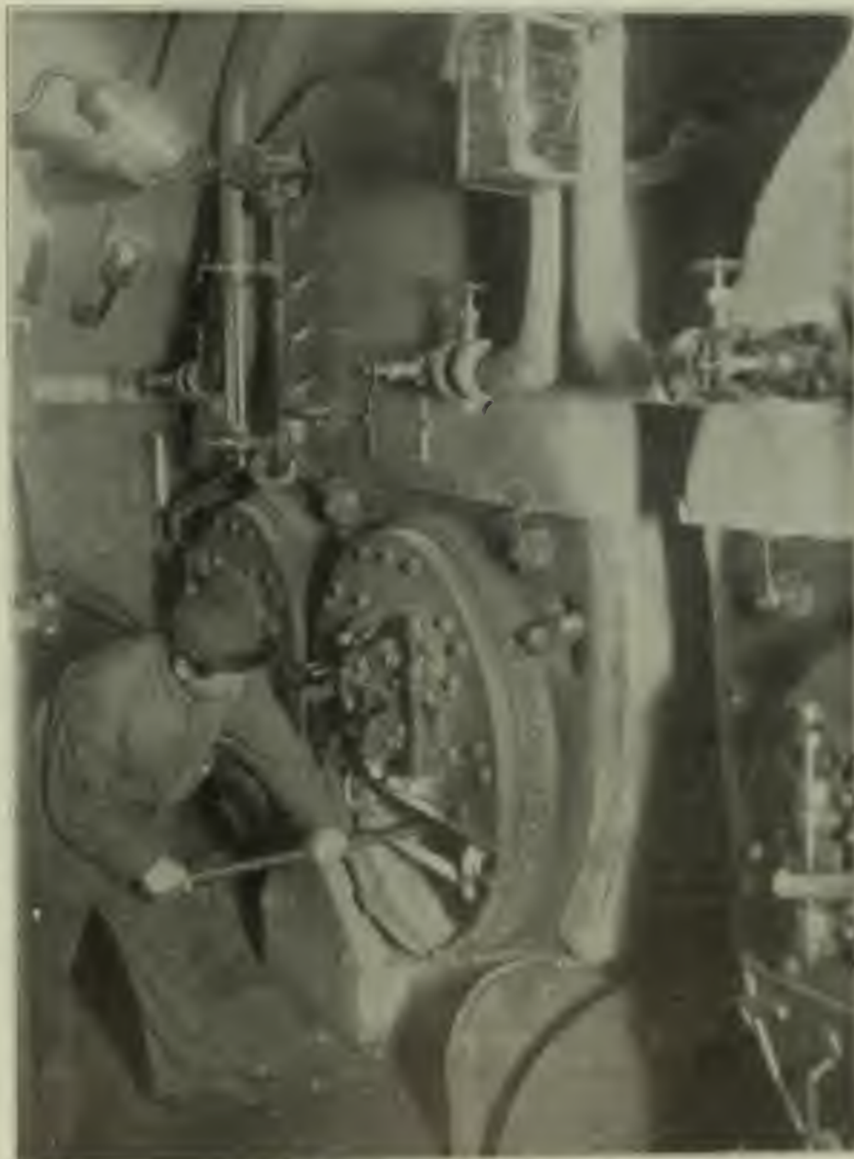


FIG. 1. SCOTCH BOILER [illegible] LIGHTSHIP

is used for all purposes. The ship is equipped with an evaporating and distilling plant with a capacity of 2500 gallons per twenty-four hours.

In Fig. 3 are shown the two generating sets used for illuminating the ship throughout and also the masthead signal lights. The generating units are in duplicate, direct-connected to a marine-type vertical engine and have a capacity of 7 kilowatts. They are of the multipolar type with a working range in electromotive force of from 110 volts no load to 115 volts full load. The armatures are of the iron-clad, bar-wound ventilated type, the cores being built up of thin, double sheet-steel laminations, in the slots of which are carried interchangeable coils separately insulated. The brushes are designed with a means of independent or collective adjustment. The circuit switches feed their respective circuits directly, and connections are made so as to operate all lights from either generator set, or both.

The vessel is wired with a two-wire feed system to which are connected fifty-five 16-candlepower 110-volt incandescent lamps. Each circuit is placed in an iron-pipe conduit with a socket so designed as to make it absolutely steam- and water-tight.

The switchboard shown between the two generator sets controls the entire electric-lighting system of the ship. It will be seen that double-throw switches are arranged so that in case of accident to one generating set, the other can be put into service. The distributing switches are also of the double-throw type and so arranged that different circuits can be carried by one engine, or any combination can be made so that one engine or both engines may be used at once on any or all circuits. The engines operate either condensing or noncondensing.

The masthead signal lights consist of three 250-candlepower 100-volt tungsten lamps suspended 55 feet above the water level. They can be seen in clear weather for 13 miles. These lamps, which are carried on the fore and main masts, are also arranged so that each can be switched onto either generator, which prevents any discontinuance of the light in case of accident to either one of the generating units. In the rear of the switchboard is the device for flashing the masthead lights, by which arrangement the lights are flashed for a certain interval and then remain dark for a certain interval, the current being automatically cut in and out. This timing device can be changed so that the period of lighting and the period of lamp extinction can be varied to suit any desired timing.

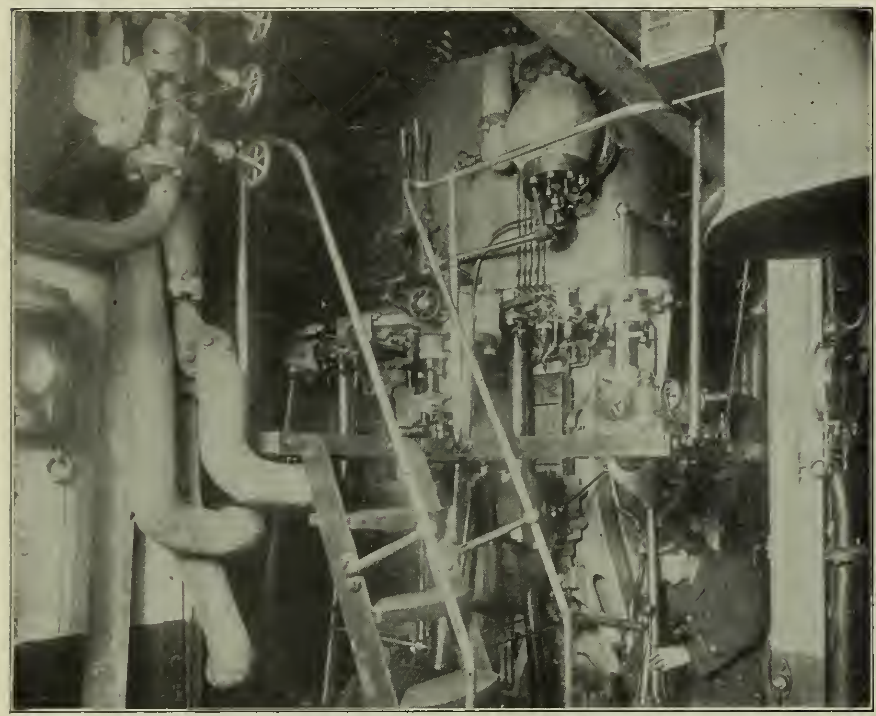


FIG. 2. VERTICAL COMPOUND ENGINE ON LIGHTSHIP

In Fig. 4 is shown a section of the upper-deck engine room which is directly over the grating of the main engine. In the corner shown will be seen a boiler-feed pump and also a small vertical engine used when operating the large fog whistle. This whistle obtains steam from a 4x12-foot wrought-iron steam drum which is connected to the boilers by short pipe connections. The steam drum was found to be necessary in order to get dry steam, as without it water would be drawn from the boilers. The whistle is so arranged that it blows for a definite period and then is silent for a definite period. The whistle blast is timed by means of blocks, the blast of the whistle representing the time it requires for the whistle lever to pass over a block and drop to its lowest position, when the whistle remains silent. When the whistle lever is again lifted by a block, its motion opens the valve in the whistle pipe and the whistle blows until the lever reaches the end of the block and drops to its lowest position again. These blocks are placed in a revolving plate and can be spaced as desired.

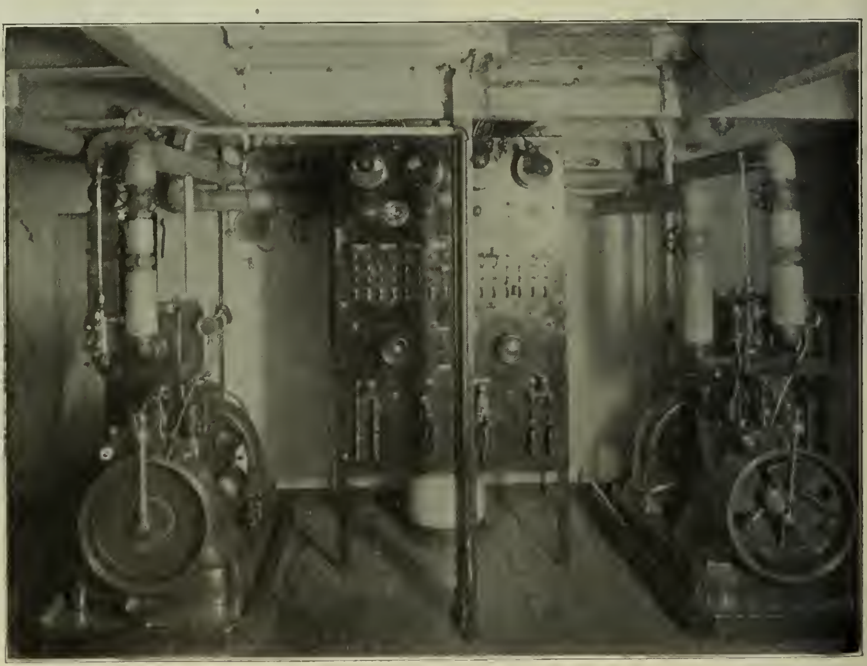


FIG. 3. GENERATING SETS ON LIGHTSHIP

On the other side of this upper-deck engine room is arranged a small vertical engine direct-connected to an air compressor. This air compressor furnishes air to the deep-sea bell of the same type which figured as an important factor in the recent collision of the steamships

"Republic" and "Florida," the bell being the means of guiding the rescuing steamship to the disabled steamer.

The operation of this bell is as follows: The bell, connected to a water-tight casing at the top, in which is a diaphragm, is suspended over the side of the ship and submerged in the water. To the top of the bell containing the diaphragm are connected two rubber pipes, which are in turn attached to the receiver of the air compressor. This bell is arranged to operate automatically by a timing device striking the number of the ship, which in this case is 22. As the air is admitted to the diaphragm and released it operates the bell clapper, which, striking the bell, sends its tone through the water for about 10 miles in all directions from the ship. The officers of a ship within that zone, if equipped with a receiving apparatus, are enabled to estimate the distance they may be from the lightship. There are usually two receivers on ships equipped with this device, and in order to determine the exact position of the warning signal, the ear is applied first to one and then the other, the one giving out the loudest tone indicating upon which side of the ship the lightship is located. In this way, the officers are enabled to determine their exact position.

The Ambrose channel lightship is said to be the best equipped lightship in the world, modern in every particular and built to withstand the heaviest sea. The writer is indebted to A. B. [illegible], superintendent of the lighthouse department, Tompkinsville, S. I., for data, etc., pertaining to this lightship.

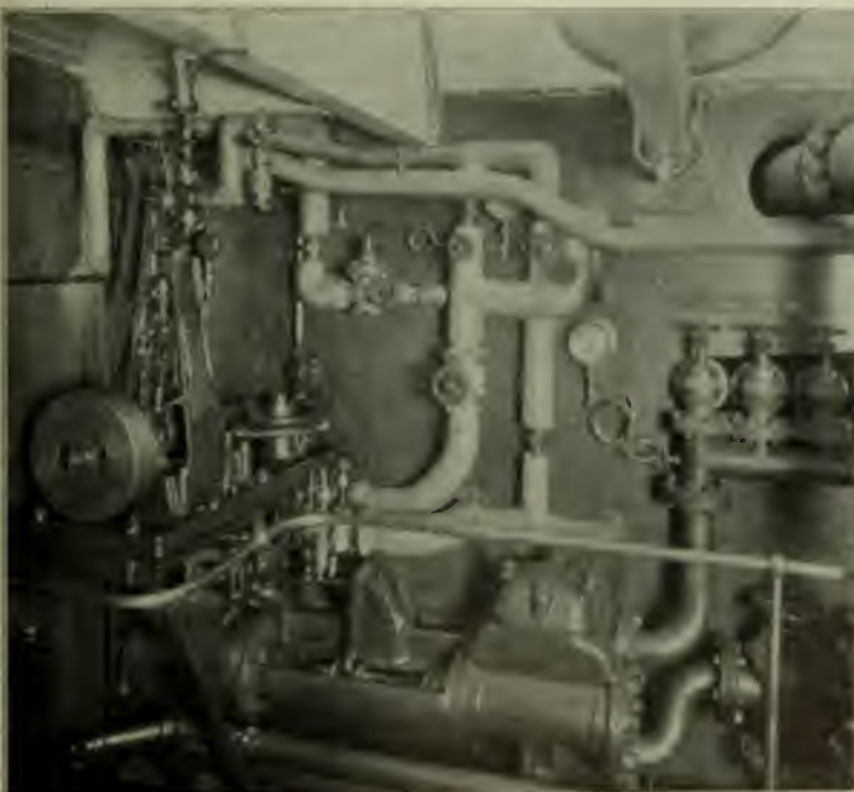


FIG. 4. PART OF THE UPPER-DECK ENGINE ROOM

Proposed Mammoth Testing Machine for the Government

On January 28, Senator [illegible] introduced into the United States Senate a bill for the purchase of an Emery testing machine of large proportions, this machine to be designed by A. H. Emery, builder of the famous testing machine at the Watertown arsenal, which was tested for acceptance in [illegible]. The proposed machine is to be able to give and weigh loads of tension up to [illegible] pounds, and loads of compression up to [illegible] pounds, on specimens up to 100 feet or more in length. The main loading platforms for testing bridge compression members, columns, etc., are to be not less than 8 feet wide and 12 feet long and are to be adapted to receive auxiliary holders and platforms. The machine, if built, will have tension holders to [illegible] and test to destruction round, square and rectangular bars with loads up to [illegible] pounds on lengths up to 100 feet or more; a pair of holders together with their pins and bushings for testing bridge links [illegible] feet or more in length under all loads up to [illegible] pounds; an auxiliary pair of compression platforms with hardened faces for testing [illegible], with all loads up to [illegible] pounds, and a pair of auxiliary platforms with pins [illegible] in diameter and [illegible] feet long for testing [illegible] with loads up to [illegible] pounds. A pair of [illegible] and the ways for these [illegible] are proposed for the erection and use of the testing machine, also the necessary hydraulic pumps and their electric motors for the operation of the presses.

The contract price for the machine complete with its foundations erected in place, together with its accessories, is to be [illegible] and the bill provides for an additional sum of [illegible] for a building in which to place the testing outfit. As designed, the main part of the machine is about [illegible] feet long, while the concrete foundation is about [illegible] feet long, [illegible] feet wide and 15 feet deep, and the metal work in these foundations is about [illegible] feet long; the width of the machine is to be about [illegible] feet. The weight of the metal work, including that in the accessories, cranes, and the metal work of their ways, will be approximately [illegible] net tons, mostly of steel, and a large part of the machine will have to be of unusually good workmanship and generally much better and more accurate than has been put in any large machine of any kind whatever.

It is to be hoped that the bill will pass.

National Gas and Gasolene Engine Trades Association

There was a meeting of the National Gas and Gasolene Engine Trades Association at the [illegible] hotel, Chicago, on Tuesday, February [illegible]. After routine business at the morning session there was a general discussion of the possibilities and the lines along which future effort should be directed. This discussion was very [illegible] and the officers and executive committee received a number of suggestions which will be incorporated in the future work. J. A. Williams, of the [illegible] Ignition Company, Cleveland, O., then read a very interesting paper on ignition, bringing out new points of the ignition of stationary, marine and automobile engines.

At the afternoon session, C. [illegible], of the [illegible] Gas Engine Company, [illegible], O., opened a discussion on the "Proper Horsepower Rating of Gas and Gasolene Engines."

A. L. [illegible], of the National Carbon Company, talked on "Multiple Series Wiring of Dry Batteries." Following this, George M. [illegible], Jr., of the [illegible] Engine Works, read a paper on "[illegible]."

Following Mr. [illegible]'s paper there was an announcement by the president of a number of committees which are to take up special subjects with reference to general investigation for future benefit of the association. It was also announced that the next meeting of the association would be held at [illegible], Ind., on [illegible] and [illegible].

Impurities Causing Scale and Corrosion*

General Characteristics of Salts, Gases and Acids Which Cause Scale or Corrosion in Boilers. Density of Water and Its Purification

BY J. C. WILLIAM GRETH

The chemist has shown the way in which to prevent scale and corrosion in boilers and also how to prevent losses in the industrial arts. His method is to remove from the water the objectionable salts which it contains by changing the soluble salts into insoluble precipitates, which can then be removed by sedimentation and filtration before the water is used. This process is rational in application, the results certain, and the cost in every case is but a small fraction of the advantage gained.

Natural water supplies furnish the water converted into steam; these supplies are rarely, if ever, pure, for water in its descent to the earth as rain absorbs carbonic acid, some air and other impurities. The carbonic acid absorbed enables it to dissolve certain salts of lime and magnesia. Other substances will be dissolved, depending upon the nature of the rocks, soil, vegetation, sewage and industrial waste with which it may come into contact.

Steam generation is a continuous process, fresh feed water being supplied to the boiler as the water evaporated into steam leaves it; this results in a continual concentration in the boiler of the impurities introduced with the feed water, since none but volatile impurities pass out with the steam. The nonvolatile impurities collecting in the boiler manifest themselves as suspended matter, scale, corrosion, or by an increased density of the boiler water.

The suspended matter may be carried in with the feed, or may be due to substances forced out of solution as a result of either heat or concentration, or both. Scale formation in the boiler is due to the action of heat, pressure, and concentration on the impurities in solution and suspension in the feed water. Corrosion of the boiler is due to the introduction of gases and acids, or their formation from some of the impurities in solution in the feed water, by the reactions resulting from heat, pressure and concentration. The increased density of the boiler water is due to the concentration of the sodium salts and of the scale-forming salts, to the limit of solubility.

Scale is the great bugbear which steam users, as a rule, fear, and make more or less of an effort to combat, and with good reason. Scale is one of the crucial items entering into boiler-operating costs. Scale can nearly always be attributed to the lime and magnesia salts in solution in the water. The character of the scale depends on the acids combined with the lime and magnesia; on the type of boiler in use, and on the rate, temperature and pressure at which the boiler is operated. For instance, the carbonates of lime and magnesia, when present alone, usually form a soft scale. The presence of calcium sulphate sometimes increases its hardness. A calcium-sulphate scale is generally quite hard.

The following are a few of the items which, from an economic standpoint, make it almost imperative to prevent scale formation, or at least to remove it periodically:

First. Reduced evaporation due to the insulating effect of the scale on the heating surfaces of the boiler.

Second. Cost of labor required for cleaning the boilers and auxiliaries.

Third. Cost of repairs to boilers, necessitated by their being subjected to overheating on account of the heating surfaces being scaled.

Fourth. Loss of efficiency and earning power of improved furnaces and stokers installed to increase evaporation, which correspondingly increases the concentration of impurities, thus forming a greater deposit of scale, and hence a greater reduction in the efficiency and life of the boilers.

Fifth. Cost of tube-cleaning machines, repairs to them, interest and depreciation on money invested, and labor and power required for operating them.

Sixth. Cost of boiler compounds, or any substances introduced into the boiler to prevent the adherence of the scale-forming matter to the shells and tubes.

Seventh. Loss due to the investment in spare boilers to be put into commission when it is necessary to take boilers out of service for cleaning or repairs.

Eighth. Waste of fuel due to heat lost in cooling a boiler for cleaning or repairs, and that required to bring it to steam again.

Ninth. Loss due to reduced efficiency of boiler auxiliaries, especially in the feed-water heaters and economizers, resulting in lower temperatures of feed water, thus materially increasing fuel consumption.

Salts Which Enter Into Scale Formation

Calcium Carbonate—This salt is in solution in natural waters as the bicarbonate. On heating the water, carbonic acid is driven off and the normal carbonate is precipitated to the limit of its solubility, which in distilled water is about two grains per U. S. gallon, but in waters containing other salts at boiler temperatures and pressures it varies from about one to five grains per U. S. gallon. This limit of solubility remains almost constant for a particular water under boiler-operating conditions. The precipitation of calcium carbonate by heat is practically complete at about 300 degrees Fahrenheit. The precipitation, however, starts as soon as the temperature of the water is raised and continues until the limit is reached. The precipitation therefore occurs, not instantaneously, but gradually, and with a diminution of precipitate as the limit of solubility is approached. This is true of all scale-forming salts that are precipitated by heat alone.

The amount of calcium carbonate left in solution in the water depends upon the other salts in solution. Heat alone will effect the removal of both the free and the half-bound carbonic acid; therefore calcium carbonate will be precipitated, and the precipitate may eventually deposit as scale. The formation of scale from precipitated calcium carbonate depends upon the other substances in solution and the conditions under which the boiler is operated. For instance, if the water contains sodium carbonate, the chances are that the calcium carbonate will be precipitated as sludge. If, on the other hand, the water contains calcium sulphate, the cementing action of the calcium sulphate will tend to form a hard scale, the hardness of which will depend upon the amount of calcium sulphate in solution in the water, and the rate, temperature and pressure under which the boiler operates.

Magnesium Carbonate—This substance has the same general characteristics as calcium carbonate, being held in solution as the bicarbonate. The normal magnesium carbonate, however, is more soluble than the normal calcium carbonate. Further, magnesium carbonate is quite easily dissociated as a result of heat, liberating carbonic acid and precipitating magnesium hydrate, which, at all temperatures, is very insoluble, rarely over one-half grain per U. S. gallon. The analysis of boiler blowoff waters will usually show both magnesium carbonate and magnesium hydrate in solution, while the scale will generally show magnesium hydrate.

Calcium Sulphate—This sulphate is solu-

*Abstract of paper read before the American Institute of Chemical Engineers.

ble in natural waters to over 100 grains per U. S. gallon, and under boiler temperatures and pressures to approximately 25 grains per U. S. gallon, depending upon the other salts in solution. It is quite generally stated that calcium sulphate is insoluble at 300 degrees Fahrenheit; this may be the case in a solution of calcium sulphate in distilled water, but it is not the case with natural water supplies or those containing other salts in solution. The analyses of hundreds of samples of blowoff waters show calcium sulphate present to the extent of 25 grains, where temperatures far above 300 degrees Fahrenheit are maintained. The amount held in solution at boiler temperatures depends upon the amount of other substances in solution, and also upon the rate of concentration of those impurities. Calcium sulphate generally gives a hard scale, deposited in layers. This is probably explained as follows:

In the boiler the calcium sulphate concentrates until it forms a supersaturated solution, from which, on agitation of some sort, it quickly deposits a mass of densely interlacing hard crystals of gypsum, until its concentration drops to the point of saturation. Further, concentration in the boiler again forms the supersaturated solution, from which later another crystallization occurs. These repeated periodic crystallizations of white gypsum, separated by the slow, constant and regular deposition of other scale, would give the laminated appearance generally seen in a calcium-sulphate scale.

Magnesium Sulphate—This substance at boiler temperatures is quite soluble, and when present alone is not likely to form scale, but in the presence of calcium carbonate will react with it, forming magnesium carbonate and calcium sulphate. Magnesium sulphate is also objectionable because it reacts with sodium chloride, forming the very soluble sodium sulphate and magnesium chloride. This reaction is the result of heat and concentration in the boiler.

Calcium Chloride—This lime salt is very soluble at all temperatures, its solubility increasing with the temperature. It is, however, a fact that with the increase of calcium chloride as a result of concentration, a point is reached where the calcium chloride begins to be dissociated, forming calcium hydrate and hydrochloric acid. The calcium hydrate is quite insoluble at boiler temperatures. Analyses of scale and sludge from boilers fed with water containing much calcium chloride show calcium hydrate, and evidences of corrosion, no doubt due to hydrochloric acid, are usually found. The calcium hydrate formed as a result of this reaction may combine with carbonic acid, either introduced with the feed water or that liberated as a result of heat, and form calcium carbonate.

Magnesium Chloride—This chloride has the same general characteristics as calcium chloride, except that it is more easily dissociated, and whenever present, scale and corrosion result. The scale is due to the magnesium hydrate precipitated and the corrosion, to the hydrochloric acid liberated. In waters containing calcium carbonate, the hydrochloric acid thus formed may be neutralized by the calcium carbonate, forming the calcium chloride and liberating carbonic acid.

Calcium and Magnesium Nitrates—These salts have the same general characteristics as the calcium and magnesium chlorides, but the quantities present in most feed waters are usually so small that not much consideration is given to them. However, there are some water supplies in which these salts are present to such an extent as to cause both scale and corrosion.

Silica—The silica in solution in a water usually does not exceed two or three grains per U. S. gallon, and by itself will not form scale, but it is always found in the scale when present in the feed water. Silica under boiler temperatures may react with sodium chloride, forming a sodium silicate and liberating hydrochloric acid.

Oxides of Iron and Alumina—These are not usually present to any great extent, but by concentration enter into the formation of scale.

Organic Matter—The substances included under this general term play an important part in the formation of scale, and in many cases when present cause the formation of a hard scale which otherwise might be quite soft. The reverse is also true with some forms of organic matter. Then again, some organic matter may prevent the formation of scale by increasing the solubility of some of the lime and magnesia salts.

Sodium Salts—These are present in nearly all water supplies and cannot be classed as scale-forming matter, although present to a slight extent in nearly all scale; this is due to their being present in solution in the water mechanically held by the scale, rather than from being forced out of solution, for long before such saturation is reached, it becomes impossible to operate the boiler.

Corrosion—Corrosion is the most dangerous of the various troubles due to impure feed water, and the one in many cases the most difficult to overcome. It is usually due to the acids introduced into the boiler in the feed water, or those formed as a result of reactions between various substances in solution, caused by heat and concentration; in some cases it is due to the oxygen of dissolved air. The different acids cause different kinds of corrosion, and it occurs in different parts of the boiler, depending upon the nature of the acid.

GASES AND ACIDS ENTERING BOILER AND CAUSING CORROSION

Oxygen—Nearly all waters contain more or less oxygen dissolved from the air. The oxygen of the air is more soluble than the nitrogen, and is frequently the cause of pitting and grooving, especially in those parts of the boiler where the temperature is low and the circulation slow, such as, for instance, in the mud drums of those types of boiler in which the mud drum is not in the direct path of circulation. The corrosion by oxygen is the direct formation of the various oxides of iron. It is next to impossible to overcome this form of corrosion, as there is no practical way of removing the dissolved oxygen from the water. The corrosion, however, is of a mild form, and does not, except in rare cases, cause much trouble. The cases where trouble from this source is experienced can almost always be charged to the design of the boiler, for if the circulation is as rapid as it should be and all of the boiler water moving, the oxygen will go off with the steam, possibly causing some corrosion at or above the water line, but not generally to an appreciable extent.

Carbonic Acid—This acid, which is mixed with the air to the extent of about [illegible] of 1 per cent., is present in all natural water supplies. It is absorbed by the water, in which it is quite soluble, from the air. The corrosion caused by carbonic acid is usually indicated by pitting and grooving, and it is shown not only in the water space of the boiler, but also above the water line and in steam lines. Its corrosive action is much greater when oxygen is present with it.

Hydrochloric Acid—This acid is rarely if ever present in natural waters, but is formed as a result of the decomposition of some of the chlorides, and reactions between such substances as magnesium sulphate and sodium chloride, and similar mixtures exposed to steam. Hydrochloric acid is volatile, also very soluble, therefore corrosion is shown both above and below the water line. This acid attacks the iron, forming the [illegible] iron chloride which, at boiler temperatures, is dissociated, the iron being precipitated as the oxide, or hydrate, and the acid thus liberated combines with more iron from the boiler, and is in turn again set free. In this way the corrosion goes on indefinitely, constantly increasing in its action on account of the continued increase in the total acidity of the water by the acid that is liberated from the dissociation of the water being added to the acid formed by the decomposition of the iron chloride. The concentration of the acid does not take place above the water line, but the heat there is sufficient to dissociate the iron chloride. Corrosion from this acid is usually shown by pitting and grooving rather than over the entire surface.

Sulphuric Acid—When this acid is present in a natural water supply it is due to drainage from coal mines or chemical plants. It is not volatile and its effects show only below the water line. Its action on the iron of the boiler is similar to that of hydrochloric acid, except that it forms the iron sulphate, which in turn is dissociated into sulphuric acid and the iron oxide or hydrate. This iron oxide usually forms a part of the scale, or is present in the water as suspended matter, giving to the water the characteristic red color of iron rust. A feed water containing only a small amount of sulphuric acid will produce active corrosion, resulting in the destruction of the boiler, on account of the continual formation of iron sulphate and its dissociation into sulphuric acid and iron oxide or hydrate. Many water supplies, especially those contaminated with the waste from galvanizing plants, contain iron sulphate, which, under boiler temperatures, is immediately dissociated.

Organic Acids—Under this head are included acids such as tannic and acetic. They are usually the result of contamination from vegetable or organic matter. The corrosion from organic acids is comparatively mild, but occurs to a greater or less extent, and is very similar to that from the other acids. However, the amount of such acids present in most waters is usually so small that little attention need be paid to it.

Density of Water in Boilers

The increase in density of the water in the boiler cannot be prevented, for the evaporation of water into steam leaves the sodium salts in solution; and there is no means by which these salts can be removed from the water, either before or after it enters the boiler. By frequent blowing off the concentration of the sodium salts in the water in the boiler can be reduced, but not entirely prevented.

That portion of the scale-forming salts soluble at boiler temperatures and pressures also increases the density of the water, but these salts are constantly concentrating and precipitating, so that after a certain point is reached for uniform pressure and rate of operation, the analysis of boiler water will remain practically the same, with the exception of a variation in the calcium sulphate and an increase in the sodium salts.

Scale and corrosion are closely related, because of the number of salts which, as a result of heat and concentration, either decompose or react, forming salts and liberating acids; the precipitated salts forming scale and the acids causing corrosion.

The analysis of the water is of undoubted value in determining the substances in solution. There is, however, among chemists a wide difference of opinion as to the proper method of making combinations from the determinations of the various substances in solution. Experience enables a chemist to formulate certain rules, and by careful observation during the course of the analysis, to note the salts present in a particular water. But in reporting the nature of the possible scale formed by a certain water, or the corrosion which might result from its use, not only the analysis of the water must be taken into consideration, but the reactions between the various salts in solution; these reactions, however, do not take place to the same extent in all waters. The amount of scale-forming impurity in the feed water rarely if ever bears a direct relation to the substances in solution in the water after concentration in the boiler, but it does to the amount of scale or sludge formed. However, there is a close relation between the amount of sodium salts introduced with the feed water and the amount found in the boiler water after concentration; this ratio indicating approximately the number of concentrations.

It cannot be definitely foretold that in a certain water containing both magnesium sulphate and sodium chloride there will be a reaction between these salts, yet hundreds of blowoff analyses show the results of these reactions, and the boilers show corrosion resulting from the liberated hydrochloric acid.

It therefore means a careful study of the water and the conditions under which the boiler operates, to determine whether scale or corrosion would result from the use of a certain water. It is almost impossible to predetermine the nature of scale from the analysis of the water. The only safe way is to feed water into the boilers, free from those substances which scale and corrode. Such general statements that waters containing only the carbonates of lime and magnesia will form a comparatively soft scale, and that the calcium sulphate will form a hard scale, and further, that it will increase the hardness of the carbonate scale, should be made with caution, for there are hundreds of instances where a hard scale is formed from waters containing only the carbonates of lime and magnesia, and also where the scale is quite soft in the presence of considerable calcium sulphate.

The nature and amount of scale formed in a boiler depend largely on the rate at which the boiler operates. For instance, in some boiler plants operating considerably below their rating, and fed with water containing as high as 30 grains of both carbonate and sulphate scale-forming salts, in a given time comparatively little scale is formed, and that quite soft; while in others, where the water contains only about 10 grains of these same salts, and the boilers are worked above rating for the same time, a considerable deposit of hard, tenacious scale is formed. The type of boiler also has a bearing on the hardness of the scale. The scale in the water-tube boiler is generally harder from the same water than that formed in the return-tubular boiler, or in the old two-flue boiler.

Softening and Purifying Water

To soften and purify a water properly means, primarily, a properly designed apparatus in which are met the requirements for complete chemical reaction. These may be summed up as follows:

1. An accurate chemical treatment, accomplished by the introduction of the proper reagents in exact quantities to react with the impurities in a definite quantity of water.
2. Thorough mixture of the reagents with the water to insure complete chemical reaction.
3. An accelerated chemical reaction, brought about by a thorough mixture of reagents and water, and by mixing the sludge of previous softening with the new finely divided precipitate. Heat will hasten the reactions, but is not essential.
4. A complete chemical reaction, brought about by a thorough mixture of the reagents with the water and by having the apparatus large enough to allow sufficient time for all the reactions to take place, and the apparatus so designed that every part of it is effective.
5. A rapid sedimentation, by having the new finely divided precipitate weighted by the sludge of previous precipitation, to cause it to settle more rapidly and perfectly.
6. A perfect clarification, by allowing time for sedimentation and final clarification by perfect filtration.

The proper softening and purification of water is, in a sense, a delicate operation, notwithstanding the large quantity of water usually handled. It is not merely a matter of lime and soda ash, but the intelligent use of the proper reagents to bring about softening and purification for a particular water supply, with neither an insufficiency of reagents nor too great an excess. A water containing 30 grains per U. S. gallon of scale-forming matter is harder than the average, yet in percentage this means only 0.05 of 1 per cent. of scale-forming impurity. Such a water completely softened should not contain more than three grains of scale-forming matter, or in percentage only 0.005 of 1 per cent. When these facts are considered, some idea is obtained of the accuracy of the treatment required for completely softening water. Of course, any reduction of the scale-forming salts is an advantage, but the maximum reduction can usually be obtained for very little extra expense with a properly designed apparatus, when such apparatus is given the necessary attention.

If a water supply contains less than four grains of lime and magnesia salts, but contains suspended matter, it should be clarified by sedimentation and filtration. If the water contains more than four grains of scale-forming salts, it should be softened and purified, that is, the reduction of the soluble impurities (not including the sodium salts, which cannot be removed) to a point where an analysis will show quantities about as follows: Volatile and organic matter, one grain; silica, one-half grain; oxides of iron and alumina, trace; calcium carbonate, two grains; magnesium hydrate, one-half grain; but no other compounds of lime and magnesia. Suspended matter should never be more than a trace. Such a water will not form scale nor cause corrosion. It will not form scale because the amount of scale-forming salts left in solution is too small, even with concentration, to form anything but a light sludge. This sludge can be kept at a minimum by proper blowing off, and the boiler, no matter how long it is in operation, will on being opened have the appearance of having been whitewashed; the iron of the boiler can be exposed anywhere by rubbing with the finger or washing out with a good pressure. Corrosion cannot take place because the water is slightly alkaline and does not contain either corrosive acids or salts which, by dissociation or reaction, will form corrosive acids.

Catechism of Electricity

956. *What other causes are sometimes responsible for excessive heating of the armature?*

Heat may be developed in some other part of the machine and be transmitted to the armature by conduction. Then, too, the motor may be overloaded and carry too much current in the armature.

If there are one or more reversed coils on one side of the armature winding, conditions will be favorable for the development of heat, because probably there will then be a local current in addition to the operating current flowing through the reversed coils.

957. *How may a reversed armature coil causing a high temperature in the armature be located and remedied?*

Stop the motor and pass a direct current through each of the armature coils in succession. Connect the source of the testing current with adjacent commutator bars and notice the deflection of a compass needle placed over the coil undergoing test. When the reversed coil or coils are reached, the deflection will be opposite to that obtained from the other coils. In order properly to adjust matters the connections of the defective coils must be reversed.

958. *What effect has dampness upon raising the temperature of armature coils?*

If the armature coils become damp their insulation is lowered, but their temperature will not be increased.

959. *How should damp armature coils be dried?*

By passing a moderate current through the coils for a considerable length of time, or by baking the armature in an oven. In either case the drying process should be continued until the insulation resistance of the windings measures over 1 megohm.

Care must be taken in applying this remedy not to overdo it, else the shellac will melt and run and the insulation will be charred or burned.

960. *If the bearings become too warm, what may be the cause of the trouble?*

The bearings may fit too closely around the armature shaft; in a new motor they may be out of line; there may be foreign matter in the bearings.

961. *How may trouble in the bearings be tested?*

By slowly turning the armature around by hand to see if it sticks, or when shutting off the power noticing if the armature comes freely to rest.

962. *What are the remedies for troublesome bearings?*

Bearings which fit too tightly must be reamed out or scraped, or the armature shaft placed in a lathe and turned down or filed.

If the bearings are out of line with each other the motor should be shut down and the bolts holding the bearings in place partially unscrewed to allow the bearings to find their proper position. When they have done so, and the clearance between the armature and pole pieces is the same on all sides, the necessary adjustments must be made for maintaining the bearings in this position. If the motor is provided with self-alining bearings which, as their name implies, are automatic in action, and which are now commonly used on all high-grade machines, little or no trouble need be anticipated from this cause.

Dirt or other foreign matter in the bearings is liable to result from unfiltered oil being used or when the room is not kept free from dust and dirt. A careful examination of the shaft will show whether this trouble exists, as there will be scratches on it when such foreign matter is present. To improve conditions the shaft or bearings must be taken out and cleaned.

963. *What is, perhaps, the most common of all causes for abnormal heating in the bearings?*

Deficiency of oil in the bearings is the most common of all causes of hot bearings. The deficiency may be due to a defect in the oiling rings on the shaft, to a stoppage or leak in the oil passages, or to empty oil cups. Usually this defect is easily made right, the nature of the trouble suggesting the remedy to apply.

964. *Could a belt too tight cause the pulley bearing to heat up?*

It would.

965. *How may the trouble referred to in 964 be detected and remedied?*

It may be detected by the unequal temperatures of the commutator and pulley bearings, the latter being the warmer. If the belt has not been run tight very long the bearing will probably not have become worn sufficiently to require rebabbitting, but in any case the tension of the belt should be lessened either by employing larger pulleys and a lighter belt or by decreasing the load on the motor.

966. *If the bearings are very warm and the armature shaft turns more easily at one point of a revolution than at another, what is probably wrong?*

The armature shaft is probably bent.

967. *What is the remedy for a bent armature shaft?*

The easiest, cheapest and, in fact, the only satisfactory way to correct this trouble is to replace the defective shaft with a new one properly turned.

968. *Are there any other shaft troubles that may produce hot bearings?*

Yes, the shaft may not have sufficient end play or it may be cut or roughened.

969. *Why is end play of the shaft necessary to keep the temperature of the bearings low?*

If there be no end play, or free movement back and forth, of the armature shaft in the bearings while the motor is in operation, the collar, shoulder, or pulley on the shaft is apt to press continually against the bearings and cause them to become heated.

970. *What should be done to correct end-play trouble?*

If, upon pressing a stick against the end of the armature shaft while in motion, there is a tendency for the shoulder or the collar on the shaft to come in contact with the bearing, a slight change in the leveling of the belt may improve matters. It may, however, be necessary to file the contact surface of the bearing or change the position of the pulley or collar along the shaft to secure satisfactory results.

971. *In case the shaft is cut or roughened, what should be done?*

The shaft should be placed in a lathe and turned smoothly. Care must be taken, however, not to remove more metal than is absolutely necessary, else the bearings will not fit and they will have to be renewed. In any case it is necessary to have them perfectly smooth before the repaired shaft is placed in position.

972. *Is a bearing liable to become hot by conduction of heat from some other part of the motor?*

It is. If the bearing on the commutator side of the machine is becoming heated from no apparent cause an inspection of the commutator and armature should be made; or if the bearing on the pulley side of the machine is hot, the pulley may be suspected. When it is found that some part has a higher temperature than the bearing on that side of the motor, the proper remedy applied to the defective part will generally lower the temperature of the heated bearing.

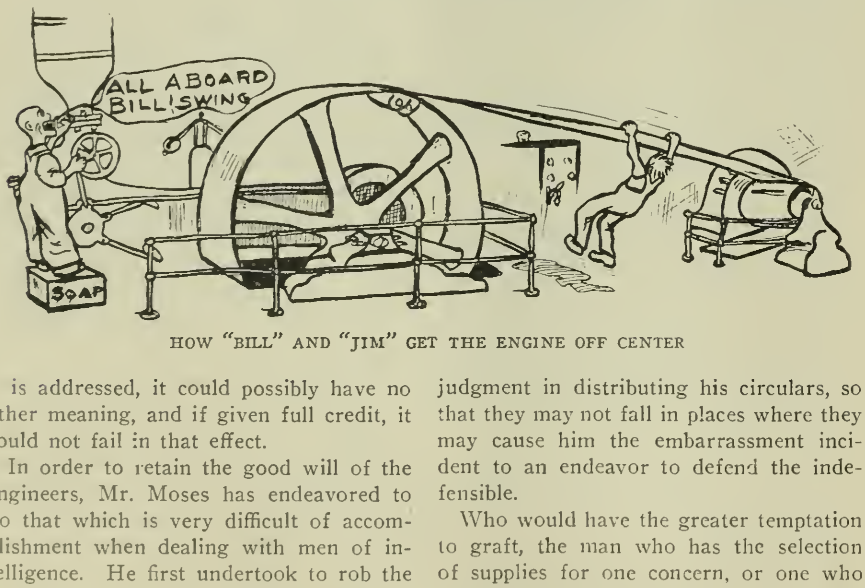
Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Extraneous Supervision of Power Plants

I have noticed with interest the matter appearing in recent issues under the above caption. I observe that the only difference between the article appearing over the name of P. R. Moses, in the issue of January 19, and the circular, a copy of which was printed two weeks previously, is that the former is addressed to the engineers, while the last was addressed to the employer. In effect the matter stands just this way: Mr. Moses cannot deny but that the circular in question had for its obvious object the undermining of the engineer's position in the esteem and confidence of the employer. If it is accepted seriously at all by those to whom it is addressed, it could possibly have no other meaning, and if given full credit, it could not fail in that effect.



HOW "BILL" AND "JIM" GET THE ENGINE OFF CENTER

In order to retain the good will of the engineers, Mr. Moses has endeavored to do that which is very difficult of accomplishment when dealing with men of intelligence. He first undertook to rob the engineer of his standing with the employer, assuming, it would seem, that this was the surest way of securing it for himself and his company. In order to get business for his concern he has assailed the engineer as the one most in his way, and since he has been caught in the act, and realizes that he has "stirred up a hornets' nest," he adopts the idea of patting the engineer on the back with a wink, and in effect saying aside, "I didn't mean it."

In his letter he virtually admits that neither he nor his company can do anything except through the engineer. That is so, but it is also a fact that the best engineers prefer to work under conditions where they will get credit for what they do, rather than where they will see it go to others. It is a virtual admission that all the advantage that the supervision company can offer over the engineer is that it can by concentration of purchases secure lower prices on supplies. What he can save in a plant of moderate capacity in this manner would not pay for the time the employer would have to spend in consultation with the representatives of the company.

Besides that, let us consider this matter of graft. This is the excuse put forward more strongly than any other for the existence of this company. This is a rather ugly compliment, but Mr. Moses began it and if, like the boomerang, it recoils and strikes him, he can blame only himself. He can also gain wisdom from the experience and hereafter use better judgment in distributing his circulars, so that they may not fall in places where they may cause him the embarrassment incident to an endeavor to defend the indefensible.

Who would have the greater temptation to graft, the man who has the selection of supplies for one concern, or one who has the same privilege with many? Is Mr. Moses so simon pure that he can withstand unspotted and unsullied tenfold, nay a hundredfold greater temptations than can we poor engineers? After all, we poor weak ones, who are incapable of dealing rightly with a case of itching palm, should rejoice that one has come forth and announced himself as willing to take from us this awful burden of temptation. If I were a grafter, I would endeavor to start an engineering supervision company of my own. I can see no shorter cut to successful and remunerative grafting. What is the use of fooling along with a few paltry quarters and fifty-cent pieces in one plant, when we can get in the supervising business so easily and have a neat income right along? Pshaw!

Grafting arises from certain causes, opportunity and a desire to get money faster than it can be secured in a legitimate way. The result of these causes will depend upon two things, the character of the man and the greatness of the opportunity to graft. When one man accuses a great number of a thing like this he is, to say the least, straining a point. Can any one man assume that he is so much better than so many others, that he is beyond temptation? And yet, business will come to this concern, as "a sucker is born every minute."

The capable engineer will get the results, but without him the engineering suvervision company cannot. The engineers who belong to the result-getting class will not work under conditions where they are obliterated. Hence the men who can get results will get out about as fast as the engineering supervision company gets in.

WILLIAM WESTERFIELD.

Lincoln, Neb.

Improving Firemen's Conditions

I read with interest the letter by W. Auld, on page 168 of the January 19 number, referring to the conditions under which firemen have to work. Firemen can improve their condition themselves if they would go at it in the right manner, but the engineers would do well to assist them. No one can do more for the engineer than the firemen, and for this reason the engineer should not be afraid to stand by his firemen. Large-minded men, and the majority of employers are large minded, like to see character in their engineers, and instead of weakening his position by standing by his firemen an engineer will strengthen it.

The firemen are not alone, however, in failing to have all that they should have in the way of conveniences in the power plant. I have known many good-sized plants where the chief engineers had no conveniences. Conditions will become better only as the importance of the operating force becomes better known and recognized by the owners. This will come through the efforts of the men themselves by bringing their work and efforts to the attention of their employers.

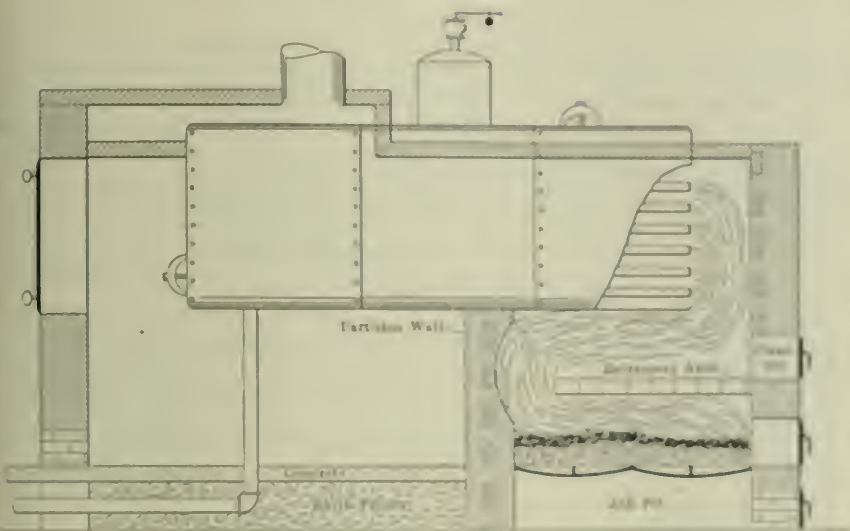
WILLIAM WESTERFIELD.

Lincoln, Neb.

An Improved Boiler Setting

The accompanying sketch shows what, in my opinion, would be an improvement on Mr. Kirlin's boiler setting, illustrated in a comparatively recent issue.

Instead of placing the fire doors on the side of the boiler, I would put them in front, where they belong, and construct a



BOILER SETTING PROPOSED BY MR. GARTMANN

fire arch, as shown, to produce proper combustion and a practically smokeless furnace.

FRANK GARTMANN.

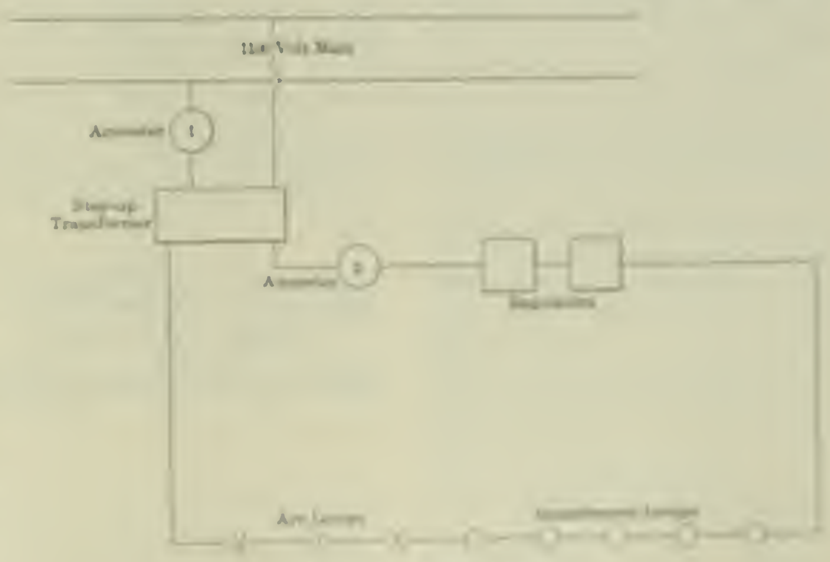
Sheboygan, Wis.

Series Circuit Supplied from Constant Potential Circuit

In one of your recent numbers you published my wiring diagram and asked the question, "Would there be any decrease in the current taken by the regulators and step-up transformer," after tungsten lamps had replaced the carbon-filament lamps?

Of the several who have made replies to the article, none has given the facts just as they have taken place since the system was changed from the carbon to the tungsten lamps. As this has been a question of some interest, particular attention has been paid to the reading of the meters during and since the change, and I will relate the facts as they have happened since the change was started.

As stated in the former letter, there were 10 inclosed arcs and 80 carbon-filament lamps in series, and operated from two 25-light regulators in series (connected together mechanically) and a step-up transformer with the secondary delivering 3000 volts. The connections were made as shown in the accompanying sketch. The ammeter connected in the primary line to transformer (No. 1) registered 20 amperes and the regulators were supplied with two extra weights in order to keep the current in the series circuit at the desired value, 5.5 amperes, when the carbon-filament lamps were in use. These were displaced a few at a time (from three to ten a day) by the tungsten lamps and the primary ammeter registered a little less after each change was made. When about 90 per cent. of the



MR. GROVE'S WIRING DIAGRAM

old lamps had been replaced with the new ones it was necessary to add six extra weights to the regulators in order to keep the current at the proper value, and the ammeter in the primary circuit registered only about 16 amperes.

Now another difficulty was encountered. The 10 arc lamps acted as if they were not supplied with enough current to close, give the magnets and the carbons burned to a point, as though the [illegible] [illegible] [illegible]; consequently the lamps would not give their rated candle power. The [illegible] [illegible] [illegible] [illegible] [illegible] the secondary connections on the step-up transformer. (This transformer is equipped with six secondary leads and connections can be made to give any of the following voltages: 4200, 4000, 3400, 3600, 3200, 3000, 2700, 2400, 1800, 1200, 600, 300.) The connections were changed from the 3400-volt connection to the 1800-volt, but this was found to be too low to give the desired current of 5.5 amperes, so the 3400-volt connection was tried and with two extra weights on the regulators it was found to be just right. After this change was made the arc lamps burned as well as they ever did, giving a nice clear light, and the primary ammeter now registers from 8 to 10 amperes.

Can anyone explain why the arcs acted so mysteriously when the transformer was connected to give the higher voltage? The candle power of the incandescent lamps was not visibly affected.

D. W. GROVE.

Covington, Va.

Knock in the Engine

I am operating a plant consisting of [illegible] simple Corliss engines, running at 90 revolutions per minute, and belted to an alternator. The engine has a peculiar sort of knock as the crank passes the centers. It can be heard more distinctly on the crank end on the gallery side and gives a clicking sound. It is heard [illegible] [illegible] [illegible] revolutions and then stops for about the same number.

Everybody in the plant has tried to locate the knock but without success. The end bearings of the crank shaft have been taken [illegible] [illegible], and the knock does not seem to be in it. All other bearings seem to be all right and are cool.

[illegible]

[illegible]

Gas Engine Valve and Ignition Timing

My experience with gas engines has led me to different conclusions from those expressed by Mr. Hollman, on page 167 of the January 19 issue. He says, near the close of his letter: "Thus the inlet valve should close when the piston has started back a certain distance, and the exhaust should open when the piston is at a certain distance from the end of its stroke."

From the language used, the four-stroke-cycle engine is being considered, in which case the theory advanced seems to be erroneous. In order to grasp the operating sequence of this type of engine it should be borne in mind that we are dealing with a gas pump during the exhaust and suction strokes, and as any adjustment that advances or retards the time of opening a valve must produce the same change in the time of closing, is it not obvious that something less than a cylinderful of mixture will be trapped whenever the valves are closed at any other time than when the crank is exactly on the center?

The fact that the gas mixture is burned in the cylinder has nothing whatever to do with the question of proper valve setting, in which case is it not apparent that in order to get the best results from our "gas pump" we must open and close the valves on the centers just as all other pumps do, or should?

The efficiency of a gas engine depends on its getting a cylinderful of a proper mixture of gas and air, compressing it to the best point and then firing at the proper time relative to the crank or piston position. All of these questions except the first one are best determined by local conditions, but the importance of starting out with a *cylinderful* of mixture is hardly open to discussion, and the only way to secure that result is to open and close the valves exactly on the dead-center points.

If the gas-engine operator will vary the quality of the mixture and the compression and the time of igniting, it will be found that the efficiency of the engine varies with these changes and that a compromise or happy medium may be arrived at where, for instance, the spark may be advanced to a point giving the highest initial pressure, the best burning conditions, etc., without going so far that the initial pressure or compression is high enough not only to overcome the inertia of the moving parts, but actually to exert pressure on the wrong side of the crank pin. In one case an engine using natural gas, compressing to 75 pounds absolute and running at 250 revolutions per minute, did its best work when the spark was set 22 degrees ahead of the dead point; that is, the crank lacked 22 degrees of having reached the dead center when the charge was ignited.

E. G. Tilden.

Downers Grove, Ill.

Keeping Motor Records on Index Cards

In large establishments where there are many motors in use, some system of keeping records is desirable to enable the man in charge to ascertain quickly any desired data about the equipment under his charge. The best method available, within the writer's knowledge, is the card index. The accompanying engravings are reproductions of the two sides of a card taken from the file of the plant in the writer's charge. In the system used here, alternating-current motors are numbered below 1000 and direct-current motors above 1000; the cards for alternating-current motors are salmon-colored and the others light blue. A group of numbers is reserved for each size of motor (for instance, 200 to 250 for 3-horsepower motors) and a guide card bearing this size on an extended tab is inserted between the groups of cards to facilitate the location of any card desired.

When a new motor is purchased a card is filled out with all the information except the rewinding data, and placed in the index, where it remains until the motor is brought to the shop for repairs. The card is then taken from the index file and the necessary winding data entered on it, an account of the repairs being also entered, but on the back, and the card returned to the file.

MOTOR No. 387
ALTERNATING CURRENT

MAKE Westinghouse	STATOR SLOTS 72	PULLEY 8" dia x 4"	STARTER Oil immersed
TYPE "C"	ROTOR SLOTS 47	SHAFT 1 5/8"	FUSE BLOCK Nat'l Code
H. P. 5	NO OF COILS 72	BEARINGS 1 3/4"	START FUSES 30
SPEED 1120	THROW 1-9	ROTATION Right hand	RUN FUSES 10
VOLTS 440	SIZE OF WIRE 14	ON PULLEY END with	H P LIGHT 1.4
PHASE 2	TURNS PER LAYER 7	crossed belt	H P LOADED 6.3
CYCLES 60	LAYERS PER COIL 2		DATE 12/27/08
AMPS PER P 6.5	HAND 36 R. 36 L.		
SERIAL NO 49368	COILS PER GROUP 6	CONTROLLER None	LOCATION Emery
FRAME Open			wheel West
POLES 6			bay Forge
			Dept
			(REMARKS OVER)

FIG. 1. FRONT SIDE OF A MOTOR-DATA INDEX CARD

Where temporary repairs are necessary they are noted on the back of the card, and the card is taken from its regular place in the index file and placed back of an index card marked "Hospital," so that the temporary nature of the repairs will be kept in mind and permanent repairs made as soon as possible.

Bearings rebabbited
7 Coils replaced } JAN 13 1909
Broken Oil ring repaired

FIG. 2. REAR SIDE OF A MOTOR-DATA INDEX CARD

This card system has proved a great convenience to the writer; it makes a complete record of every motor in the plant instantly available. This letter is written with the hope that the system may prove of value to others similarly situated.

R. H. Fenkhausen.

San Francisco, Cal.

What Caused the Valve to Break ?

Following is an account of an accident that has twice happened since installing a drip-return pump and new feed line. The first accident was the cracking of a flange at the end of the feed line and the breaking of the body of a 6-inch valve. The second time a joint blew out at a flanged ell and the bonnet of the stop valve cracked.

The discharge from the drip pump enters the feed line at about its center. The feed line is of 6-inch pipe, 150 feet long and feeds water to twenty 318 horsepower water-tube boilers. Four duplex pumps, 10 and 6 by 12-inch, take water from two open heaters at a temperature of 190 degrees Fahrenheit. This feed line is supplied with a 4-inch release valve, set at 140 pounds. It is well braced and has an expansion bend in it.

The drip pump takes its water from six separators, large and small, situated on the main steam lines leading to the engines. The steam pressure is 115 pounds, and the pump is located 25 feet below the feed line. At the time when the accidents happened there were twelve boilers in operation and the head fireman reported everything as usual. All fittings and pipe are extra heavy.

FRANK J. [illegible]

New Aberdeen, C. B.

Homemade Condenser

The accompanying sketch represents a condenser such as may help Mr. Casper out. The return pipes are fitted to the

MR. [illegible]'S HOMEMADE CONDENSER

header, with a connection for the exhaust steam, and return to the side of the bottom piece, which shows the connection for the condensed water coming out of each end and flowing to the receiver, from which it may be handled by a pump.

The return pipes may be made any length, depending on the size of condenser required. The condenser is submerged in a tank, the water running in and out all the time, so as to furnish cool water for the condenser.

THOMAS [illegible]

Chemawa, Ore.

Connecting Steam Boilers

Referring to the letters by Frank Eastman and M. Kennett in the December [illegible] number, I would say that both describe a very faulty method of connecting up steam boilers, which is more or less in vogue.

It seems to be the idea of some engineers that the valves must be placed as close as possible to the boiler. This practice is wrong, as it leaves more or less

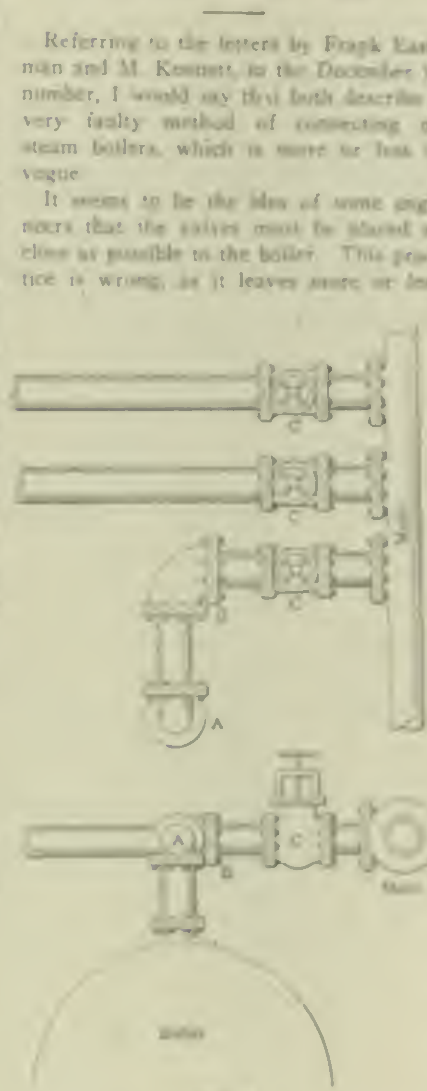


FIG. 1

pipe in which there is no circulation when the boiler is idle, causing condensation of steam, which is apt to form a dangerous slug when the boiler is put in operation.

A better plan is to put the stop valve as close to the header or point of distribution as possible, as there will presumably be steam in the header at all times when one or more boilers may be idle.

A still better plan is to put a nonreturn valve or automatic stop valve, working both ways, near the header and a plain valve near the boiler. This is according to the latest practice for high-pressure work. The valves, however, should be kept at the highest point, so that there will be no chance for water of condensation to accumulate.

Referring to Mr. Eastman's arrangement, if stop valves only were used, I should recommend placing them at C, Fig. 1, herewith, or if both stop valves and nonreturn valve were used, I should place the nonreturn valve at C, and the stop valves at either A or B, but to be placed on the vertical pipe down near the boiler.

In reference to Mr. Kennett's plan, the nonreturn valve should be placed at B, Fig. 2, herewith, and the stop valve at A.

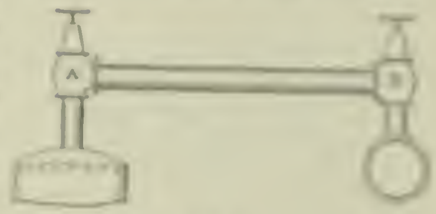


FIG. 2

Regarding the matter of draining headers, it is not a good idea to drain back into a boiler, where a number of boilers are used, as each boiler should be positively and completely cut out by one valve only. This lessens the chance of turning steam onto a man who might be inside the boiler for cleaning or inspection. A good, reliable steam trap will drain a header very satisfactorily. [illegible] headers are drained satisfactorily by using steam to run the boiler-feed pumps from the bottom of the header.

G. [illegible]

Los Angeles, Cal.

Cooling a Prony Brake Wheel

In the steam-engine laboratory of a certain school there is a small [illegible] engine, used for testing the brake horsepower developed at different valve settings.

For a long time I had trouble on account of the heat generated by the friction of the brake on the surface of the

[illegible] COOLING A PRONY BRAKE WHEEL

wheel. The plan used to overcome the difficulty was as follows: I had some [illegible] angle iron bent to a circle with a flat face out and made to fit snugly the inside of the wheel. After making two of these I bolted one on each side of the wheel, with a flat face outside, so as to form a [illegible] flange all around the inside of the wheel, as shown at A in the sketch. Water is kept in the trough thus formed, and when the wheel is revolved all parts of the inside face of the wheel are bathed, thus keeping the temperature from getting too high for some time. At B is shown the brake as it is used on the pulley wheel of an engine.

E. S. Rodney.

Baton Rouge, La.

Determination of the Calorific Value of Low-grade Fuel

In reading F. H. Neely's very interesting and valuable article in a recent number of Power, I was reminded of a modification (if it may be called such) of the well-known Dulong formula for calculating the heat value of a coal, adapting it to lignite and peat. The Dulong formula given by the American Society of Mechanical Engineers in its "Rules for Conducting Boiler Trials" is as follows:

$$14{,}600\ C + 62{,}000 \left\{ H - \frac{O}{8} \right\} + 4000\ S,$$

in which C, H, O and S are the percentages of carbon, hydrogen, oxygen and sulphur in the coal, by the true analysis. The number 14,600 represents the number of B.t.u. in one pound of carbon; 62,000 that for hydrogen and 4000 for sulphur. The ratio $\frac{O}{8}$ takes into account the oxygen which would combine with the hydrogen to form moisture and is, therefore, subtracted from the total hydrogen.

For those unfamiliar with this formula, the following analysis will clearly show its use: Carbon, 74.79 per cent.; hydrogen, 4.98 per cent.; oxygen, 6.42 per cent.; nitrogen, 1.20 per cent.; sulphur, 3.24 per cent.; moisture, 1.55 per cent.; ash, 7.82 per cent.

Substituting, we get:

$$14{,}600 \times 0.7479 + 62{,}000 \left\{ 0.0498 - \frac{0.0642}{8} \right\} + 4000 \times 0.0324 = 13{,}650\ B.t.u.$$

A calorimeter test showed 13,480 B.t.u. for this coal.

To apply the Dulong formula to lignite or peat, instead of taking the true analysis, use the analysis corrected for moisture, and to this result add the heat carried away by the moisture in the fuel.

As an illustration, take the North Dakota lignite given in a bulletin of the United States Geological Survey: Hydrogen, 5.22 per cent.; carbon, 52.66 per cent.; nitrogen, 0.71 per cent.; oxygen, 27.15 per cent.; sulphur, 2.02 per cent.; ash, 12.24 per cent. The moisture equals 15.42 per cent.

Substituting in the Dulong formula, the following is obtained:

$$14{,}600 \times 0.5266 + 62{,}000 \left\{ 0.0522 - \frac{0.2715}{8} \right\} + 4000 \times 0.0071 = 8862.9\ B.t.u.,$$

the heat carried away by the moisture.

Assuming the lignite to be at 62 degrees Fahrenheit when fired and the gases to be at 420 degrees Fahrenheit on entering the breeching, we have 150 B.t.u. to head one pound of water from 62 to 212 degrees Fahrenheit; 966 B.t.u. to evaporate one pound of water from 212 degrees Fahrenheit to steam at 212 degrees Fahrenheit; 210 B.t.u. to raise the steam to 420 degrees Fahrenheit; and 1324 B.t.u. total heat carried away by one pound of water.

$$1324\ \text{B.t.u.} \times 0.1542 = 204\ B.t.u.$$

Adding the two values gives

$$8862.9 + 204 = 9066.9\ B.t.u.$$

per pound of lignite. The fuel actually gave in the calorimeter 9061 B.t.u.

The assumption as to fuel and breeching temperatures is very close to average practice and can vary several degrees and not make an appreciable difference in the results.

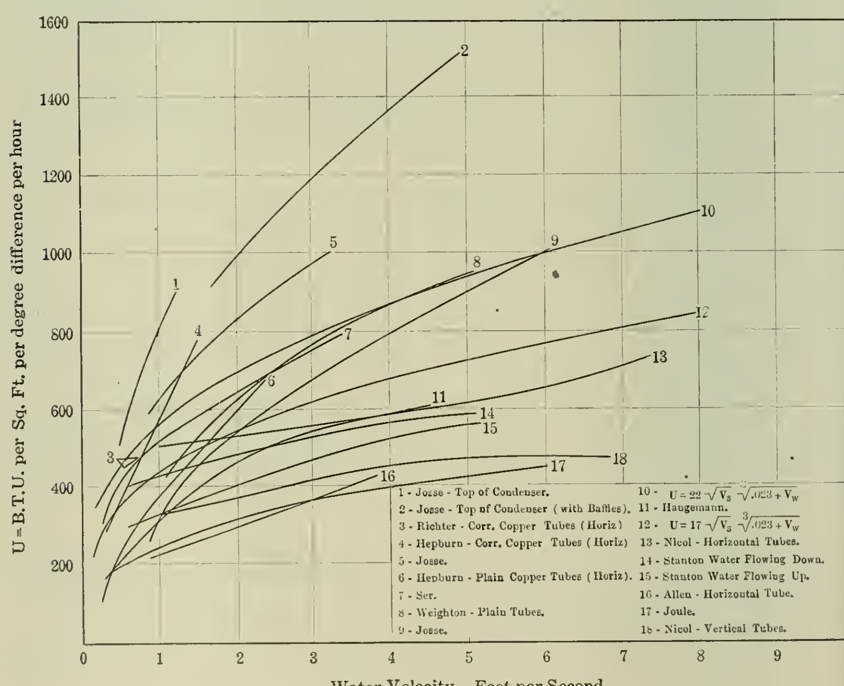
I discovered this relation while preparing a course of lectures on "Fuel Technology," which was given at the University of Wisconsin in 1906, and have applied this modification to a large number of lignites and peats and find it always gives very close results. I have never applied it to wood, but believe it would work equally well.

W. A. Richards.

Chicago, Ill.

Surface Condensation for Steam Turbines

I note with pleasure that you have published an abstract of Professor Josse's paper on surface condensers, referred to by Mr. Mueller in his criticism of my article on the same subject. Professor Josse's paper is of great value, supplementing as it does the work of Weighton and Morison. The curves given in Fig. 2, page 234 of the February 2 number, are particularly interesting and I have plotted them on the set of curves you reproduced before. The curves representing the value of U when "baffle strips" were used in the tubes are not applicable to ordinary condenser conditions, as the increase of head and power for the circulating pumps must have been quite marked. The other curves are even bet-



HEAT TRANSFERENCE THROUGH TUBES

ter than Weighton's and more nearly agree with the theoretical formula, although with a slightly different constant. It is not strange that Josse should have fallen into the error of considering that U varied with the square root of the velocity of the cooling water when it is understood that he used the metric system and all his velocities are near one meter per second; the differences between the square root and the cube root at that point would not probably be larger than the error in the value of U. With the English system, however, the numerical values of the velocity are higher and the differences much more marked. It will be seen that the values given by Ser conform more nearly to the cube-root curve than to the square-root curve.

It is also interesting to learn that Professor Josse has developed the formula for surface

$$S = \frac{Q}{U} \log_e \frac{t_1 - t_2}{t_1 - t},$$

which has been in use in this country for some time, and found it better to represent actual conditions than Weiss' old formulas so often quoted in foreign works. Hermann Wilda in his "Marine Engineering" (Hanover, 1906), gave a formula similar in form, but the further possible simplification was apparently not seen.

The experiments showing the transmission of heat to air are interesting and of value. Josse's air pump is known in this country as the Bailey pump, and has been installed in a number of naval vessels. The only new thing in it is the additional air inlet above the piston, making the pump somewhat similar in action to the new Bedmer pump of the Allis-Chalmers Company.

Professor Josse's remarks on the contraflow principle are very well taken and represent American practice fairly well, except that we find it usually advisable to use the contraflow principle. The fact that every condenser tube must necessarily be filled with water at all times with this system is sufficient reason for its adoption.

George H. Orrok.

New York City.

Babbitting a Main Bearing

On one occasion when babbitting a main bearing of a medium-sized engine I had trouble with seams in the babbitt.

At first it was thought the babbitt would have to be taken out and repoured. The following idea was carried out, however, and its success was well worth the small amount of trouble it caused.

Where the seam showed, the metal seemed to have run smoothly enough, but close to the edge of the box the outer edge was loose. A 7/16-inch drill was used to bore a string of holes down the seam, so as to catch a portion of the solid and loose metal. The holes were quite close together so there were very thin bridges between. After melting the babbitt as much as it would stand, a hot iron was used on the string of holes, melting down the bridges and thoroughly heating the metal. While this was being done the hot babbitt was poured in, forming the whole in one solid piece.

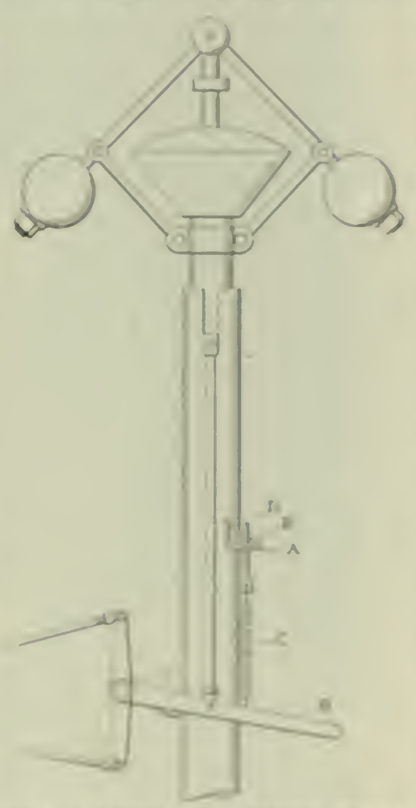
It is a good plan, when using the iron to warm the metal, to put in a little powdered rosin. These seams, flaws and holes, so annoying in babbitting, are mostly caused by not having the shaft, arbor, or whatever is used to cast around, hot enough. Then, too, it is sometimes difficult to get the metal in the bearing hot, but this should be done at all odds. A good material for preventing the metal from leaking while pouring is composed of flour and common engine oil, mixed to a dough. This is far better than clay or such material, as the moisture causes steam and blowouts are likely to occur.

Joseph W. Lotch.

Fruitland, Wash.

Prevents the Governor Dropping

The accompanying sketch is of an attachment we recently installed on the governor of a 150-horsepower Corliss engine driving a two-phase generator. For some time we had been troubled with the governor dropping to its lowest position when the engine was carrying full load or



DEVICE TO PREVENT THE GOVERNOR DROPPING

was slightly overloaded and the steam was a little low.

This engine was designed to run at [illegible] revolutions per minute, and in case of a heavy load would lose from six to eight revolutions per minute, thereby allowing the governor to drop, causing the safety device to prevent the latch catching the valve, thus stopping the engine. To obviate this difficulty we bolted an angle iron A to the governor post with two [illegible]-inch machine screws, and through the upper end of the angle iron drilled a [illegible]-inch hole. Through the governor lever B, and directly in line with the [illegible]-inch hole in the angle iron, a [illegible]-inch hole was drilled. In this hole was fastened the lower end of a [illegible]-inch steel coil spring C, and to the upper end was fastened a [illegible]-inch bolt D, extending through the [illegible]-inch hole in the angle iron. A butterfly nut E was placed on the upper end of the bolt.

Increasing the tension of the spring prevents the governor from dropping quickly under variable steam pressure, but the tension must be varied with different loads. The spring, however, will not prevent the governor's dropping and cutting the steam off in case the governor belt should break or fly off for any reason.

D. M. Grove.

Covington, Va.

The Sense of Proportion

Most inventors lack that sense of proportion which helps a man to keep himself from looking the ass, as many of us really are. The same inventors are constantly bobbing up to the top, but there is a new inventor and a new one of genius, a new man with a fur coat. I wouldn't give a red cent for any invention unless at least one man, as the [illegible] [illegible] [illegible] [illegible], at the demonstration, wears a fur coat, or at least has fur collar and cuffs to his overcoat. He adds that we [illegible] that makes the inventor so sure he has fallen among [illegible] [illegible] [illegible] [illegible] of [illegible]. At one time it is a rotary engine. Now, of late years, there has sprung up a new development of rotary engines. Some of your [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] valves, has [illegible] [illegible] and [illegible] mechanical [illegible] [illegible] [illegible] [illegible] the [illegible] and make it [illegible] [illegible] for the benefit of the [illegible]. Some of these are [illegible] [illegible] [illegible] and [illegible] [illegible] there are new rotary engines that will work [illegible] [illegible]. And the hopeful inventor [illegible] up his little [illegible] [illegible], [illegible], [illegible] and [illegible], and in a few [illegible] he has shown you that you [illegible] the "[illegible]" it would knock [illegible] off the [illegible] [illegible] [illegible] [illegible].

Most of the men connected with these affairs are [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] of [illegible] and [illegible]. They [illegible] to me [illegible] the "[illegible]." A [illegible] [illegible] [illegible] [illegible] [illegible] when I [illegible] them a [illegible] of [illegible] and [illegible] [illegible] [illegible] [illegible] [illegible].

Then there is the [illegible] [illegible] [illegible], "in a peculiar adaptation of a [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] of [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] of [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]." At [illegible] [illegible] [illegible] [illegible] the [illegible] of [illegible] [illegible] that is [illegible] on my mind [illegible] [illegible] [illegible] of the [illegible]. [illegible] [illegible] [illegible] think of hiring myself out to some honorable promoter as a writer of prospectus catch sentences. Why should such a gift of language lie fallow? I think it a beautiful sentence. As a rule if one succumbs to the temptation to go and see the wonderful invention at work there is much to be learned.

This is a great city. I have been in it for twenty years and before we had so many tubes it was often better to walk when one was in a hurry, better even than a cab, for a cab always runs its head into a block and one is held ten minutes for the block to melt away. Of course, if you are a promoter you take a cab anyhow. Well, as I was saying, I have done much walking to save time, and as I carried the map in my head and a compass in my pocket, I could usually steer a direct course from point to point. Needless to say I thereby became acquainted with strange labyrinths. But for out-of-the-way concealed curiosities there is nothing so weird as the dens into which one penetrates in finding the home of the invention which is to revolutionize all our existing ideas and wreck so many prosperous manufacturers who have but little longer to palm their obsolete productions on a too confiding public.

It reminds me of when I was a child and had a toy consisting of a house and a sort of turntable with animals on it. The table revolved and a constant stream of animals went into what I suppose must have been a model ark. One hid from one's understanding the fact that the same animals recurred like a decimal; and so now when childhood No. 1 has gone away into the dawn of nothing the old turntable turns again, but in place of animals it carries rotary engines, and boilers and new types of all manner of furnaces and smoke devices, which are usually perfect but for the one essential without which none can be. There are water circulators and occasionally a perpetual-motion device cleverly cloaking its features behind some such beautiful veil of words as I have outlined.

A story is told of an absent-minded but learned man who bumped into a cow and raised his hat in apology. The true facts gradually sank into his mind and in a bit he ran down a lady. But now he was fully aware of the enormity of his previous folly and rapped out: "Is that you again, you brute?" And so with the stream of epoch-making inventions. You don't quite know whether to raise the hat to them or treat them as brutes, and the worst is that when the real lady invention trips along she receives the welcome of a brute, and unless the idealist inventor is of tougher material than most of his kind he usually gets no better treatment by the world than the inventor of the perpetual-motion crankiness.

W. H. Booth.

London, Eng.

Leak in Belt Driven Air Compressor

In the plant where I am employed we have a small belt-driven air compressor, supplying air at 80 pounds pressure to molding machines. The capacity of the compressor is about 35 cubic feet per minute. It has an automatic governing device which holds the pressure at any predetermined point within its capacity.

While on my vacation this machine refused to deliver the quantity of air needed and no amount of coaxing on the part of my assistant, who was in charge, would get it to do so. A machinist was called in, who stripped the machine and on using his caliper found the cylinder to be out of round about 0.005 or 0.006 of an inch. This he claimed was the cause of the trouble, and wanted the cylinder bored and a new piston fitted.

Upon my return a few days later I overhauled the machine, but could find no reason for the failure to do the work, as the cylinder, piston and rings were in good condition. I concluded that air was being wasted somewhere about the plant, and looked for leaks for several days. At times the pressure would go to 65 or 70 pounds and at others down to 25 pounds. Finally a search resulted in locating the trouble. It was in a beautifully arranged ventilating system using a sort of spray jet, having a head with nine 1/16-inch holes and was supplied by a 3/8-inch pipe with a valve to regulate the amount of draft. This device was not used all the time, which accounts for the fact that at times we could get our air pressure about up to normal.

The ventilating scheme was put in without my knowledge, or I should have known that it was the cause of the many hard names I had to stand for from the foundry foreman. The moral I have learned is, in case of failure of supply from no visible cause look for leaks. Also look for the inventive chap with a club.

O. M. Dow.

Lowell, Mass.

Drilling a Tank

In W. H. Wakeman's article on page 1085, Volume 29, he describes how he drilled the tank for his oil gage, using a board cut out as at *A*, Fig. 1.

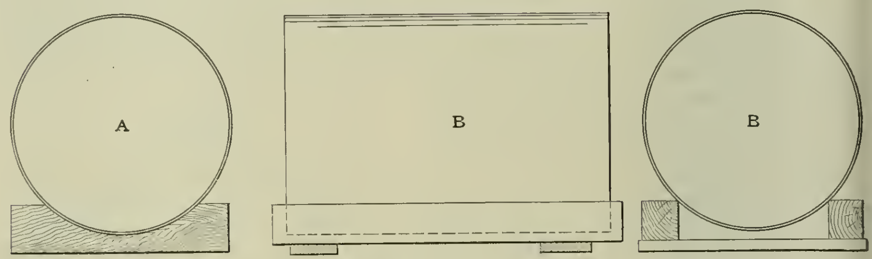


FIG. 1

This method is all right, but it is usually easier to take two pieces of 2x4 or 4x4 stock and fasten them together by nailing two strips or boards across the bottoms, as at *B*. In this way any size of cylinder can be fitted in a minute, and a bandsaw is not always available to circle out with.

If the cylinder or pipe has flanges on each end, the side pieces should be cut so as to go between them. Sometimes where the cylinder is long and the drill-press platen small, it is better to nail several pieces on the bottom.

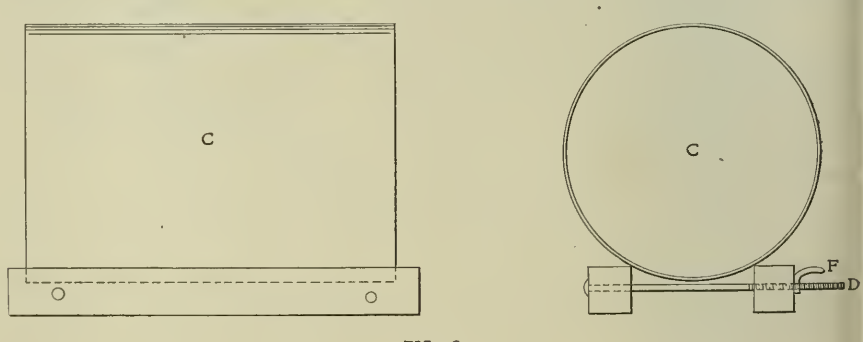


FIG. 2

An adjustable rig used in the repair department of a railroad shop is shown at *C*, Fig. 2. The 4x4-inch side pieces are conected by long bolts *D*, which have a rather loose-fitting "crank nut" *F*. These adjustable supports are not only handy for holding various sizes, but anything placed on them can be quickly leveled by working only one of the "crank nuts."

Ethan Viall.

Decatur, Ill.

Edwin Reynolds Dies After a Long Illness

Contemporary of Corliss and Superintendent of the Corliss and Allis-Chalmers Shops Passes Away at Milwaukee; Sketch of His Career

Edwin Reynolds died at his home in Milwaukee on Friday, February 19, after a three-years' illness.

Edwin Reynolds was born March 23, 1831, at Mansfield, a little town in northeastern Connecticut. He was descended from William Reynolds, who had come from England about 200 years before and settled at Providence, R. I. His father's name was Christopher Reynolds and his mother's maiden name had been Clarissa Huntington. There was a large family, six boys and six girls, and Edwin was next to the youngest. His father, though then a farmer, had been a cloth dresser and had on his place a fulling mill run by water power, but this had not been in operation within the boy's recollection. Edwin worked on the farm and went to the district school, his last schooling being in his sixteenth year, and then a change came in his life. He had up to this time little or no knowledge of the machine shops and nothing had turned his thoughts or inclinations in that direction. At the age of 16, Mr. Reynolds started out as a farm hand, engaging first with a neighbor for six months at $13 per month. He had worked only about a month when one day, as he was busy in the middle of a field, a man climbed over the fence and came to him. The man asked first if he was one of the Reynolds boys, and then whether he would like to learn the machinist trade. It was a new idea to him, and he had to think over it for a little while before he said that he would, but he immediately added that it would not be possible to begin just then, as he was engaged to this farmer for six months. The farmer was a reasonable man. On being consulted he said:

"Would you like to learn the trade, Ed?"

"I think I would," said Mr. Reynolds.

"Well, a trade is a mighty good thing to fall back on. I'll tell you what I'll do. You come and help me for a month in July and I'll let you off now."

THE LATE EDWIN REYNOLDS

So a three years' apprenticeship was begun with Anson P. Kinney, or Kenney, who had a general machine shop, with a specialty of sewing-silk machinery; several cards, or carding machines, also being built during Mr. Reynolds' apprenticeship. A country shop in 1847, we can well understand, was a crude affair. There was in the first place no foundry. The tools of the shop comprised one 20-inch engine lathe, one bench lathe, or, as we might now call it, a patternmaker's lathe, one vise and a circular saw. Some creditable machines were, however, turned out, and Mr. Reynolds' apprenticeship consisted largely in learning, not the trade as we understand it, but "how to do things without any appliances wherewith to do them." A memorable event of Mr. Reynolds' apprenticeship was the addition of a 16-inch lathe to the plant. Mr. Reynolds lived with his employer and their relations were more like father and son. His wages were [illegible] the first year, [illegible] and his board, the next year $45 and for the last year $60.

On the completion of his apprenticeship Mr. Reynolds worked as a journeyman for a year with Smith, Winchester & Co., of South Windham, Conn., who built paper machinery, and then he went as a journeyman to the Woodruff & Beach Iron Works, at Hartford, one of the large companies of that time, which built slide-valve steam engines and general machinery. While Mr. Reynolds was working there, Mr. Wright became engineer of the works, and they began the building of the Wright engine. No concern in those days, however, built engines exclusively, and the Woodruff & Beach works, among other things, turned out a lot of wire-drawing machinery, in the building of which Mr. Reynolds soon became a gang boss, eventually taking charge of all that line of work in the shop and in the erection of the machines after they were sent out. This connection continued for six or seven years, or until about 1857, when Mr. Stedman, of Stedman & Co., Aurora, Ind., who had been a classmate of Woodruff, came East looking for a superintendent, and Mr. Woodruff — as some other employers have nobly done, but as some would not have done—recommended his subordinate as precisely the man for the position, and so Mr. Reynolds went to Aurora as general superintendent. The silent partner of Stedman & Co. was a resident of Aurora—J. W. Gaff, a wealthy distiller and steamboat owner—and, with Grey and Gordon, the owner also of the Niles Tool Works. Stedman & Co. had a general machine-shop business, building also plain slide-valve engines, sawmills, farm machinery and pumps for Southern plantations. The designing of large pumps for drainage and irrigation was a promising field which Mr. Reynolds proceeded to develop. Patents of the old Andrews pump and others were offered the firm, but none showed or promised satisfactory efficiency, so Mr. Reynolds decided to design a pump, and in connection with this scheme he made some crude experiments, the results of which have been of value to him in connection with his largest and most daring work of later years.

The breaking out of the war between the States interfered so seriously with the business at Aurora that Mr. Reynolds found himself out of employment and came East, making Boston, New York and other places his quarters for the next few years. These were no more years of idleness than the others had been. He took charge of a shop in Boston for George T. McLaughlin, and besides that he was interested in the development of a number of special machines, either as designer or consulting engineer.

In 1867, Mr. Reynolds, who had become known as a manager combining technical knowledge with executive ability — then, as now, a rarity—was offered a commercial and engineering position with the Corliss Steam Engine Company, whose shops at Providence, R. I., were the largest and most important in the country, if not in the world, for the manufacture of steam engines. The Corliss plan of operations had from the first and always called for salesmen who distinctly were competent engineers. After four and a half years in this position, Mr. Reynolds was made general superintendent of the works, which position he held until 1877. He had not held the position so long without suggestions and invitations to change. His old friend, Mr. Gaff, and also Mr. Gordon, of the Niles Tool Works, tried hard to get him to take hold of that institution, offering an interest in the works on terms exceedingly favorable. Having declined this offer, the acceptance of a connection with the Reliance Works of E. P. Allis & Co., Milwaukee, Wis., may have a rather unaccountable aspect. The position held by Mr. Reynolds at Providence was then perhaps the highest in the engineering business in the United States. He went to the remotest corner of the manufacturing field, and connected himself with a firm practically unknown and in embarrassed circumstances. The firm had failed the year before; they had a ramshackle shop; the foundry, which had been fitted up for pipework, was of a piece with the rest; and, all told, only about 150 men were employed. It is scarcely probable that Mr. Reynolds foresaw what the business would so soon grow to, but he must have seen in it more or less clearly the opportunity of his life. Mr. Corliss had grown rich and dictatorial, seemed to believe that his word was law in steam engineering, and took the position, more or less pronounced, that any man who wanted the best engine must buy it of Corliss and must pay the Corliss price for it without question. In the meantime, Mr. Reynolds, as events would seem to indicate, had ideas of his own about Corliss engines and other things. He evidently believed that the original Corliss engines could be greatly simplified and improved, that he knew the way, and that the improvements, combined with correct business methods, must result in the building up of a great business. There may have been more than a little of sympathetic benevolence in it, also. Here was a concern in a bad way. Neither Mr. Allis nor his sons had engineering knowledge or ability. He could help them, assume an independent position for himself and find full employment for his teeming engineering ideas, and so he became the engineering brains of the Allis works.

It has been erroneously stated, on many occasions, that the attention of Mr. Allis was particularly attracted to Edwin Reynolds by the "Reynolds-Corliss compound engine" exhibited at the Centennial in 1876. As a matter of fact, however, this unit consisted of two simple Corliss engines compounded, and they were of the regular type built at the Providence shops. Further than for his being general superintendent of the works at the time, there is no reason particularly to identify Mr. Reynolds' name with that of the Centennial engine.

After entering upon his duties for Mr. Allis, the first and most essential thing was to place the business on a paying basis. This was done almost at once through the development of the "Reynolds-Corliss" engine, which has become a synonym for simplicity, economy and reliability, collectively expressed. The first engine was a 14x36-inch girder-frame Corliss stationary engine. It was sketched on the back of an envelop during a ride from Milwaukee to Chicago, after his first visit to the scene of what were to be his life's greatest successes. This design was not his best on general principles, but the best to build with the shop equipment at the time. This, it will be understood, was not only miserable, but there were no means at hand for the purchase of better. The first tool put into the shop after Mr. Reynolds took charge was an 8-foot boring mill, furnished by Mr. Reynolds' old friend, Mr. Gaff of the Niles Tool Works. Mr. Reynolds had to and did design the thing which it was possible to build in the shops as they stood, without spending a cent at first for equipment. It was necessary to compromise, not only with the machine shop, but more especially with the foundry, which was worse, and even the facilities, worst of all, for transporting the castings from the foundry to the machine shop had to be yielded to. The frame, then, was made in two parts, so it could be handled, so either right or left could be made from the same pattern, and so, in deference to the lack of skill in the foundry, the core work was reduced to a single simple core in the jaw. At a later time, when the demands of the business were growing faster than the facilities, the wrought-iron-frame engine was designed as a means of relief. The Reynolds engine of 1890 may probably be said to be the first design in which serious concessions have not been made to the facilities of construction or other imperative conditions. Mr. Reynolds' method of work has seemed to be first to make a careful study of all the conditions of the individual case, and first of all with reference to the underlying engineering principles. On these for a foundation he would work out the simplest machine possible, remembering always the possibilities of the shop as well as the idealities of the drafting room. This has usually practically ended the matter. Once the design has been decided upon, he has been prepared to fight for it, and usually successfully, and a very large part of the Allis business has been obtained, not so much by underbidding in price as by embodying the best engineering features.

It would be difficult to overstate the character and importance of the work that Mr. Reynolds accomplished during his unostentatious life. In brief, he was the foremost practical man, the responsible technical manager, in an engine-building establishment which, under his guidance, grew to occupy a position in the very front rank of reputation, and in point of magnitude to surpass all others in the United States. The machinery built by it has been of varied nature; it has included many large Corliss-engine units for pumping service, mining, air compressing, furnace blast, street-railway work and other purposes. In the name of the "Reynolds-Corliss" type of engine, this engineer received one of the deserved marks of recognition which raised him out of anonymity in his business relations with the public.

To him especially is attributed the use of compound and triple expansion engines in manufacturing plants, one of the first large ones employed for that purpose being installed by him in the Eagle Mills, at Milwaukee, in 1878. He was the first to build the low-speed direct-connected type of engine for driving a generator.

Among achievements of his life, long before the close, was the construction, in 1888, of the first triple-expansion pumping engine built for waterworks service, which he installed at Milwaukee, to run under a pressure limited to 80 pounds. The steam consumption proved as low as 13.84 pounds per indicated horsepower per hour. Some time later, two engines installed in the West Harrison street station, Chicago, showed a steam consumption of 12.67 pounds, which was believed to break the existing economy record. An engine built for Omaha, with 40-, 70- and 104-inch diameter steam cylinders had a capacity of 18,000,000 gallons in 24 hours, raised 310 feet. A 30,000,000-gallon triple-expansion pumping engine was built for the Boston waterworks, its installation being completed in December, 1898. It made the world's record for efficiency and economy of operation, its average consumption of dry steam per indicated horsepower per hour being 11.335 pounds, and its duty per 1000 pounds of dry steam, 178,497,000 foot-pounds. A 15,000,000-gallon triple-expansion pumping engine for the St. Louis works, also built by the Allis company, proved a close second, showing an average dry-steam consumption of 10.676 pounds and duty of 179,454,255 foot-pounds.

When constructing an engine for flushing the Milwaukee river with Lake Michigan water, Mr. Reynolds designed a propeller type pump, which was built against strong opposition, but the performance of which amply vindicated his judgment. The efficiency of the wheel was 86.75 per cent. The large centrifugal units for sewage plants, each driven by vertical shaft from a horizontal triple-expansion engine, with piston rods 120 degrees apart, originated in his fertile brain. The centrifugals were originally designed to handle Boston sewage.

Another product of his skill is the Reynolds ore stamp, in which he substituted a solid cast-iron foundation for the wooden spring bottom that formerly had been deemed necessary. The result was nearly 50 per cent. increase of output. This invention added much to the value of the great copper properties.

When he built his blowing engine for the steel works at Joliet, Ill., he stirred up the experts. Although his design marked a radical departure from previous types, its valuable features were recognized at once and received the contract. Andrew Carnegie ordered one like it before it had been running a month, this being the beginning of work for the same company that [illegible] years ago had amounted to $1,000,000.

Among other works of Mr. Reynolds was the combined horizontal and vertical reversing engine built for the American Steel and Wire Company, at Worcester. The cylinders of this engine were both high-pressure, 44x60 inches, the construction leaving one end of the shaft free for direct connection to the rolls and doing away with the gears, which have always been an objectionable feature.

An instance of the marvelously quick inventive genius of Mr. Reynolds was afforded when he designed the engines for the Manhattan elevated railroad, of New York. A staggering problem of getting a maximum of 12,000 horsepower in limited space and without undue weight on the bearings seems to have been very simply solved, and the weight of the flywheel was reduced one-half. This engine may be taken as illustrative of the building up of the Allis business by Mr. Reynolds. The contract was secured because as an engineering proposition the design submitted was so superior to others offered in competition that the price was a secondary consideration. As a sample of the confidence in Mr. Reynolds' judgment and skill, $3,000,000 worth of this type of engine were ordered in a lump before one of them had been built and erected. Regarding the circumstances attending the design of the Manhattan engines, the following anecdote is related.

The Allis-Chalmers Company, having built eleven 4500-kilowatt standard cross-compound, vertical, direct-connected engines for the Metropolitan Railway Company, was called upon for advice as to the type of engines to be used in the immense new power house then being planned by the Manhattan Railway Company in New York City. It was the intention of their engineers to install units of 8000 kilowatts capacity. The first type of engine considered was the cross-compound, vertical machine, similar to those furnished for the Metropolitan Railway Company, and some correspondence passed between Mr. Reynolds and the engineers of the Manhattan Railway Company on the subject, so that finally Mr. Reynolds was invited to visit New York and discuss the matter in detail. Mr. Reynolds left Milwaukee with the question of the type of engine still unsettled, but with the understanding that the straight cross-compound, vertical unit would be used if it were found practicable. Mr. Reynolds was traveling from Albany to New York when the question demanded his attention, and he was informed by telegram that a committee representing the owners of the elevated road would meet him at the Grand Central station. During the ride down along the Hudson he thought the matter over; then, as the train reached the Harlem, he hastily sketched on the back of a letter the substance of the plan ultimately adopted, including the practically unique design of the horizontal-vertical, four-cylinder compound engine, with cylinder sizes and approximate dimensions of all other principal parts, such as crank pins, crosshead pins and main journals. When the work came to be laid out on the board, there was very little variation from his original figures. At this time, Mr. Reynolds, in common with the engineering world at large, was [illegible] to see similar engines installed in all important urban stations where [illegible] were an important consideration; but the steam turbine was then beginning to demonstrate something of its possibilities, and many large projects were held back until the merits of that type of prime mover could be more definitely determined, with the result now universally known.

Mr. Reynolds' ability was not evidenced by his engineering successes exclusively. He was also the man of business. It was by the combination of engineer and business man and all-round manager that the enterprise with which he was connected has so marvelously grown. He was held in the highest esteem by Mr. Allis. In the will of the latter, who died about the beginning of the nineties, he was named as one of the trustees of the Allis estate. Upon the reorganization of the business, which followed, he was elected director and second vice-president of the E. P. Allis Company.

In 1901 the Allis-Chalmers Company, with $50,000,000 capitalization [illegible], was formed to consolidate the E. P. Allis Company, Fraser & Chalmers, Gates Iron Works and Dickson Manufacturing Company. In the organization Mr. Reynolds played a prominent part, being a director and the chief engineer of the new corporation. This gave him the opportunity of laying out at West Allis, a suburb of Milwaukee, the great engineering and machinery building works which constitute one of his greatest monuments. It is so constructed that it never can be what was Mr. Reynolds' personal aversion, an "accretion"—the adding on of one building or bench after another without proper sequence. Instead, it is built throughout on the unit system, the extension of general works being capable of indefinite extension toward the "rear" with [illegible] for the corresponding machine shops to be at right angles between them.

In the fall of 1905 Mr. Reynolds retired from active service, with the title of consulting engineer, and, although in failing health, he maintained a hospitable [illegible] in his beautiful residence on the bluffs overlooking Lake Michigan, loved and honored by all his associates.

Mr. Reynolds was interested in various business undertakings outside of the Allis company, being president of the [illegible] Mills, Milwaukee Boiler Company, [illegible] Mining Company.

The University of Wisconsin conferred upon him the degree of LL.D., and later placed his name upon the frieze of the new engineering building. He has received honors from institutions of learning throughout the civilized world. His election to the presidency of the American Society of Mechanical Engineers for 1901-1902 was a recognition of his eminence in the profession, which the society honored itself by conferring. He was received into active or honorary membership of the leading engineering societies at home and abroad, and he became the first president of the National Metal Trades Association.

The influence of Edwin Reynolds remains expressed not only in mechanical types, but in human personalities. To be a brilliant designing engineer, particularly in the field of power generation and application, is a matter of self-gratulation to anyone so gifted, and is a benefit to many affected by his work; but to lead the way so plainly that others may follow with no uncertain step, to train a large number of young assistants so that they become efficient, original co-workers and themselves the chief officers of engineering works, and to found, develop and leave in sound condition a great manufacturing establishment—such is the province of a master mind, one of the few which a century produces.

A good paint for boiler fronts can be made from asphaltum let down with turpentine or coal tar mixed with graphite and thinned with turpentine.

That Harwood Boiler

In our issue of December 15, under the title "The Lap Seam Boiler Again," we described the finding of a cracked sheet in a boiler belonging to the Charles E. Harwood Counter Company, of Lynn, Mass. The engineer noticed steam coming through the brickwork, put the boiler out of commission, and inspection showed that the middle sheet had cracked. Our original article said: "Removal of the brickwork over the leak revealed a crack 18 inches long in the outer sheet along the row of rivets," and the article assumed that it was one of the hidden cracks the recurrence of which has caused so many failures of lap-seam horizontal tubular boilers.

SHOWING CRACK IN SHEET OF THE HARWOOD BOILER

In our issue of December 22, Arthur M. Clawson presented a more detailed account of the accident in which he said: "The crack was not located under the lap as has generally been found to be the case, but ran parallel to the edge of the overlapping plate."

We have recently had the opportunity to inspect the plate in question, which is in the office of the chief boiler inspector at the State House in Boston, and have obtained the photograph reproduced herewith. The crack is shown in the upper left-hand portion of the sheet just under the lower row of rivets and is very plainly one of the hidden internal cracks occurring, as is usually the case, just under the edge of the rivet heads and so hidden by the inside sheet as to be impossible of detection by any inspection short of unmaking the joint.

Saving Life and Property

The American Anti-Accident Association held open meetings Thursday afternoon and evening, February 11, in the Y. M. C. A. hall, 215 West Twenty-third street, New York City, for the purpose of presenting and receiving ideas as to the true underlying causes of accidents, the best way to prevent them, and incidentally to augment the number of its members.

It is the intention of the organization to establish boards in our towns and cities that would be under the control of the State, with a national head, and similar in a great many ways to our present boards of health. Its purpose is the education of carefulness in homes, schools and vocations, to develop a greater realization of the suffering and afflictions caused by accidents, and to create a public sentiment which in time will cause anything pertaining to the prevention of accidents to command the highest humanitarian consideration. Thomas D. West, president, discussed the fundamental features involving work for the association, and other speakers, such as Edward Bunnell Phelps, editor of *The American Underwriter*; W. H. Tolman, director of the American Museum of Safety, and L. P. Alford, of the *American Machinist*, took up the subject of accidents and their prevention in its different phases.

Some Useful Lessons of Limewater

Interesting Experiments in Softening Temporary- and Permanent-Hardness Waters; the Importance of Chemistry; Its Chief Elements

BY CHARLES S. PALMER

There is one suggestion that may well be made at this point; that is, that you will save time and effort in getting things cleared up and in remembering things if you just *talk* these lessons over with some friend who is interested with you. The reason for the gain is that you will talk your notions out, and you will hear the notions of your friend; you will find your eye, ear and hand working together to help your mind in grasping the facts, in remembering them and, most important of all, in using them. But to get back to the hard water.

FIG. 1

Softening Hard Water

Get two large bottles of clear glass. Common quart bottles will do, but if they are large enough to hold several quarts, so much the better. Pour into one of these, until three-quarters full, a solution of temporary-hardness or carbonate-hardness water, throwing in with it two slips of litmus paper, one red and one blue. Pour into the other bottle, until three-quarters full, a solution of permanent-hardness or sulphate-hardness water, also putting in two similar slips of litmus paper. You may not get many surprising results from the litmus paper, but you will have the satisfaction of knowing that you have kept your eyes open in that direction, and litmus paper will always tell you something. If the solution of carbonate-hardness water is strong with carbonic acid, you may almost get the litmus paper red, but you should remember that litmus paper turned red by carbonic acid will turn blue of itself usually, if taken out of the solution, as it dries in the air; because carbonic acid is volatile and is driven off by the [illegible] acid in the litmus itself. We will return to this subject of litmus paper a little later, for it teaches one much about the acid and the base parts of "salts."

Now throw into the bottle of temporary-hardness water or carbonate-hardness water about a teaspoonful of milk of lime, shaking the bottle well, and letting it stand. You want to learn how to add just enough of the milk of lime to soften the water by Clark's process, and there are different ways by which you can tell this. One way is to let the water settle clear, pour out a few drops and add some filtered limewater; if there is still any carbonate or bicarbonate of calcium in solution, there will be a slight milkiness; and you keep on adding the milk of lime until there is no more milkiness on adding filtered limewater to the clear hard water. Another way to tell whether you have added enough milk of lime to the temporary-hardness water is to watch the litmus paper; as soon as you have added just a bit too much of the milk of lime, the water will change the litmus to blue, because the milk of lime is itself a turbid solution of limewater. To the bottle of permanent-hardness or sulphate-hardness water you will add a solution of soda ash (or sodium carbonate or washing soda; they are all essentially the same thing). You will also know in this case, as in the other, when you have added enough soda ash. Let the water settle clear, and then test a few teaspoonfuls, poured out into a tumbler, with some of the soda solution to see whether there is more precipitation. Keep this up until you get no further precipitate; also watch the litmus paper, it may tell you something.

Now let both bottles of hard water settle, noting the time required to get clear solutions. It may take some hours, sometimes nearly a day or even longer. All this will start you to do some thinking. It will suggest that large settling tanks may be necessary. It may suggest that it will pay you to look up some of the newer ways of clearing hard water. There are some patented methods, with some merits and in some localities, to give really good results; but all this will help the selling agent give you a scientific explanation for what he tries to do, and which he may really be able to do. You will note that the chemistry of softeners is one thing that you have begun to study. You also note the time taken for the water to settle, but it will be well for you to try the settling, sizes and tanks; these things sometimes make all the difference in the world.

But there is another thing that you need to notice; that is the way to mix the softener with the hard water. It is one thing for you to add a teaspoonful to a bottle which you can shake up with your hands; but it is quite another matter to mix a pailful of the softener with a [illegible]-gallon tank of water. It is worth while for you to study how this mixing is to be done. Will you feed the softener [illegible], the water supply to a constant [illegible] stream? Or will you throw in a bucket or barrel of it at a time? The special form of apparatus must attend to all these matters and must do it right.

Then there are some of the other things which get into "hard" water; for, as we have noted already, it is not alone lime and its compounds that make water hard, but often the compounds of magnesium, and perhaps one or two other metals. Also, while much temporary-hardness water has to do with carbonates and much permanent-hardness water has to do with sulphates, yet there are some other complications, such as the *chlorides* of magnesium, which are not only difficult to throw out of the water but which also corrode the boiler iron. As you examine the samples of scale which you will collect you will find some iron in all of them, and this iron stain is or may be partly from the water, and partly from the iron tubes or plates themselves; so you see that all scale is not only in the way, but it is also a corrosive, eating thing. All this suggests that there is much to be learned about the scale-forming substances, and this means that we must use this study of lime as a broad basis for getting hold of enough chemistry to understand the action of both scale formation and burning. And, in the study of burning or combustion, or "oxidation" in its broadest way, we shall have to dip into *wet* chemistry, and *dry* chemistry, for there is a dry combustion and there is a wet or moist combustion. All of this, or some of it, will come along in due time.

But just now turn your eye to the experiment shown in Fig. 1 and note the amount of sediment which has formed or gathered in each bottle. You will see that in both bottles there is the *same* insoluble sediment, plain carbonate; and you must stop and think how it is that you get the lime-like part of the hardness thrown out of solution from either temporary- or permanent-hardness water, as this same old plain carbonate. You will remember that this plain carbonate of lime came from the extra carbonate, by heating or by addition of limewater or milk of lime; and you will see that you get this same plain carbonate from sulphate water and soda ash. But in the case of the temporary-hardness water you left the water nearly pure, while in the case of the permanent-hardness water you had to leave the water as a dilute solution of sodium sulphate.

Testing the Sedimentation

It will be a good thing if you collect the sediments from both the bottles shown in Fig. 1 and test them. First, just note the relative quantity. You will usually find that there is more sediment from sulphate-hardness water than from temporary-hardness water, although both are the same chemical compound, plain lime or calcium carbonate. Again, you will want to test both of the sediments with hydrochloric and nitric acids, when they will entirely dissolve with effervescence; that is, bubbling of some gas which you will rightly guess is carbonic-acid gas. Now if you test the clear solution left in the bottle that had the temporary-hardness water you will find that it is nearly pure water, with a little lime from the slight excess of milk of lime; but when you test the bottle of purified permanent-hardness water you will find that it has considerable sulphate of soda (Glauber's salt) in it. The sulphuric part you can test for by the same way used in the test given near the last part of the third lesson in the February 16 number.

You pour a few teaspoonfuls of the water left in the permanent-hardness water of Fig. 1 into a tumbler or test tube, and then add a few drops of your solution of barium nitrate. Down comes a quick cloudiness, which soon settles as a heavy sediment. Now try this with either hydrochloric or nitric acid, or both; its persistent insolubility shows that it is barium sulphate, the common test for sulphuric acid or the sulphates. But there is still the sodium part of the

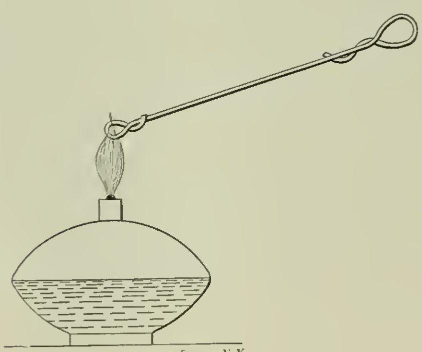


FIG. 2

Glauber's salt, left from the softening of the permanent-hardness water, to test for. It is not easy to throw the sodium out of solution; but if you take a clean bit of iron wire and moisten it with some of the solution of sodium sulphate left from the bottle of permanent-hardness water and then hold it in the flame of an alcohol lamp (Fig. 2), or of a common gasolene or gas stove, you cannot help noticing the strong *yellow* flame produced, and that is due to the sodium. You can always get this yellow flame from any of the sodium compounds, but you cannot easily throw sodium down from solution. Indeed, it is one strange peculiarity of sodium that of all of its hundreds of salts about all of them are soluble in water, and you will find when you get on farther into analyzing things that there is no good, easy way of throwing sodium completely out of solution in the insoluble form, as you can easily do with lime in a score of ways.

Chemical "Elements"

You will have a good deal to do with analysis as you go on with these lessons, and with other studies in chemistry later; for live as long as you will you will never get beyond the study of chemistry, which is the separating of things into their ingredients, putting back those ingredients so that you can get the original substance, the letting of this substance act on that and the reaction of that on this. From the air and water to the earth everything is made up of chemicals, and the curious ways in which things act on each other make up the study of chemistry. As you begin to separate things into their ingredients you get simpler things, and these can be separated into still simpler things, and so on. But before long, you come to a set of things that can't be separated into anything simpler, and those things are called "elements."

There are between seventy-five and a hundred of these elements, but only about twenty or twenty-five are of common importance; and you will have to do with only about a dozen at the start. You have had something to do with the element carbon, which makes up the bulk of coal, and which also is in carbonic-acid gas. You know sulphur, or brimstone, which is the thing at the bottom of sulphuric acid or oil of vitriol—sulphur is another element. The air is mostly made up of two gaseous elements: Nitrogen, which for the most part in the air is only a "filler," as far as burning goes, and oxygen, the element that helps burning. The common metals, iron, lead, zinc, copper and tin, the less common mercury, silver and gold, the new metal, aluminum, these are all elements; they cannot be separated into anything but themselves; at least, not up to date, for in these piping times of new and strange discovery it is not well to say that anything is impossible to the thousands of chemists who are hard at work after the secrets of nature. But if the elements are made up of anything simpler they have forgot to say anything about it, except possibly in the curious cases of uranium and radium; all of which has apparently little to do directly with hard water, but a great deal indirectly, because you want to learn analysis, so you can find out for yourself what are the ingredients, and what are their relative quantities, in the substances you handle every day.

You perhaps have never seen or handled the metal sodium, also an element; but you may like to be reminded that it is probably the stuff which the street fakir on the corner uses to light his pipe when he seems to light it with a bit of ice. He packs his pipe with common dry tobacco and tucks down on top of this a piece of the metal sodium (or perhaps of potassium, which is much like sodium, only stronger); then he touches the "quick" metal with ice, which is only so much solid water, and the heat resulting easily makes fire enough to light the tobacco. Theory says that when metals like sodium and calcium unite with oxygen they should first form the oxides, and calcium does form its oxide, CaO, quicklime, but sodium's oxide is so thirsty for water that it does not stop at the oxide, as calcium does, but at once goes right on to the water compound, NaOH, sodium hydroxide or hydrate, or caustic soda. That the lime metal, calcium, does form both the plain oxide (quicklime, CaO) and the slacked lime, $Ca(OH)_2$, is interesting (as shown in the February 23 number). It is also interesting to know that there is a flame test for this lime metal, calcium, just as there is a flame test for the salt metal, sodium. Take a little of the milk of lime and add just enough hydrochloric acid to it to dissolve it all and leave it barely acid, or nearly neutral. Of course, you now have a solution of calcium chloride. Now make a loop of clean iron wire, as shown in Fig. 2, dip it in the lime solution, and hold it in any colorless flame, as the flame of an alcohol lamp (you can make an alcohol lamp out of an ink bottle), or of a gas stove, and note the bright orange-red flame. That is the calcium flame. There is a special and a beautiful scheme of studying flames (with an instrument called a spectroscope), the science is called spectrum analysis; but these tests of sodium and of calcium are two of the fundamental tests. You can carry this testing of metals on quite a way by yourself, if you file any metal, iron, copper, zinc, lead, tin or silver. Gathering a pinch or two of the metal dust on a sheet of paper, sprinkle them, one at a time, in any hot and fairly colorless flame. You will be surprised to see what elegant and beautiful "parlor fireworks" one can get by simply burning the filings of any common metal in a hot flame; the dust will burn like powder and with a different colored light in each case.

This all goes to show how great is the subject of chemistry; but it will help us if we stop and ask ourselves: What are the really great and important subjects in chemistry? We will not let ourselves get confused by any absurdly complicated answers, but we will stick to a few fundamentals. The great subjects in chemistry are: First, *fire* and *water*; second, *acids* and *alkalies*; and of the acids, sulphuric acid is easily king, as the soda compounds make the queen set of alkalies. But in much of all of this you will find our good friend lime plays an important part. The story of lime has only been begun.

On page 64 of the January 5 number, in John B. Sperry's letter on "Pump Suction Limit," the second half of formula

A_s = *Total suction limit* =

$$H = \frac{v^2}{2g} + F_s$$

is erroneous. It should have been

$$H + \frac{v^2}{2g} + F_s$$

Central Station versus Isolated Plant

As bearing upon the vexed question of the extinction of the isolated plant by the central station, we reproduce the following open letter addressed to the Public Service Commission of the State of New York by Percival E. Moses:

Gentlemen: The question of rate discrimination as between the large and small consumer is presented for your consideration. So far the result of your rulings and investigations on this subject has been twofold:

1. To make the methods of discrimination matters of public record.
2. To make the discrimination practised between various classes of consumers equal as between classes.

"Do you mean to stop here and leave the main question unsettled?

"On behalf of the great majority of users of electricity, and of all whose interests are connected with isolated plants this plea for a 'square deal' is presented. Let the selling price of electricity be based upon the cost of manufacture and distribution plus even a liberal profit and let the present system be stopped of charging on the basis of 'all the traffic will bear.'

"Under present methods the user of a small quantity of electricity is charged three or even four times the rate charged the user of a large quantity, because the small user has no competition to offer, while the large user has, in the shape of the isolated plant.

"Occupants of lofts in large buildings where isolated plants are a possibility, by combining with the owners pay from 5 cents down per kilowatt-hour, while occupants of lofts in small buildings where isolated plants are not economically possible have to pay 10 cents per kilowatt for light and from 10 cents to 6 cents for power. Owners of small stores are charged 10 cents per kilowatt-hour, while owners of large stores pay as low as 5 cents. Apartment-house residents pay 10 cents if the building does not use 150,000 kilowatts per year, but if it does use this quantity the electricity they use is paid for at 5 cents per kilowatt-hour. In all the foregoing instances the cost of manufacturing and supplying electricity to the small users is substantially the same as the cost of manufacturing and supplying electricity to the large user. Where, then, is the justification for a variation in the charges?

"A certain difference in rates between current used during a short period and current used for a long period per day is justifiable because of greater fixed charges per kilowatt-hour supplied, but there can be no justification for any discrimination based on the total quantity of electricity used.

"The Edison and the other companies operate under a monopoly granted by the whole body of citizens, and it is easily understood that all citizens shall be treated equally. Where is, then, the justification for the unequal rates to small and large consumers?

"Mr. *Jones*, occupying a store room, with 20 lights costs the company, let us say, 10 cents—not 10 per cent.—to supply per kilowatt of use than Mr. Smith with 2000 lights. Yet Mr. Jones will pay 10 cents and Mr. Smith less than 5 cents per kilowatt-hour. When Mr. Jones goes home to his small apartment he will again pay 10 cents per kilowatt-hour, but Mr. Smith, if he lives in a big enough building, will pay, or his landlord will pay, only 5 cents per kilowatt-hour. The cost to the Edison company is exactly equal in each case. Is this condition to be continued? If so, why?

"If the Edison company can manufacture and sell current for lighting to the large users, apartment houses, or hotel or other building for from 4½ to 5 cents per kilowatt-hour, the rates to small consumers are far too high and they should be reduced to the rates charged the large consumers for the same kind of service irrespective of the total amount of their use."

Burning Ash

The statement that coal should be burned as completely as possible when it is first on the grates, and that the practice of refiring ash as it is often done is seldom of greater loss than it is of economy, is well borne out by the following results of recent tests conducted in the Arthur D. Little laboratory at Boston.

Just previous to these tests some of the grate bars had burned out very rapidly and allowed a considerable amount of coke and siftings of coal to be taken out of the ash conveyor.

The better part of the ash pile was returned to the coal conveyor and delivered to the bunkers, where it was mixed with the coal and was being returned at the time. At first thought it was considered as the proper thing to do, but a sample of the coal and ashes being sent to the boiler indicated that there was a considerable increase in the percentage of ash in the coal being fed and that the loss due to unburned coke invariably increased with this, so that instead of sending to the stokers New River coal which contained about 6 per cent ash the mixture contained 11.79 per cent ash.

The ashes and refuse being taken from the ash conveyor contain 20 per cent. of combustible, corresponding to a loss of 8.5 per cent.

From these analyses and the analysis of ashes being put into the coal bunkers, the chemist suggested discontinue the practice of ashes being added to the coal, as was done in the past.

POWER AND THE ENGINEER

DEVOTED TO THE GENERATION AND TRANSMISSION OF POWER

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March 2............... 42,000

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Contents PAGE

Edwin Reynolds

The death of Edwin Reynolds, announced in another column, has not come unexpectedly. For several years after he had passed the allotted span he continued in active charge of the great Milwaukee works in the creation of which he was so large a factor. But, three or four years ago he began to fail, and his friends have long known that the end was imminent.

The story of his life, as told elsewhere in this paper, is that of another rugged genius who, without exceptional advantages of birth or education, threw himself into his work as he found it, did it not merely for so much per hour but because his interest was there—because he loved to do a good job and to see it *go*—and he naturally became a power in a field where there was a great development and developed with it. It was largely he who molded the slower-speed and larger-sized engine into the forms demanded of it through the successive changes of the development of large central-station work, and who stood ready to adapt the materials of nature to the varying demands of man. The great works which he planned for this purpose, as well as the many notable products of this and other works with which he has been connected, will be living monuments to his genius and industry.

Foundation Vibration

Vibration from generating units causes more or less annoyance in office buildings, and is due to the condition of the soil upon which the foundation is built, the unbalanced condition of the engine and, possibly, unequal distribution of load in the cylinder.

Many unique methods of preventing vibration transmission have been devised with more or less success. In one instance the ingenious engineer carried out the scheme of building a scow upon which were placed a small engine and generator that had given trouble from vibration. The scow was placed in a tank of water, and although the idea cost money it prevented all vibration from being transmitted to the building.

In another instance the engine was to be placed in the basement of a building built on a ledge. In order to overcome the transmission of vibration from the engine a portion of the ledge where the engine was to be set was cut away and a layer of asbestos felt placed under and around the engine foundation, which was then built in the usual manner.

These methods of preventing transmission of vibration have been confined to reciprocating engines, but from recent advices it seems that it has been deemed advisable to take precaution against this trouble in steam-turbine operation. At St. Pancras, England, the borough council has recently put in operation a 2000-kilowatt steam turbine mounted on a special rubber foundation as a precaution against vibration, such as has given trouble from reciprocating engines.

An ordinary concrete foundation has been built, upon which rests the turbine with its rubber foundation. The turbine is bolted to a slab of concrete about two feet thick, which is reinforced by steel bars, and between this concrete slab and the foundation proper are placed a number of 4x3-inch circular rubber pieces. No part of the turbine or concrete slab above the rubber pieces is allowed to come in contact with the floor, thus preventing any possibility of vibration being transmitted to the building.

From what is known of steam-turbine operation this precaution would seem unnecessary if the machine is in proper balance, and there is no reason why it should be put into operation until it is. In justice to the contractors of this installation it can be said that they were willing to guarantee that the turbine would run without vibration.

Cultivate the Habit of Observation

To see without noticing is one of the commonest habits of mankind, and this fact has been taken advantage of by a class of men who call themselves "Business Doctors." They have cultivated and improved the faculty of noticing what they see. They go into business houses and industrial establishments and, without previous experience in any particular line, except that of observation, put their fingers on sources of loss. Under their direction, methods of business are reorganized and industrial establishments are remodeled. Wastes are stopped, losses reduced and production increased. Members of this same class of men have turned their attention toward the power house, and lubricating engineers, combustion engineers, supervising engineers and what not are looking for revenue from the mistakes of carelessness and ignorance on the part of the operating engineer.

Claiming to have saved in some instances as much as ten per cent. of the total fuel used in large industries, by intelligent use of the right kind of lubricating and cylinder oils, the lubricating engineer is able to interest the man who pays the coal bills and he often makes good, because the engineer has not noted the things which he has seen while attending to matters of lubrication. Altogether too often with the engineer oil is oil, and as long as bearings do not unduly heat one oil is just like any other oil. Observation is the long suit of the lubrication expert and he notices every spot where oil is used and how it is applied, and he gets from an apparently simple glance at things in general an amount of information that the engineer would not acquire in a lifetime, because he naturally notices only that which is out of the ordinary, while the habit of observation cultivated by the expert teaches him to see all that is not ordinary in ordinary things.

Sometimes the engineer uses new oil on a part of his plant and filtered oil on the rest of it. Sometimes all of the new oil used in a plant is added to the oil already in the filter as makeup oil and only oil from the filter is used for lubrication. But how often does the engineer know or even think whether the machinery under his care runs with less friction in one case than in the other? In an installation of five hundred or more horsepower, a saving in the amount of friction of even one per cent. is an item which is well worth looking after, and the ignorance of the man who directs the oiling of this plant is the opportunity of the lubricating engineer.

In the boiler room it is the same. Improper and unintelligent methods of firing may obtain, cold air may seep through the known or unknown cracks and openings in the boiler setting, lowering the furnace temperature and the temperature of the products of combustion before they reach the heating surfaces of the boiler, reducing the efficiency of the plant.

Through various channels, the outsider is invading the field that belongs especially to the engineer and with more or less success as the engineer is alert or inert. Obviously, the moral pointed to is that the man who is in the power plant and responsible for its operation should know more about every detail of its operation than any outsider, however well trained he may be. Special knowledge comes only as the result of special application and the engineer has better facilities for special study of his own plant than any other man in the world and should take advantage of them.

State Supervision of Boilers

Even those who most loudly decry paternalism on the part of the State, and governmental interference with the prerogatives of the individual, will not deny the right of the State to insist that steam boilers shall be used under such conditions as not to menace the public safety.

The Massachusetts law contains a provision for a Board of Boiler Rules consisting of the chief of the boiler inspection department, one representative each of the boiler-using, boiler manufacturing and boiler insurance interests and an operating engineer. This board is directed "to formulate rules for the construction, installation and inspection of steam boilers, and for ascertaining the safe working pressures to be carried on said boilers; to prescribe tests, if they deem it necessary, to ascertain the qualities of materials used in the construction of boilers; to formulate rules regulating the construction and sizes of safety valves for boilers of different sizes and pressures; the construction, use and location of fusible safety plugs, appliances for indicating the pressure of steam and the level of water in the boiler, and such other appliances as the board may deem necessary to safety in operating steam boilers."

These rules, when approved by the governor, have the force of law and several sets have been promulgated and reproduced in part in our columns.

It is now contended by some of the boiler manufacturers that certain of these rules transcend the authority of the board in that they are not essential to safety, and efforts are being made to have them repealed. Those to which objection is specially urged are:

Rule 11, sections 2 and 3, specifying that fusible plugs shall be placed in a tube not less than one-third the length of the tube above the lower sheet.

Section 4: "This board does not recommend the use of externally fired boilers over eighty-four inches in diameter."

The specifying of standard sizes of manhole and handhole and prescribing their location.

The requiring of horizontal return-tubular boilers over seventy-eight inches in diameter to be supported from steel lugs by the outside-suspended type of setting.

The requiring of the feed pipe between the check valve and boiler to be of brass.

Another proposed amendment is for the purpose of exempting the boilers of steam fire engines from inspection, and another the exemption of attendants upon boilers and engines used for horticultural purposes from examination and license.

The board requires builders of boilers built in or coming into the State to fill out a report giving sizes and full particulars, including destination, to the end that the department may have a record of every boiler from its setting up to its [illegible]. Another proposed amendment is to the effect that the data so required shall be simple in form, including only information necessary to be known for public safety, and that the manufacturer or person making such report shall not be required to furnish the name of the purchaser or the location of such boiler.

Another proposed amendment provides that the governor shall give notice and hearings before approving rules, and that anybody making or using boilers who shall feel aggrieved or injured by any of the rules may petition the superior court for the annulment of the rule.

Still another amendment to the bill, [illegible] decrees that the board shall make such rules only as are necessary for public safety and revokes all rules heretofore issued not so necessary, without saying who shall decide.

We have had a recent opportunity of examining the system of standardization, inspection and record inaugurated by the Massachusetts department. It is possible that in some respects it does transcend the bounds prescribed by a simple provision for the public safety. A boiler may be perfectly safe with a manhole varying in size from that which the board has adopted as standard and the use of which is prescribed by the rules, and if the case were taken to court it might be found that even the legislature cannot compel a man to use an 11x15 or 12x16 manhole if he wants to use some other size. At the same time a wide variation from these sizes is not practicable in one direction, on account of inadequacy for a man of ordinary size, and in the other for safe and practicable reinforcement of an abnormally large opening in the shell. The rules allow a variation of half an inch in the foregoing dimensions giving a range of from 10½x14½ to 12½x16½, which ought to cover any exigencies of practice, and the advantages of standard sizes does not have to be explained to those who have had to hunt the town for a gasket or to replace a broken plate.

Much is being made of the regulation that brass feed pipe shall be used between the boiler and the check valve, but in view of the proneness of iron pipe to corrosion and scaling up, and of the possible serious consequences of a breaking out or obstruction of this pipe inside of any valve or possible means of shutting off, is not brass pipe better and safer? It requires only a nipple between the check valve and the boiler to comply with the rule, and the tendency which would be induced to put the check valve nearer the boiler is also in the direction of safety.

The right of the board to require information of new installations is indisputable, and if they are reported the department learns in that way of the destination and location of all new boilers whether made in Massachusetts or imported. Why, then, should the manufacturer object to reporting the destination or purchaser of a boiler as well as its dimensions and proportions?

It would be well enough to provide for hearings by the governor before he approves rules, but protests should be first made to the board, and if the protestants were not able to convince the board of the injustice and inadvisability of a rule it is unlikely that they could convince the governor to withhold his approval. [illegible] necessary [illegible] and manufacturers of the country [illegible] necessary in the [illegible] tion."

Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

International Harvester Gas Engine

The engravings presented herewith illustrate the details of the latest two-cylinder vertical gas engine manufactured by the International Harvester Company of America, Chicago. As apparent from Fig. 1, the design conforms in many respects to standard construction for vertical single-acting four-stroke-cycle engines, having an inclosed crank case and splash lubrication, valves in the cylinder heads operated by push rods and rockers, and a flyball governor controlling the admission of mixture to the intake manifold. In working out the details, however, absolute interchangeability of parts has been the guiding principle, and there are no "rights and lefts" in its construction. Any piece used for any given purpose on one cylinder may be used equally well on the other, and the positions of the cylinders themselves may be transposed at will.

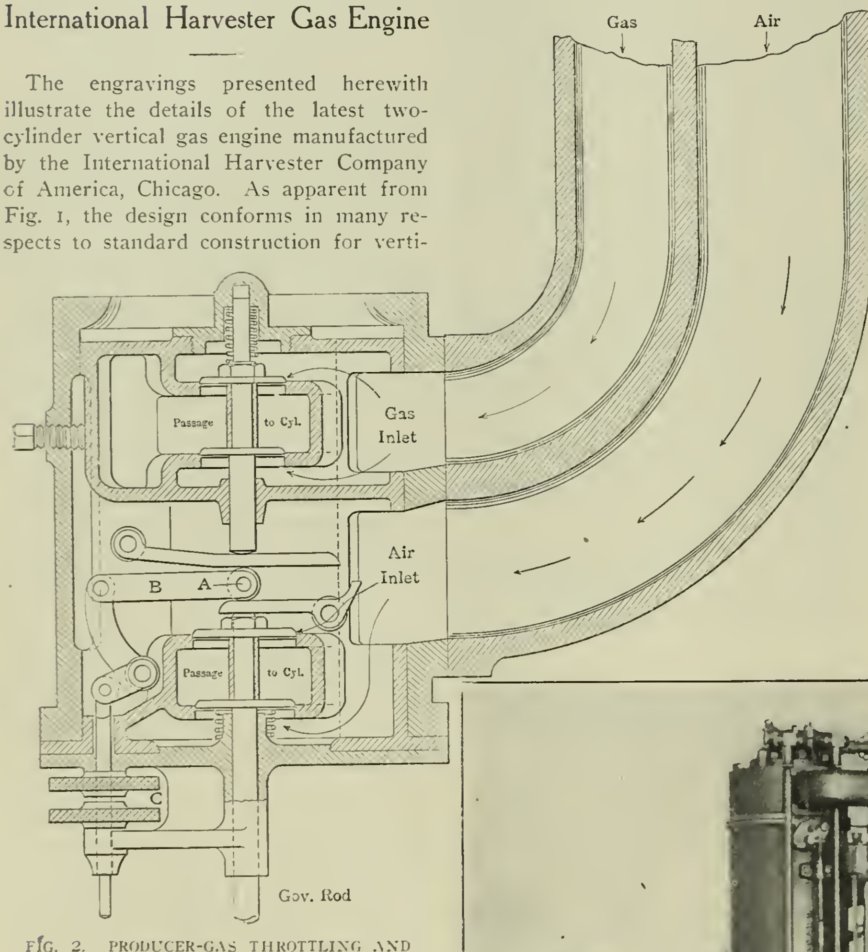


FIG. 2. PRODUCER-GAS THROTTLING AND VALVE MIXER

As shown in Fig. 5, both the inlet and the exhaust valves are in the cylinder heads, and both are mechanically operated from a half-time cam shaft located in the crank case. One size of valve cage is used for both inlet and exhaust valves, and the cages are held in place by two large studs instead of several small ones. To reduce the velocity of the entering and outgoing gases in the valve ports, the valves are made as large in diameter as consistent with the size of the cylinder. The inlet valves are integral with their stems, but the exhaust-valve heads are screwed on their stems to permit renewal of a disk alone if it should become necessary.

Regulation is effected by throttling the mixture of gas and air according to the load requirements. The governor is gear-driven from the cam shaft and is equipped with a spring mechanism designed to take up the shock and jar caused by the cam action. The vertical governor spindle, which extends up through the crank case, as shown in Fig. 5, carries three lugs, which correspond to three similar ones on the governor yoke. Between these two sets of lugs are interposed coil springs, so that the governor-valve stem is not affected by momentary changes of speed due to shock or jar, backlash of the gears, or other similar causes.

Fig. 2 shows in section the combined

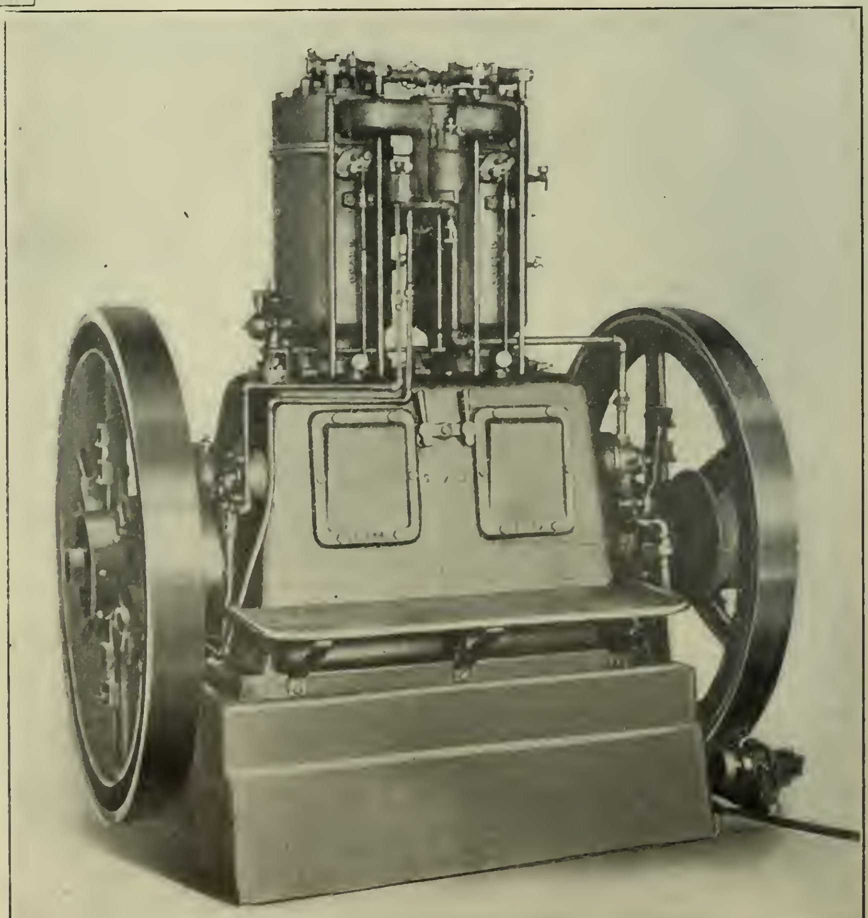


FIG. 1. INTERNATIONAL HARVESTER COMPANY'S GAS ENGINE

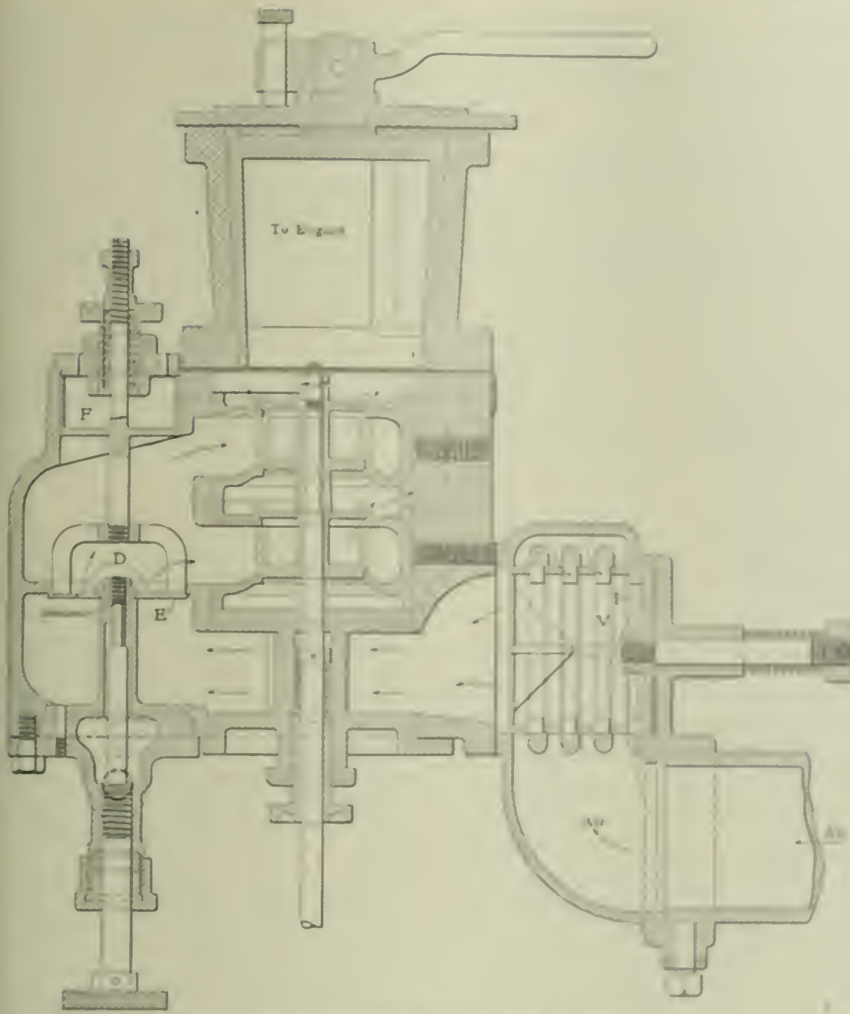


FIG. 3. GASOLENE VALVE AND MIXER

throttling and mixing valve for the producer-gas engine. Both the air and the gas valves are of the balanced poppet type and are raised or lowered by the governor reach rod. It will be noticed that between the gas and air valves is interposed a roller A, mounted on the end of an arm B, the position of which is adjustable horizontally through a set of links by the adjusting nuts C. When the roller is in the position shown both valves will have equal lift, but when it is shifted over to the right the lift of the gas valve is less than that of the air valve, and vice versa. By means of this mechanism any desired quality of mixture may be obtained within reasonable limits.

The engine is also built to run on gasolene, in which case shorter pistons are provided and lower compression is used. The gasolene-mixing attachment is shown in Fig. 3. The liquid fuel is introduced into the mixing chamber through a cone-shaped nozzle which reduces it to a fine spray. Air is admitted in direct proportion to the opening of the balanced throttle valve V, the movement of which is due to the air piston P responding to the engine suction. The spring on the horizontal stem pulls the valve back to the closed position after each suction stroke. At light loads, and on starting, all the air passes through the opening D, in an auxiliary air valve E, the stem of which is attached to the diaphragm F. All the air then comes in contact with the gasolene vapor and produces a rich mixture, insuring regular explosions. On heavier loads, however, the increased suction pulls down the diaphragm F, and opens up an annular passage around the outer edge of the auxiliary air valve, allowing additional air to pass through as indicated by the dotted arrows. This arrangement is provided so that with the increased amount of gasolene required at heavy loads, the mixture will not become [illegible].

Like the valve cages, the igniter plugs are held in place with yokes and large studs, which, making them easy to remove. Make-and-break ignition is used and the movable electrode is provided with an outside bearing to support the end of the spindle and reduce the liability to leakage. Near the top of the crank case, in Fig. 1, will be seen attached to the igniter rods two notched cams. By turning these, late ignition for starting may be obtained, and when the engine is up to speed they are turned back for early ignition. Further adjustment of the ignition timing is made by means of right- and left-hand threads on the igniter trip rods.

Starting is accomplished with compressed air by throwing out the valve gear on one cylinder in the usual manner and turning on compressed air for a few revolutions. The feature of the starting mechanism is the air valve through which the air is admitted and exhausted from the cylinder. This, as shown in Fig. 4, consists essentially of a tapered rotary valve or plug cock W, which is fixed on the end of the cam shaft J and rotates with it. The rotating part of the valve is movable endwise on the shaft and, when the engine is in operation, it is held away from its seat by the [illegible] K and a small helical spring, so that no wear takes place. When it is desired to use the

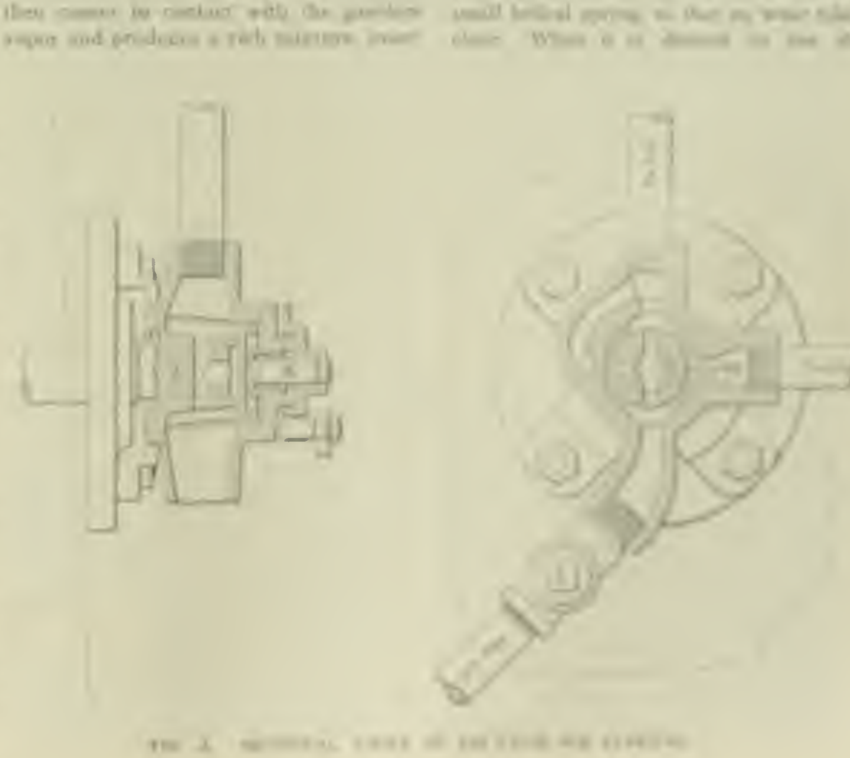


FIG. 4. SECTIONAL VIEW OF AIR VALVE FOR STARTING

valve, the air is turned on by means of an ordinary plug cock L in the supply pipe, the lever of which is connected by an arm with a collar on a beveled seat connecting with the pin K. The action of turning on the air withdraws the pin K, allowing the air pressure to seat the valve tightly, and it then operates as an admission and exhaust valve until the air supply is shut off, which allows the pin to force the valve from its seat again.

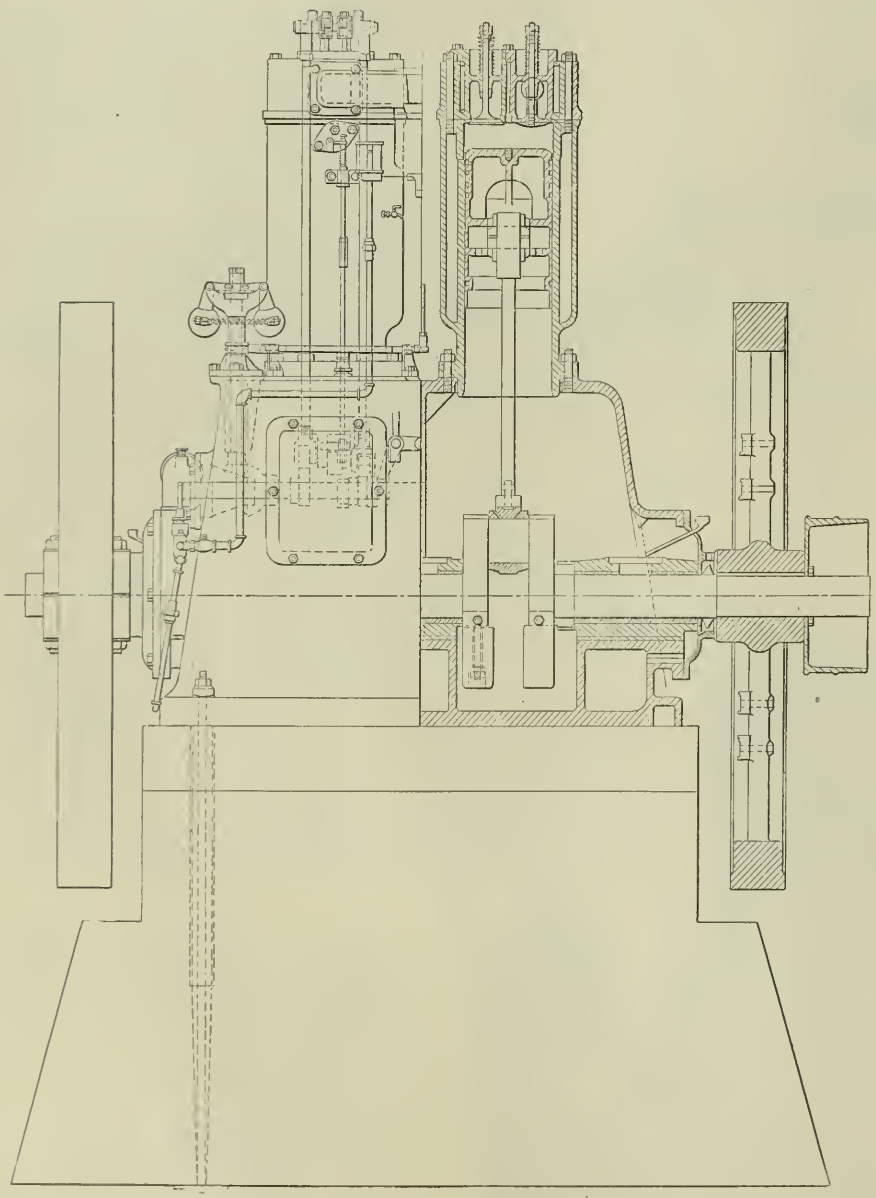


FIG. 5. SECTIONAL VIEW OF INTERNATIONAL HARVESTER COMPANY'S GAS ENGINE

The shaft runs in three babbitted bearings set into the base and resting on flat surfaces, so that they can be easily shimmed up when necessary. Ribbed projections are cast in the crank case so that the dripping oil from the top will run into the main bearings and insure ample lubrication. The upper or wristpin box of the connecting rod is slotted out of the solid forging and has brasses with wedge adjustment. The top of the rod carries an oil pan, draining to the pin, and the lower end of the rod contains oil pockets on each side which collect the oil and carry it to the crank pin.

"Eureka" Belting

The Eureka Fire Hose Manufacturing Company, 13 Barclay street, New York City, has been at work for a number of years perfecting its "Eureka" solid-woven cotton belting, which was recently placed on the market. This belting is intended for both transmission and conveying. It is manufactured on special machinery, owned by the company, the invention of the president, B. L. Stowe.

"Eureka" belting is woven under an immense tension in one solid body and, therefore, has no plies to separate. A natural tendency of the belt in work is to form itself into a coil, adhere to the pulley and make a powerful drive. The texture of the belt allows of the escape of air between the pulley and the belt. It is made treated and untreated. Treated belt will stand moisture and climatic changes, and both styles are so solidly put together that what stretch is necessarily left in the belting is minimized, avoiding the necessity of tighteners and annoying delays in taking up.

Removal of Oil and Grease from Boiler Feed Water

By Arthur E. Krause

Among the many problems with which steam users, managers of power plants, ice manufacturers and others have to contend, and have always been attempting to solve, that of completely removing the oil or grease from condensation water has probably been the most baffling and difficult, particularly that portion of it which is in the finely emulsified state indicated by the cloudy or milky appearance of the water.

This emulsion is caused by the churning of the mixture of condensed steam and lubricating oil in the steam-engine or steam-pump cylinder. It passes out with the exhaust and is found in the hotwell water resulting from the condensation of the steam. Attempts to remove the oil sufficiently to make a safe boiler water by means of separators in the exhaust line have been successful only at so much expense, uncertainty and vigilance that many stations reject the water from surface condensers and purchase city water at enormous costs.

Coarser particles or drops of oil which have not been emulsified or gone into the milky condition can be readily removed by either skimming tanks or coarse filtration through hay, excelsior, turkish toweling, terry cloth, etc. It will be found, however, that no matter how fine the filtering material has been, the milky appearance of the water caused by the oil has not appreciably changed, showing that considerable quantities of oil are still retained and leaving it unfit for ice making, boiler feeding or other purposes where a clear and pure water is the most important consideration. As long as this cloudy appearance remains, the water will be unsafe for boiler feed and will sooner or later be sure to result in serious trouble.

It may also be mentioned that by the use of coagulants and chemicals involving reactions of various kinds, the oil and milky appearance of such water may be removed, but any chemical treatment which necessarily leaves in solution many substances deleterious for ice manufacturing or boiler purposes cannot be recommended nor trusted by careful engineers, owing chiefly to the well known harmful effects of chemicals upon the valves, boiler plates and brass fittings.

In consequence of this, oily condensation water in large quantities in power plants, ice plants and other industrial establishments is now run to waste, which, if the oil were completely removed, would be ideal water for boiler feeding, ice making and many other purposes, and which, if saved, would result in considerable economy, particularly in cities where water rates are high, and on shipboard, where special evaporators must be used to obtain pure water.

In seeking some suitable substance that would clear this condensation water completely, and without chemical treatment with its attendant evils, the writer has discovered among the magnesian products of serpentine quarries a peculiar fibrous sand which is practically insoluble and, by reason of its extraordinary physical property of attracting and retaining the oily matter in condensation water, is eminently fitted and suited to remove the last traces of oil from the latter. Its strong physical property of attracting greasy matter may be judged by the fact that the material will retain or absorb from 50 to 100 per cent. of its own weight of emulsified oil from the water after the coarser oil particles have been removed.

That this method of purifying or freeing water from oil or grease is a purely physical and not a chemical one is shown by the fact that by suitable solvents the oil can be readily removed from the spent fibrous magnesian filtering material, and the oil so obtained may be used over again for lubricating, etc.

The process, which is patented, and which is now being introduced, requires no more care than an ordinary sand filter, needs no expert attendance and is continuous in operation, the only special requirements being a pressure pump of the requisite capacity.

An additional advantage of this process is that by passing through the serpentine fiber or material the effects of the free sulphuric and other acids found in certain streams and brooks throughout the coal regions become neutralized and the water rendered entirely safe and serviceable for boiler use.

I have also discovered that this serpentine waste or fibrous serpentine sand has the property of removing the coloring matter and peaty substances contained in many well and other waters when these are filtered through or otherwise brought in contact with the before-mentioned material.

The apparatus for this process is manufactured by Alexander Miller & Brother, Jersey City, N. J.

A New Pipe Joint Cement

The H. W. Johns-Manville Company, of New York, recently placed on the market what is known as "H.O." pipe joint cement. This cement is put up in powder form and can be kept in stock indefinitely, as it does not dry out or deteriorate, it is claimed. To use the cement it may be mixed with water or linseed oil.

The chemical properties of "H.O." cement are said to be such that it expands after the joint is made up, thereby making a perfectly tight joint. It does not harden and the joint made with it can be easily broken at any time without danger of breaking the fittings. It is not poisonous.

Water Power in Tasmania

Consul Henry D. Baker, of Hobart, Australia, reports that there is considerable agitation at present in Tasmania for governmental aid for the development of the large water power resources of that island. The premier of Tasmania said that the difficulty is to induce capitalists and companies to utilize the power if it were developed. The cost of such works would be hundreds of thousands of pounds (£1 = $4.86). The government only required some guarantee that the power would be utilized if made available, and it would be willing to go ahead in the matter.

At present the only water-power development in Tasmania is at the city of Launceston, where for thirteen years a portion of the water power available in the South Esk river has been used by the municipality for the electric lighting of the city. The power station is about two miles from the city and the machinery comprises four three-phase generators and turbines of 450 horsepower each. In the city there are over thirty miles of streets lighted by electric lamps, and business places and private houses use the electric light largely. Electricity is also used for motors and heating appliances. The municipal council of Launceston has so far spent over [illegible] in construction work.

No state in Australia has such abundant water power as Tasmania, but so far, however, there has been no systematic investigation, either by the government or by private persons, as to the cost of developing most of this power, or as to whether or not the power could be produced in sufficient amount at all seasons of the year and cheaply enough, so that it would pay manufacturers to carry on industries of considerable importance in Tasmania in competition with those of the mainland of Australia.

The centre of Tasmania is mainly 2500 to 3000 feet above sea level. The tributary lakes, though from the northwest discharge most of their contents on the first highlands they meet. In the northwestern part of this plateau there are a number of large lakes, the four principal ones being St. Clair, Echo, Great lake and Lake Sorell. In the northwestern part of this lake country the rainfall is said to average 80 inches, but at the southeastern end only about 35 inches. Any successful power plant, therefore, would probably necessarily be located in the northwestern part of the lake region. It has been roughly estimated that from Lake St. Clair could be produced a minimum of 48,000 horsepower, from Lake Echo 9000 horsepower, and from Great lake 27,000 horsepower, a total of 84,000 actual horsepower. These three lakes are from 2000 to over 3000 feet above sea level, and natural reservoirs.

As it is probable that the power could not be profitably utilized at the different power stations which might be constructed in the lake region, the power would have to be transferred to places where it is required.

In case it should be possible to make Hobart the manufacturing centre of Australia, among other reasons, on account of her facilities in producing inexpensive and reliable power, the 84,000 horsepower at the different power stations in the lake region would be reduced by about 40 per cent. (namely, by converting the mechanical energy into electric force, by friction and loss on line from power stations to Hobart, and by reconverting the electric current into mechanical energy), and the power which could be distributed at Hobart would be, say, 50,000 actual horsepower.

At present but 1000 horsepower is consumed in Hobart for tram service and for lighting, but if it be a true maxim that "supply creates demand," and if inexpensive and plentiful supply of electric force were offered here, the demand would increase; perhaps, under such conditions, Hobart itself might absorb from 5000 to 7000 horsepower, and 40,000 horsepower would be available for large manufacturing industries.—Consular and Trade Reports.

Enlarging a Central Station

The Union central power station, Pittsburg, Penn., is being entirely rebuilt and greatly enlarged to handle the increased load. William Boyle, who has had charge since the plant was first installed, retired February 1, going into business for himself as consulting heating and ventilating engineer, [illegible]

Some Useful Homemade Apparatus

By R. O. Richards

A few months ago I received a letter from the manager of a small plant, under whom I once was employed, requesting me to devote my spare time to aiding his engineer to remodel the steam plant. Besides installing some fuel-saving auxiliaries and simplifyng the piping system, which was in such an intricate state that it could be likened only to a lot of snarled fishing lines, we introduced some novel apparatus and methods of our own.

To distinguish the different steam pipes and valves we had several pipe-covering bands painted various bright colors (a suggestion obtained from Power), and these were secured to the pipes at every turn, in each side of such walls as the pipes penetrated and on each side of every valve. We found, however, that these were distinguishable only in the daytime, the night watchman discovering that all colors looked alike to him. To overcome this obstacle, each valve was given a number, which was painted on a glass tag framed with tin. A card was hung in the engine room, showing the location, color and number of each valve.

A card system for keeping track of all work done was also introduced (another suggestion from Power). Thus, one card would tell how often the pump valves were renewed, another would show how long the rod packing lasted, etc. Then, when the drummer came around, the engineer would show him a record of his wares, and if a disgruntled salesman went to the office and hinted that the engineer must be accepting graft from a competitor, the "old man" knew better, for the records were always accessible.

This plant is situated near the retail section of the town, and we were up against the smoke question. Provided the fireman stoked according to instructions, we feared no smoke inspector, but —well, I guess we have all been up against these conditions. Moreover, we were troubled with lack of draft. A request for stokers was turned down at the office, on the ground that if we could sometimes fire for a whole day without producing smoke, the management failed to see why we could not always fire that way (there is a moral here for firemen). They were, however, willing to have a fan installed, and this gave me a chance to try a certain form of furnace that I often thought would at least be handy, if not economical.

A New Type of Furnace

After seven months' constant use, I am beginning to feel proud of it, and as I have not seen anything similar to it, a short description follows. The reader will bear in mind that this is a small plant consisting of one 72-inch and one 60-inch return-tubular boilers. The plan was to use forced and natural draft at one and the same time. Fig. 1 gives a good idea of it. It will be noticed that two one-brick-width walls divide the ashpit into three parts. The jog in the sidewalls of the furnace is such as to admit of one extra grate bar on each side. The letters *F D* stand for "forced draft" and *N D* for "natural draft."

Green coal is thrown on the grate subject to the forced draft. After coking, it is spread over the natural-draft grate. Barring and spreading is done through the small door *A*. The opening is just large enough to admit the free handling of the bars, and is so constructed as to form a hump to act as fulcrum, thus greatly facilitating the throwing over of the caked coal. Sections through one of the castings forming the bar doors are shown in Fig. 2. With the improved draft and the greater grate surface, the engineer is able to dispense with one boiler and not have to force the one in use unduly. The fireman, believing that the method of stoking produced this result, religiously adhered to instructions. Indeed, he has to, for I have never yet seen a furnace that will stand less monkeying with.

The forced draft is at no time objectionable, having but a slight tendency outward when the furnace doors are opened—just sufficient to prevent the inrush of cold air while coaling. Control of the forced draft is obtained by connecting the balanced throttle valve of the fore engine to the cord of the regulator, the fore engine being made, however, to close ahead of the damper. There are also the usual hand dampers in the ashpit. Fig. 2 shows the manner of clearing the forced-draft grate The bars are raised and lowered by the chains shown and manipulated by a handwheel at the side of the boiler. The necessary extras were made and attached to a common "hoo-hoo" grate by ourselves. The chains are used only while the boiler is being fired, the regular cleaning being done through the large doors in the usual manner.

A phenomenon of this furnace is that when the forced-draft grate is properly coaled, the natural draft exerts itself sufficiently to keep steam up; but when the green coal is caked the forced draft seems to kill the natural draft. This works advantageously, as the fireman is compelled to fire just so, for, unless the

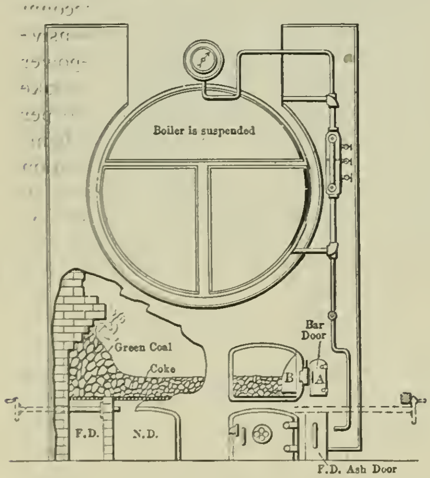


FIG. 1. SPECIAL TYPE OF FURNACE

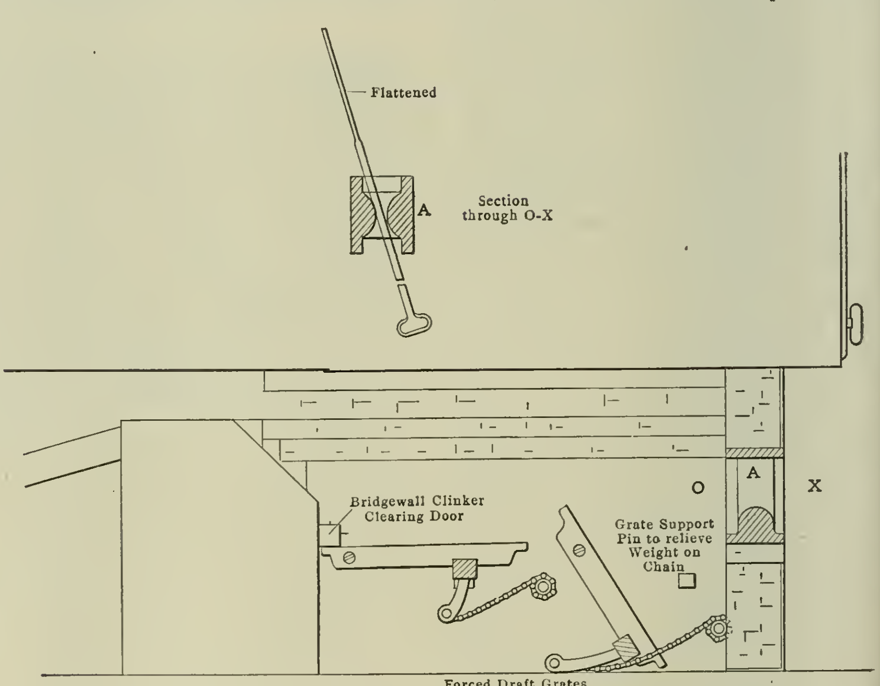


FIG. 2. SHOWING SECTIONS THROUGH CASTING FORMING THE BAR DOOR, ETC.

natural-draft grate is covered with good live smoke-consuming coke, the steam pressure will drop and any attempt to put on green coal (which would produce smoke) is paralyzed by the extra work required to keep the steam up. If, however, the firing is done according to instructions, no difficulty is experienced.

Two tons of coal is burned per ten hours. The evaporation per pound of coal is 8.39 pounds, as against 8.11 pounds previously. The design of the furnace could easily have been improved, but we had to bear in mind that should it not be a success we would have to restore it in a very short time to prevent a shutdown. All that is necessary is to break down the dividing walls in the ash-pit and either natural or forced draft may be used under the whole furnace.

Hydraulic Damper Regulator

The writer believes that the only place left to practice economy is in the boiler room. A great variety of expensive devices are in use to save 2 or 3 per cent., while the fireman has a free hand to waste 10, 15 or even 20 per cent. of the coal pile. Therefore, an engineer is justified in installing anything that will *compel* his fireman to do his duty with due regard to economy. Such devices may be an insult to a good man, but good firemen are rare articles—somehow they quickly climb up to the engine room.

There is provided a cast-iron pit-round plate which makes it necessary to keep the dead plate clear. Fig. 3 shows an hydraulic damper regulator to which is attached the cup *A*. When the piston of the upright hydraulic cylinder rises, water enters the small pipe *B* and flows into the cup, from which it trickles through the pipe *C*. When the damper is wide open and water is automatically shut off from entering the cup, the regulating cock *D* is so set that it takes a certain definite time to empty the cup.

We all know that with the fires in good condition, with no air holes in them, the damper will be continually playing from open to shut, unless the boiler is unduly forced. When, however, they need attention, the damper will remain open and a fireman onto his job will get busy. The careless man will wait until the steam drops 5 or 10 pounds, so that he can put in a greater amount of coal when he does get up. The purpose of the cup and the float is now apparent. If the damper remains open beyond a definite, certain and reasonable time, the cup becomes empty and the nut *E*, pressing on the terminal contacts of the wires shown, causes the ringing of a bell, which will or should bring the wise engineer to the boiler room.

Discretion must be exercised, of course, and every ringing of the bell should not merit a call down; but when it begins to work overtime, don't expect to reach that best evaporation record. Maybe the device has something to do with the success of the furnace described; for the fireman seems very anxious not to have that bell ringing. One thing is certain, it has certainly made a good man of him.

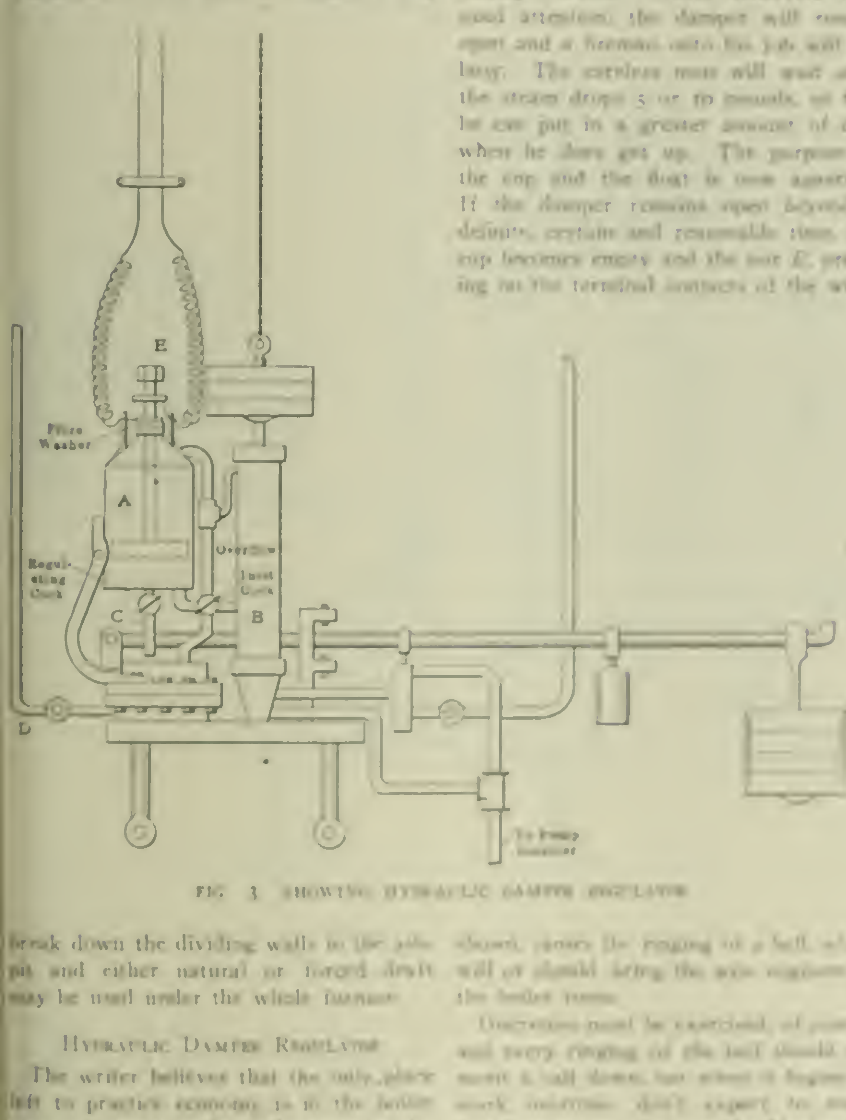


FIG. 3. SHOWING HYDRAULIC DAMPER REGULATOR

A Bypass Telltale

Another telltale as shown of fig. 4 [illegible] for a careless fireman in a small plant is by letting the water in the boiler get too high, necessitating a hasty, often clandestine, jerk on the bypass valve.

From a record kept by the engineer, after we had installed the device shown in Fig. 4, it was found that the bypass valve had been opened four times in twenty-four hours, and at no time had it been opened wide. How much good boiling water went out that way, and how much dirt, there was back of the valve, that could not pass through the limited opening but was gradually working its way under the valve seat, would be difficult to estimate. This device shown (Fig. 4) would tell us (1) how often the bypass valve was opened, (2) if it was opened wide, (3) the time it was opened, (4) if opened with the engineer's permission or without the [illegible] at the time.

The device is extremely simple and can be made. Referring to the sketch, it will be seen that [illegible] the bypass valve [illegible]. This [illegible] the [illegible] of which has been removed. A piece of [illegible] is attached to *F* and to *E*.

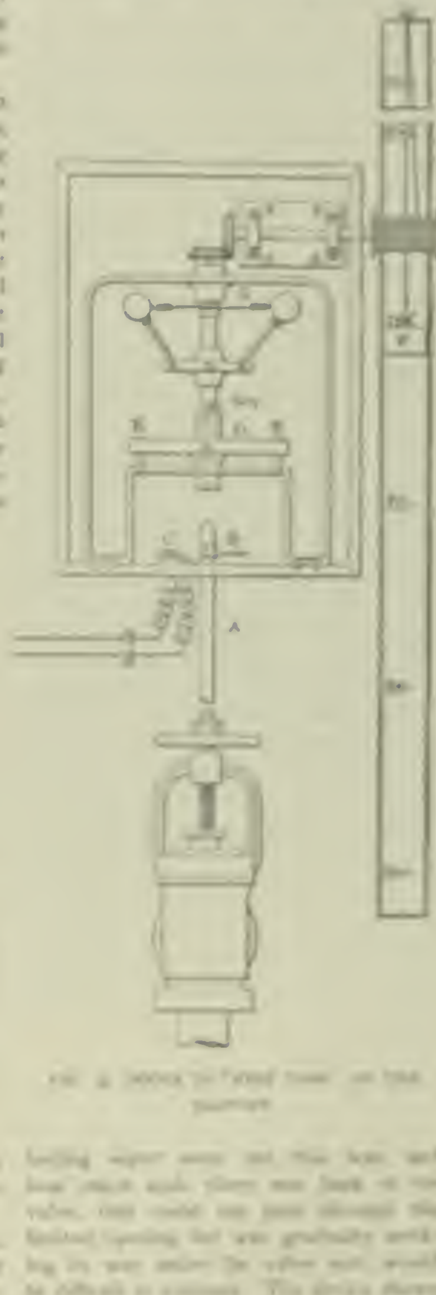


FIG. 4. DEVICE ATTACHED TO [illegible] ON THE BYPASS

is a watchman's pushbutton, which connects with a needle in the magneto clock. It is evident that the blowoff valve cannot be opened even halfway without pushing the button, thus the time the boiler is blown down is read from the paper dial, and the pressure at that particular time is obtained from the recording steam-pressure gage.

Those not possessing a pressure-recording gage may easily fix a needle point to the finger of a small gage in such manner that the projection *B* will cause the needle to punch a strip of paper placed under it. The position of the punch mark will show the pressure at the time the blowoff valve was opened. When the blowoff valve is wide open the extension rod *A* will come in contact with and raise a small casting *D* which is free to slide along the spindle of the governor shown. This will release the stop pins *E* and the weight *F* connected to the governor by the cord-and-miter gears shown and start it revolving.

It is evident that without something to retard the downward moton of the weight *F* the mechanism would have to be wound up daily. So, connecting the governor balls and supporting them, with one turn around the stationary guide, is the stout cord *G*. It was found to work better by putting a light spring on each side in series with the cord. A small tube is provided in the cover of the box to carry a drop of oil once in awhile to this cord. By marking on the long board to the right distances equal to the daily travel of the weight *F*, when, say, a gage of water is blown out, we would very nearly determine the actual quantity of water that left the boiler via the blowoff valve. The weight *F* should be boxed in and the cover locked, for if open the operator is liable to watch the descent of the weight, instead of watching the water in the gage column. These automatic affairs are liable to get out of order.

Apparatus to Control the Power Pump

For boiler feeding we had a duplex steam pump and a belt-driven power pump of the crank and crosshead type. Of these the power pump was preferred, and to control it was built the apparatus shown in Fig. 5, which was installed in a conspicuous but out of the way corner in the boiler room. On the flanges of the base elbows shown are the diaphragms *A*. Resting on the right-hand one on a suitable lever are the weights *B*; on the other rests the stem of the 2½-inch valve *C* on the suction line of the pump. The thread by which this valve is ordinarily operated is removed and the stem neatly bushed, so that it opens and shuts with a sliding motion.

Between the two diaphragms is a solid body of water, so that any movement of one diaphragm causes a corresponding movement in the other. The weights *B* balance a certain hight of water in the apparatus, as shown by the gage glass. When this hight is exceeded, the valve diaphragm *A* is depressed and valve *C* will consequently open. It was found, however, that this was not quite sensitive enough, so the float shown in the cut (and taken from an old steam trap) was added to balance the weight of the valve stem and disk. On top of the receiver will be seen in section a small cylinder, the pistons *D* of which connect by the levers shown to the diaphragm weight lever *B*, so that any fluctuations in the hight (weight) of the water in the receiver will cause a reciprocating movement of the pistons *D*. Between the two pistons a certain water pressure is maintained by the small pipe shown, which connects with a common float tank stationed near the roof. In the position shown this pressure is also maintained in the pipe *E* which, as clearly shown in small sketch, leads into another small cylinder *F*, causing the piston contained therein to shift the belt onto the loose pulley.

In the same manner, when the pistons *D* move upward, the pipe *G* will then be under pressure, and as it connects with the cylinder *G* the belt is shifted to the tight pulley, while the water in cylinder *F* is now free to empty into the receiver. The quantity of feed water is, as in all other pump receivers, governed by the cold-water valve *L*.

Pump controlling, however, is only one of the many uses of this apparatus. For instance, it would immediately tell when one of the steam traps leaked, for then no water would show in the glass, and the weight lever *B* would be up against the stop *H*. Thus it becomes an excellent means of "keeping tabs" on the steam traps. When a trap leaked, the vent was opened, until that trap could be bypassed and fixed. Again, we could tell exactly how much steam any live-steam apparatus in the plant was consuming by weighing the water of condensation as drawn out through the valve *K*; we could get a fair idea of the efficiency of our pipe covering, and the highest water level that could be carried in the boilers and still furnish dry steam. We even have disconnected it and used it to condense the exhaust from the fan engine, air pump and tank pump to find the actual amount of steam consumed by these appurtenances. For this purpose is the spray plate shown. Any back pressure could be maintained in the receiver by shifting the weights *B*, piping a gage at *M* and careful manipulation of the cold-water valve.

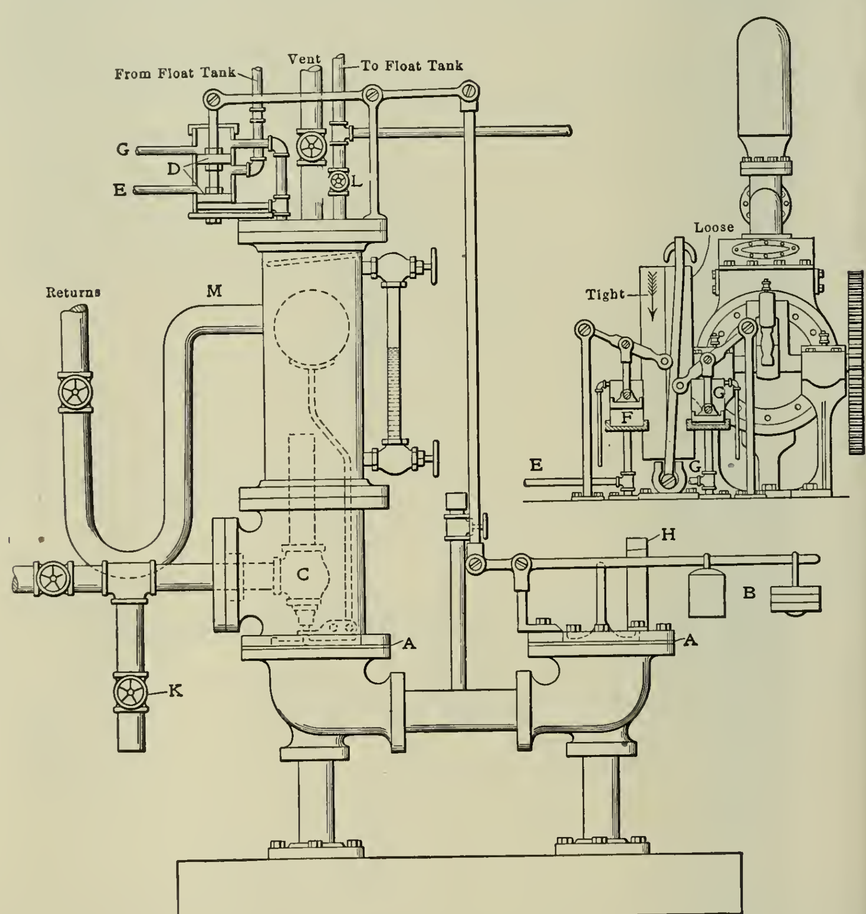


FIG. 5. APPARATUS FOR CONTROL OF THE POWER PUMP

Potblyn, P. D.

By John Watson

"Say! I believe she put him up to it, don't you?" I had been so deep in a series of calculations that I had not heard my office door open, and the above query was the first intimation that I had of the "Doc's" presence. I swung around in my chair, put down my slide rule and pushed back my papers, as an indication that I was a willing listener.

The "Doc" had just returned from a trip South and I was anxious to hear about the results of his surgery. I knew that he had performed a successful operation, for the smile on his face was that kind of a smile. He had three kinds of smile and I had learned to recognize them. When he was contented with himself, the world in general and yesterday's baseball scores, he wore one kind of a smile and was a very agreeable sort of a chap. If things were going sort of crosswise, he grumbled and swore a lot in a half good-natured sort of way. If he thought that a man had not used him right, and he was "mad" clear through, he also smiled, but it was a still different sort of smile, and at such times it was well to let him alone. The gage indicated fair weather this time, so I settled back in my chair to listen to his tale. Of course it was some time before we reached the point, for the "Doc" had first to discuss the news of the day and a prizefight or a murder case was even more interesting to him than the baseball scores. The recent murder in New York, where a girl was held as accomplice of the man on trial, held the floor until we had clearly proved her to be guilty and then we could take up the pump problem.

"Well, 'Doc,' what was the matter with it anyway? Was it the suction pipe this time?"

"Doc" grinned at the reference to his hobby, for it was well known that just as some M.D.'s always diagnose any kind of a stomachache as appendicitis, especially if the patient has money, so Potblyn, P.D., usually started out on a case with the firm conviction that the suction pipe leaked. It was astonishing the number of cases that he had operated on for leaky suction pipe and effected permanent cures.

"Naw! It wasn't the suction pipe this time, but the darned thing leaked, though, and needed fixing just the same."

Having got a fair start the "Doc" proceeded to tell his story about as follows:

"Say! Of all the complications of diseases you ever heard of, this pump had 'em all a-goin', and had me a-goin' for a while, too. You remember the trouble, don't you? Old 'Whiskers' wrote you all about it. Say! You don't know old 'Whiskers' do you, except by his letters? You ought to see him—made of odds and ends and got the 'Yaller Kid' and 'Happy Hooligan' beat for first money. Gee! but I had to laugh when I saw him. Didn't look as if he knew enough to pound sand into a rat hole. Well he took me out back into the woods where the pumps are located. There's got two little compound duplex direct-actin' pumps, just alike. One ran slick as grease; you couldn't ask for anything better. The other feller, right side of it and just like it, was knocking to beat the New York Sun.

"Opportunity knocks but once, but this darn thing had opportunity left at the post, for it was knockin' seventy-five to eighty times a minute right along. Old 'Whiskers' was discouraged and felt like doing a little knockin' on his own hook. First look out the corner of my eye, I seen they had separate suction pipes—and I put on my 'Gosh! this is easy' kind of a smile; but, say that wouldn't do for 'Quaker Oats,' for it came off—way off—before I got the blamed thing fixed.

"I let 'er run awhile and I loafed around the engine and boiler room rubber-neckin' the place and lookin' wise. I finally saw the old goat was gettin' nervous because I didn't do something, so I got into my warpaint and started to imitate a man getting busy. I shut her down and looked over the water end. The valves were in pretty good shape; I guess you wrote him to make sure that they were all right. Then I traced out the suction pipe; lucky there wasn't as much of it buried as there was on that job up in Massachusetts. I found several leaks but they were small ones and didn't amount to much.

"Next, I tried the air chamber and found it solid full of water. No wonder she pounded. I put on an air-chargin' rig and a glass gage and thought that I had things all fixed and my job done. We started up again and got the air chamber full of air, and about then your uncle began to get interested in the game, but while the heavy pound had disappeared there was still a decidedly hard knock that seemed to be in the steam end.

"I knew that the water end was all right, so I shut 'er down and as soon as she had cooled off a bit I opened up the steam end. It seemed to be the left-hand side that was 'bumpin'' so I opened up the right-hand side first, just to be sure not to miss anything, as I wanted to make a complete job of it this time. I looked over both the high- and low-pressure pistons and found them all right. Then I opened up the left-hand side and found the low-pressure piston loose on the rod. 'Eureka!' says I, and I called 'Whiskers' over to show him where the trouble was. He was so pleased to have found the trouble that he gave me a treat. 'Say! I was as badly fooled on that cigar as I was on the pump. He handed it out to me with the regulation two-for-a-quarter wave, instead of shovin' it at me like a three-for-five.

"I fixed the piston, closed the cylinder and told the engineer to start up. I was through. I lit my cigar and started to get my overalls off. Bill! an uppercut right in the jaw. I felt as if I had got one when that pump started out just the same as ever—bang, bang, every stroke; gosh, it was enough to make a perfect little saint swear. Two operations and no cure. 'Whiskers' probably wished he had kept his cigar; so did I, for by this time I was looking for a chance to lose it.

"It was getting late, so we concluded to wait until mornin' before investigating further. Let me tell you the time was when I would have lost sleep a long time worrying over a job like that, but I'm too old for that now and besides, I had a card or two up my sleeve to play in the mornin' when the game opened. I can't say much for the hotel in that measly town. The soap in my room wasn't worth luggin' away. The darnedest lot of loafers around there; they think 'Fire' is all [illegible] and hasn't got any light left to lose. What's the use of talkin' to fellers like that?' I couldn't convince them of nothin'.

"Old 'Whiskers' was on deck bright and early in the mornin'—darn these country hotels anyway—and we went back on the job. I had concluded that there was too much power somewhere that made her hit the heads and first off I had a look for the old enemy, cross-talkin'. 'Nothin' doin'.' Then I opened up the steam chests and had a look. Once more I smiled but this time I kept quiet; I didn't want any more cigars. Say! I wish I'd brought you one of those just for luck.

"Well, there was the left-hand high-pressure valve cocked up well over one side [illegible] on the guide so that that side was three-eighths to one-half an inch off the face and the steam had a chance to blow right through into the low-pressure chest. That side was takin' high pressure while the other side was running compound. No wonder the piston did get loose [illegible] the rolling [illegible].

"I slipped the valve back into place, closed her up again and started off once more. By [illegible] if she didn't still knock [illegible] as ever [illegible] the knock was still there, [illegible]. Up to this time I had been sort of [illegible] lookin' for the usual things in the usual places and applyin' the usual remedies. Things were beginnin' to look suspicious and I didn't just know what to look for next.

"I opened up the whole steam end and looked it over carefully. Then I had the engineer run the pump while the heads and covers were off and I watched the pistons and valves, one at a time, to see that they were all right and fitted throughout the full stroke. In this way I discovered that the same old high-pressure valve cocked up on one end and allowed steam to blow through. Looking for the cause I found that the valve rod was bent between the high- and low-pressure chests. Evidently somebody had dropped a carload of freight on to it but, of course, they wouldn't investigate to see if a little thing like that had damaged the pump in any way.

"Well, I took out the valve rod, straightened it, made sure that the valve seated properly and then closed her up and started again. Knocked out in the fourth round—I had got her fixed for keeps this time and she ran as smooth and slick as could be. I tell you I felt somewhat relieved, for, after the way things had been goin' I didn't know what might show up next.

"Pumps are as bad as kids. When they get cantankerous it is safe to expect most anything and some pumps, like some kids, seem to ketch everything there is goin', and no reason for it, either. Old 'Whiskers' was pretty well pleased and thought I was quite a fellar. I guess he will get along all right, now, without any more trouble, but say, you fellars ought to put gage glasses on all of your air chambers.

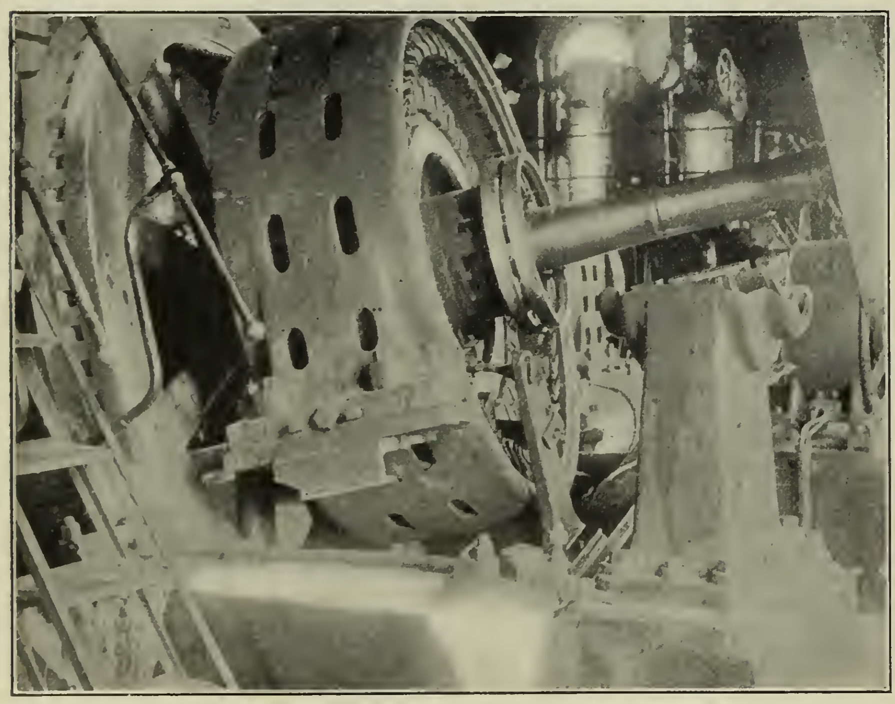
"What good is an air chamber full of water? They'll fill up sure as preachin' and how is a man goin' to know how they stand unless you put a gage on? What's the use of being a tightwad? Loosen up a little, give a fellar something for his money and when you send out an air chamber send a gage glass with it."

With this parting advice the "Doc" departed for the shop. I had hardly turned to my work again when he opened the door, just enough to stick his head through, and remarked.

"Say! I wish you could see 'Whiskers,' he's a peach."

Broken Shaft Wrecked Engine and Generator

The accompanying illustration depicts the wreck due to the breaking of the main shaft of a 440-ampere generator at its center bearing. It will be seen that the frame supporting the generator field is broken, also that the top of the outer pillar block was wrenched in pieces. The real cause of the accident is not known, but it is supposed to have been due to a flaw in the shaft. No one was hurt, but the engine was entirely wrecked and almost a total loss.



WRECK DUE TO BREAKING OF SHAFT

Boiler Specifications

We design a large number of horizontal tubular boilers for our assured and patrons, giving them the benefit of the wide experience of our steam-engineering experts. These specifications are, of course, unprejudiced, and the boilers designed by us can be readily built by any modern shop. We have not, for several years, designed a boiler using a lap-joint, double-riveted, horizontal seam. We have been fully aware of its inherent weakness. We have had no difficulty whatever in convincing our patrons of the superiority of the butt joint as against the lap joint. Some recent disastrous explosions due to the lap-joint type of boiler indicate that our view is sound.

In the standard butt joint, the net section of the plate between the rivet holes is the weakest part, although this runs theoretically from 84 to 94 per cent. of the solid plate. In practice, however, with ordinary punched rivet holes, due allowance should be made for the injurious effect of the punch on the plate, and this is an unknown quantity. All authorities agree that the metal is injured, but differ as to the extent. Various experiments show, however, that the injury increases with the thickness of the metal.

If the rivet holes be drilled full size in flat plate, we would have the usual bend strain between the rivet holes when the plate was being rolled up. On the other hand, if the rivet holes in plates ½ inch and under are punched ¼ inch below size, we have more metal to resist the bend when rolling. Bearing this in mind, together with the injury done by punching, we have adopted the rule of calling for all rivet holes to be punched ¼ inch below size, then the plate to be rolled up, assembled and the holes reamed out to full size, thus removing the evil effects of the punching and having the rivet holes in perfect alinement. The reaming of the holes is today done with pneumatic tools, and is a simple, cheap and rapid operation. This change has received the approval of several authorities and commends itself to every thoughtful engineer as far better than the common practice of reaming the hole 1/16 or ⅛ inch.

In this connection it is well to note the increase in sizes of horizontal tubular boilers. A few years ago a 60-inch shell was called a large boiler, while today the larger per cent. of the boilers being installed are 72 inches by 16 to 18 feet in length, practically doubling in capacity the 60-inch size. It is also true that the evaporation per square foot of heating surface has been increased, when soft coal is used, by artificial drafts, mechanical stokers, etc. With the heavier plate used in the large sizes of shells, greater care must be observed in keeping the boiler free from scale, grease and deposits of sediment, and all appliances must be in the best of order.—Fidelity and Casualty Company's *Bulletin.*

Personal

Harry J. Marks, formerly mechanical engineer of the Empire State Engineering Company, has become associated with Edward P. Hampson, 170 Broadway, New York City, in a general engineering business, including the handling of a line of engines and boilers and making a specialty of the American Ball angle-compounds.

Inquiries

Questions are not answered unless they are of general interest and are accompanied by the name and address of the inquirer.

Safe Speed for Cast-iron Flywheels

I have an engine running at 250 revolutions per minute and I should like to know if it is safe to increase the speed to 300 revolutions, the flywheel being 78 inches in diameter?

W. A. L.

With cast-iron flywheels a rim speed of 90 feet per second should not be exceeded. At 300 revolutions per minute the rim speed of a 78-inch wheel would be more than 102 feet per second and manifestly unsafe. A cast-iron wheel running at 300 revolutions per minute should not be more than 66 inches in diameter.

Windings for Choke Coils

Is there a simple rule for determining the winding for a "choke" or reactance coil?

A. P. K.

Two rules are necessary, one for the size of wire and the other for the number of turns in the coil. To ascertain the size of wire, multiply the current to be carried by 1500; the result will be the cross-section of the wire in circular mils. To ascertain the number of turns required, multiply the desired counterelectromotive force by 13, for 60-cycle current, or by 9 for 125-cycle current, and divide the result by the cross-sectional area of the core measured in square inches.

EXAMPLE: A core having 1 square inch cross-sectional area is to be wound for a counterelectromotive force of 40 volts, at 60 cycles frequency, and the wire must be large enough to carry 10 amperes without overheating.

To carry 10 amperes, the cross-section of the wire must be not less than

$$10 \times 1500 = 15,000$$

circular mils. No. 8 is the nearest commercial size, its cross-section being 16,510 circular mils. To give an electromotive force of 40 volts, at 60 cycles, the number of turns must be not less than

$$\frac{13 \times 40}{1} = 520.$$

The disposition of these 520 turns will depend on the length of the available coil space along the core; the coil should occupy the full length of the space, leaving its thickness to come as it may.

Large Engines, Steam and Gas

Please tell me the rated horsepower and dimensions of the George H. Corliss engine used by the Pullman Car Company, Pullman, Ill. Also, what is the largest single unit in the world, steam or gas, used for the generation of power?

F. J. E.

The horsepower of the Corliss engine at the Pullman works is [illegible]; the steam pressure 30 pounds and the revolutions per minute, 36. The dimensions are: Cylinder diameter, 40 feet; stroke, 10 feet; piston rod, 6¼ inches in diameter; connecting rod, 25 feet long; bearings, [illegible] inches; walking beam (cast), 25 feet long; flywheel, 56 tons, 29.7 feet in diameter, 24-inch face, 216 teeth with 5¼-inch pitch. The largest stationary steam engine or power generator is the Manhattan engine. The largest steam turbines are those in the Commonwealth Edison Company's station in Chicago. They are rated at 14,000 kilowatts maximum continuous load. The largest gas engines for power purposes are the engines built by the Snow Steam Pump Company for the California Gas and Power Company. The cylinders are 42x60 and the engine runs at 88 revolutions per minute. A larger cylinder is 44x54 inches, but it does not deliver as much power as the Snow engine, as the revolutions per minute are 83⅓ and the gas used is of much lower heat value.

It is understood that there is a gas cylinder 52x55, single-acting, developing 700 brake horsepower at 90 revolutions per minute with furnace gas, but this unit is in Germany. The largest engine known in this country is a 25,000-horsepower rolling-mill engine at South Sharon, Penn., at the Carnegie Steel Company's plant. The frames and slides are cast in one piece and weigh 118 tons. The total engine weighs 330 tons. This is a horizontal twin tandem rolling-mill engine, with cylinders 42 and 70 by 54, to operate with 175 pounds of steam, condensing, at from 150 to 200 revolutions per minute, developing its maximum power at the highest number of revolutions.

Book Reviews

MECHANICAL WORLD ELECTRICAL POCKET BOOK. Published by Emmott & Co., Ltd., Manchester, Eng. Cloth, 278 pages, 4x6 inches; illustrated; many tables. Price, 8 pence, postpaid.

The 1909 edition is considerably more comprehensive than the previous one. The topical scope now includes [illegible], rotary converters, motor generators, [illegible], balancers, boosters and electric [illegible]. The discussions, however, are brief [illegible] the verge of perfunctory [illegible].

MECHANICAL WORLD POCKET DIARY AND YEAR BOOK. Published by Emmott & Co., Ltd., Manchester, Eng. Cloth, 350 pages, 4x6 inches; 61 illustrations; many tables. Price, 8 pence, postpaid.

This is the twenty-second annual edition of this useful little manual, and it shows the effects of revision notwithstanding its long life. The discussion of friction clutches has been made more comprehensive; the steam-turbine section has been extended to keep abreast of recent developments, and a section devoted to [illegible] drive has been added. The section devoted to gas power remains inadequate, as before.

THE TEMPERATURE-ENTROPY DIAGRAM. By Charles W. Berry. Published by John Wiley & Sons, New York, 1908. Cloth; 393 pages, 5x7½ inches; 109 illustrations. Price, $2.

This is the second edition of Professor Berry's excellent work, and a mere comparison of bulk would suffice to indicate extensive revision, as the present edition [illegible] more than twice the number of pages in the first edition. The chapter on the flow of fluids has been thoroughly revised; a graphical method of passing from the pressure-volume plane to the temperature-entropy plane for perfect gases has been worked out and its application illustrated in two chapters on hot-air and gas engines; a chapter on the thermodynamics of gas and vapor mixtures has been added, and the various factors affecting the efficiency of actual gas-engine and steam-engine cylinders are discussed. For the information of those unfamiliar with the first edition it may be stated that the work is mainly mathematical in character; the discussions are, however, correspondingly accurate and complete.

NOTES ON MECHANICAL DRAWING. Victor T. Wilson and Charles L. McMaster. Second edition. Published by Wilson & McMaster, Lansing, Mich. Cloth, 190 pages, 8x6 inches; illustrated.

Students of engineering, whether at school or engaged in home study, will find in this book nearly if not all the instructions needed by one who desires clear, intelligent and concise instructions in the elements of mechanical drawing. Exercises as such for the purpose of training the hand and eye in the use of drawing instruments have been reduced to the smallest possible number, and practical problems substituted. Minute directions for every operation in the process of mechanical drawing are given in the belief that these, if followed by the student, will give a ready grasp of the subject. Differing from the ordinary methods of textbooks on this subject, lettering is made the subject of the first chapter, which is followed by chapters on projection, straight-line drawing, curves, sections, geometrical drawing, working drawings, [illegible] sketching and miscellaneous instructions. The [illegible] being [illegible] the work is [illegible].

Books Received

"[illegible] Tables." By [illegible]. [illegible]. Cloth; [illegible] pages, [illegible] inches.

"[illegible] Lectures on Electrical Engineering." By [illegible]. [illegible] & [illegible]. Cloth; [illegible] pages, [illegible] inches; illustrated; indexed. Price, $2.

Silk City Council Entertains

Silk City Council No. 18, Universal Craftsmen, Council of Engineers, of Paterson, N. J., held its first annual entertainment and reception at Turn hall, Paterson, on Friday evening, February 12. The engineering craft was largely represented, as well as the various Masonic lodges, there being many visitors from nearby cities. The first part of the evening was devoted to the rendition of an enjoyable entertainment, following which Past Worthy Chiefs William Brameld, F. W. Johnson and Edward Livingstone were presented handsome jewels. The grand march then took place, and dancing was enjoyed until the early morning.

The committee in charge of the arrangements comprised Edmund Whittaker, R. Templeton, E. B. Lupton, F. W. Johnson, Edward Livingstone, George Robinson, B. Chandler, C. Van Gieson, D. McHenry, R. McCullough, C. McLean, W. McDonald, J. McCullough, A. Thomas, F. W. Johnson, William Patrick, Andrew Young, M. Zocklein and Alexander Young. Robert J. Hanna was stage director. It was an especially enjoyable occasion.

Stevens Institute Alumni Dinner

The alumni of the Stevens Institute of Technology had their annual dinner on Friday, February 19, at the Hotel Astor, Broadway and Forty-fourth street, New York. There was an attendance of about 350, and great enthusiasm prevailed. The toastmaster was Henry Torrance, Jr., of the class of '90, and the speakers were President Alexander C. Humphreys, of Stevens Institute, who spoke about the institute; Alfred Noble, past-president of the American Society of Civil Engineers, and a former member of the Panama canal commission, who advocated the lock system for that great enterprise and gave an authoritative review of the whole project; Col. H. G. Prout, vice-president of the Union Switch and Signal Company, who spoke of the ethical and ideal aspects of engineering; John A. Bensel, commissioner of the Board of Water Supply of New York City, whose subject was New York's water supply; and Col. George Harvey, who wittily commented on the remarks of the preceding speakers, and in more serious vein referred to the engineering features of the Panama canal.

Business Items

The Boston branch of Charles A. Schieren Company is now located at 641 and 643 Atlantic avenue, opposite the South station. There they have a floor space of about 5500 square feet with one of the best-appointed leather stores and belting shops in Boston.

George W. Hoffman, Indianapolis, Ind., manufacturer of the United States metal polish, reports a rapidly increasing business since the first of the year. This polish has been improved and Mr. Hoffman aims to keep it the best on the market for all classes of bright work around a power plant. A free sample will be galdly sent to any engineer upon application.

A directory of engineers and power plants of Greater New York for 1908 and 1909 has just been issued by the Engineering Directory Company, 100 Nassau street, New York City. An alphabetical list of plants is given, together with their capacity and names of engineers-in-charge; also, an alphabetical list of licensed engineers in Greater New York. The price of this directory is $10.

A new style of hot-blast heater coil, distinguished by a positive flow of steam, water of condensation and air in the natural direction due to gravity, and suitable for use with live and exhaust steam and also with water for heating or cooling purposes, was recently placed on the market by the Green Fuel Economizer Company, of Matteawan, N. Y. They advise us that they have made recent sales of this apparatus to 25 well-known concerns.

The Wm. B. Scaife & Sons Company, of Pittsburg, Penn., manufacturer of the "We-Fu-Go" and Scaife water-softening, purifying and filtering systems, has found it necessary to build an addition to the present plant at Oakmont, Penn., to accommodate the increased business in the building of systems for the purification of water for steam boilers, industrial and domestic uses, and is about to begin the erection of a shop 40 feet wide by 200 feet long, equipped with the latest improved machinery, which will be used in addition to the present shops for manufacturing the "We-Fu-Go" and Scaife systems. They have under construction at the present time for steam-boiler plants systems aggregating 95,000-horsepower, in addition to plants for softening and clarifying water to be used in manufacturing processes, such as dyeing and bleaching in woolen and cotton mills, and for washing in laundries; also a number of mechanical gravity filter systems for manufacturing and domestic use.

A shipment of unusual note was recently made to the Isthmian Canal Commission. Colon, Isthmus of Panama, consisting of seven 2½ kilowatt generator sets, built to meet the requirements of the I. C. C. Circular No. 472, Class 3, which called for them to be "built for high speed, self-oiling and automatically governed, and to be able to control, and also strong enough to withstand a change from no load to full load, to be of sufficient capacity to drive the 2½-kilowatt dynamo at the proper speed when under full load and with initial pressure of 60 pounds per square inch," etc. The Fort Wayne Electric Works, of Fort Wayne, Ind., which was awarded the contract furnished and shipped to the American Blower Company's Detroit plant, seven Type M. L. Frame D, 110-volt generators for mounting upon the extended subbases of seven 3¼x3 ABC vertical inclosed self-oiling Type A engines. The combined sets were tested and inspected by a Government inspector and readily approved.

New Equipment

City of Newton, Ala., voted to issue $8000 bonds for water works.

T. H. Marsden, Brady, Tex., will establish an ice plant and cotton gin.

The Torrington (Conn.) Electric Light Company will enlarge its power house.

The Board of Trade, Spencer, N. C., is considering erection of electric-light and power plant.

The Union (Ia.) Electric Light Company contemplates the construction of an electric plant.

Plans have been completed for the construction of the municipal electric-light plant at Bergen, N. J.

W. A. Potter, Mizpah, Minn., has been granted franchise to construct and operate an electric-light plant.

The Bluestone Traction Company, Bluefield, W. Va., will install additional equipment in power plant.

The city of Brewton, Ala., contemplates the installation of engine and dynamo in the light and water plant.

The city of Franklin, N. C., will vote on issuance of $30,000 bonds for water works and other improvements.

The output of the municipal electric-light plant at Anderson, Ind., is to be increased. About $20,000 will be expended.

The Tryon (N. C.) Hosiery Company contemplates enlarging mill and will need new equipment, including boilers, engines, etc.

The Rockford (Tenn.) Cotton Mills, whose electric plant was recently destroyed by fire, is making arrangements to rebuild same,

The Hobart (Okla.) Water Power Company recently incorporated, is said to be planning to construct a hydroelectric plant. C. T. Blake is president.

Plans for installing a motor for pumping water in the municipal electric-light and water plant at Rockport, Mo., are under consideration. W. E. German is manager.

Plans are being prepared for a new factory for L. Adler Bros. Company, Rochester, N. Y. Equipment of plant will include four boilers, automatic engines, generators, motors, blowers, etc.

The Alabama Railway and Power Company is planning to start work on the proposed electric railway between Birmingham and Chattanooga. J. H. Hill, Fort Payne, Ala., is vice-president.

It is reported that the New York Edison Company will soon commence the construction of a central power station in the upper part of the city. Plant will have an output of about 20,000 horsepower.

Bids will be received until March 1 for the construction of a municipal electric-power plant in Lethridge, Alb., Can. George W. Robinson is secretary and treasurer. Smith, Kerry & Chace, Toronto, consulting engineers.

The Williamson Cold Storage Company, Williamson, N. Y., has been incorporated with $75,000 capital to conduct a cold storage, refrigeration and ice-making business. Incorporators, W. B. Freer, W. P. Rogers, K. M. Davies.

Plant in Public Service Building, Milwaukee

A Large Noncondensing Turbine Plant Operating against 22 Pounds Absolute Back Pressure to Furnish Exhaust Steam for District Heating

BY OSBORN MONNETT

It is not often that a noncondensing turbo-generator plant of 4500 kilowatts capacity is designed to operate against a back pressure of seven pounds gage, or 22 pounds absolute. There is such a plant in operation in Milwaukee, and aside from the unusual fact that it is a simple noncondensing plant, there are operating features and conditions under which it was installed which make it of more than ordinary interest. Whenever possible, it is customary to locate a plant where the operating conditions will be most favorable; nevertheless, the engineer must, when necessity arises, be ready to design an installation and operate it when conditions are just the reverse. In the plant under consideration it would hardly have been possible to impose a more formidable array of adverse conditions, and the solution of the various problems are especially interesting from an engineering standpoint.

The plant was installed by the Milwaukee Electric Railway and Light Company and occupies the basement of the Public Service building in the heart of the business district of the city. This building is used as a terminal and waiting room for the various interurban street railway systems and for the general offices of the company. After the building was nearly completed the company undertook a contract to furnish exhaust steam to

FIG. 1. THE TURBINE ROOM, MILWAUKEE PUBLIC SERVICE BUILDING

the Milwaukee Central Heating Company for its American district steam-heating system, and it became necessary to arrange for a plentiful supply of exhaust steam. It was not desired to rely entirely upon either the Oneida or Commerce street stations to supply the [illegible] and in any case it would have been necessary to install additional noncondensing equipment in these stations or to limit the capacity [illegible] of the [illegible] stations [illegible] ing. So the extra generating capacity, instead of being divided up between the existing stations, was concentrated in an independent plant, the peak electrical load of which would come on simultaneously with the peak heating load.

Ordinarily it would not appear advisable to tie up such a heavy investment in noncondensing machinery, which would of necessity be idle for several months in the year, and which could be relied on in emergency during this idle period only at a great sacrifice of economy. However, in every lighting system there is a considerable part of the generating capacity which [illegible] but which is necessary to meet the peak load of short duration in the winter. The [illegible] of peak load generating capacity for the [illegible] lighting system [illegible] mind it can be seen that the existence of the plant is justified.

As the building was about completed before commencing to install any of the equipment, the machinery had to be lowered into the basement at the rear, literally through "a hole in the sidewalk," conveyed a distance of some 200 feet and erected under limited head room without cranes or other conveniences. The installation is a simple, noncondensing steam plant consisting of boilers, heaters,

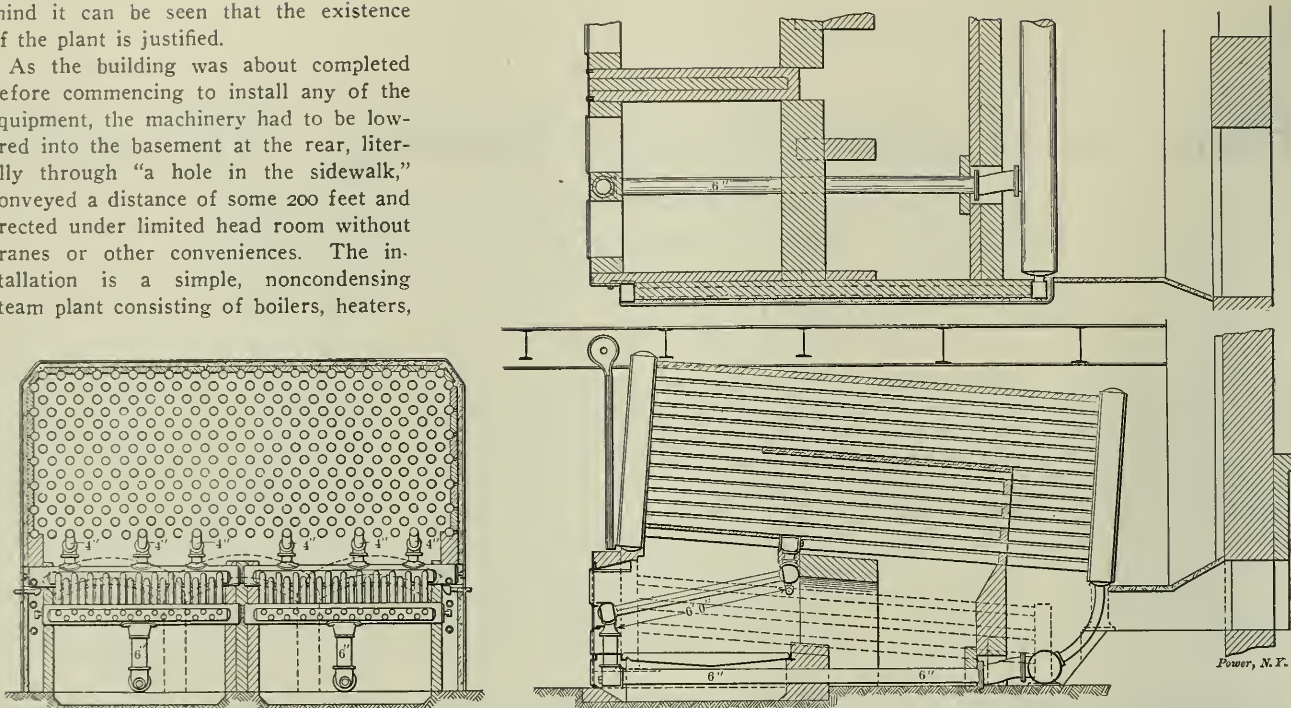


FIG. 2. ARRANGEMENT OF BOILER SETTING

feed pumps, generating units and the switchboard. Absence of the usual amount of auxiliary machinery in a plant of this size is marked, what there is of this pertaining more to the building as an office building than to the generating plant.

Steam Generating Equipment

For generating steam there are installed ten Edge Moor water-tube boilers of the drumless type, each rated at 400 horsepower on a basis of 10 square feet of heating surface per horsepower when neglecting 1500 square feet of superheating surface in the tubes above the water line. They occupy the southern side of the basement, as shown in Fig. 4, so that the space under the sidewalk becomes convenient for the storage of coal, a capacity of approximately 2000 tons being available. Youghiogheny screenings, which is the fuel used, are brought to the plant by wagons, dumped into the storage bin and fed to the furnaces by hand, and a motor-driven ash hoist elevates the ashes to the street level and loads them into wagons.

The columns of the building are supported on pedestals which spread out over a considerable area below datum and rest on piles, and owing to the slope of the foundations only a limited amount of excavating was permissible, this being done at the expense of the floor space. For this reason a head room of only 11 feet 10 inches could be obtained between the boiler-room floor and the I-beams of the ceiling. By arranging the highest points of the boilers to come between the I-beams, as shown in the elevation, the equipment was installed.

With the exception of having no steam drums, the boilers are of the standard Edge Moor construction. The handhole plates are made up with lead gaskets below the water line and with asbestos gaskets above, as superheat of some 30 to 50 degrees is obtained in the upper tubes. The mud drums slope forward from the rear header to conform with the limited floor space and are fitted on each end with two 2-inch Chapman gate valves in series. Squires feed-water regulators are used, and there is a feed valve on each side of the boiler, the feed entering each end of the mud drum.

One of the features of the boiler setting is an arrangement whereby some of the heat ordinarily radiated from the side walls is saved. This arrangement consists of a water leg, extending downward

FIG. 3. VIEW IN BOILER ROOM

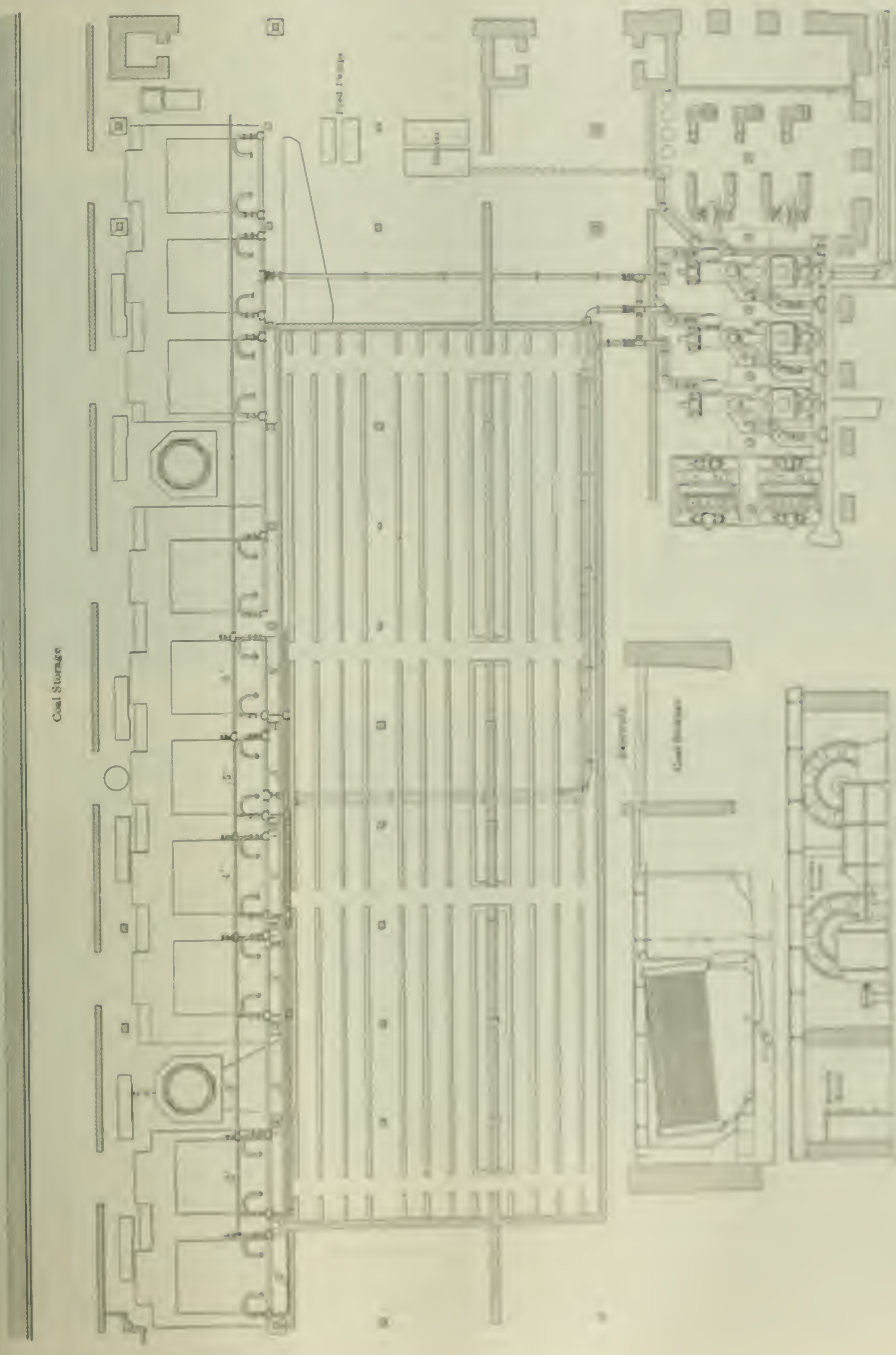


Fig. 4. PLAN OF POWER PLANT AND SECTIONAL ELEVATIONS OF BOILER AND TURBINE ROOMS

on each side of the front header, into which tubes are expanded and terminate in similar legs connected to the mud drum to allow free circulation of the water. The construction is indicated in Fig. 2.

Steam is taken from the top of the rear header on each side and passes to a 10-inch steam main immediately behind the boilers, through two 5-inch short-radius bends and Chapman stop valves. Hollow staybolts are provided in the front header for blowing the tubes. Fig. 3 shows a front view of the boilers. The piping is arranged so that the boilers are divided into three groups, each connected to its independent 10-inch header. These headers have no bypass connection with each other at the boilers, but the feeders to the turbine room are so tied together that any group of boilers may furnish steam for any turbine unit. Four boilers are connected to the first header and three to each of the two remaining headers. From the center of each header there extends a 10-inch line to the outside of down from the rear header to the mud drum, thence through the horizontal central tubes to the lower manifolds at the front and up through the water-tube grates to the front header.

Feed water comes from the city mains to either of two 1500-horsepower Hoppes open feed-water heaters. It is fed to the boilers by two Worthington 14x8¼x15-inch outside center-packed pot-valve pumps which are controlled by Mason regulating valves in conjunction with the feed-water regulating system. It was necessary to excavate to get sufficient head room for the pumps.

Two stacks, each 9 feet in diameter and 150 feet high, serve the boilers, five boilers to each stack, the gases being collected in rectangular flues and uptakes built of blast-furnace-slag cement.

Turbine Room

There are three Allis-Chalmers-Parsons type of noncondensing turbo-generators installed, each of 1500 kilowatts capacity, pump to be used in starting and in emergencies.

The principal point in which the turbines differ from the standard condensing turbine is in length of rotor, a shorter machine being required for noncondensing service. The velocity of the steam is not enough to demand the low-pressure blades, which, if supplied in this case, would have had a velocity greater than could have been utilized by the steam under the excessive back pressure at which it goes to the exhaust. The machines were installed under a guarantee to develop a kilowatt-hour on 44 pounds

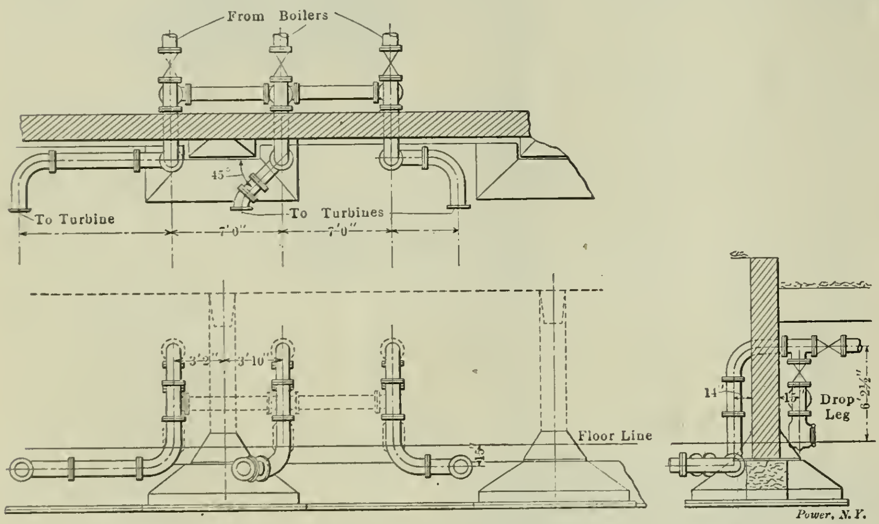


FIG. 5. STEAM HEADER MANIFOLD BETWEEN BOILERS AND TURBINES

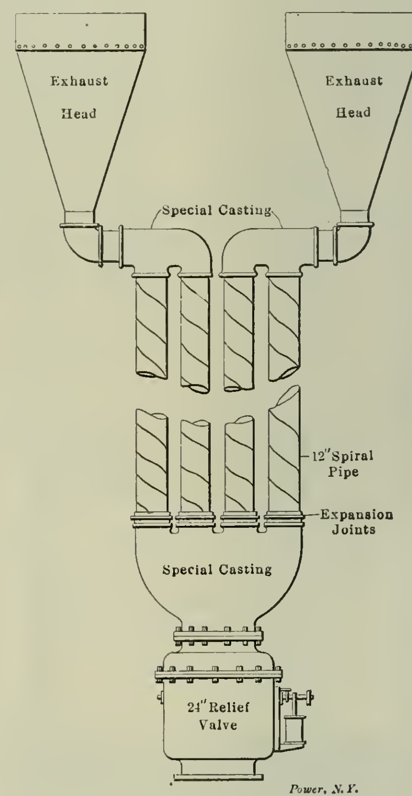


FIG. 6. DETAIL OF EXHAUST RISER

the turbine-room wall, where the three lines are connected to a 10-inch manifold. By this arrangement any one of the steam lines may be cut out and steam supplied by the remaining two. Fig. 5 shows a plan and elevation of this arrangement. It will be seen that there is a drop leg under each steam line to collect condensation, if any should occur, and if desired the manifold may be cut out entirely and each unit be run on steam from its own battery of boilers. On passing through the turbine-room wall, the steam lines drop below the floor and at this level connect to the turbine throttles.

Owing to the restricted head room the boilers were necessarily made wide to get the required heating surface, and this construction permitted the installation of two Hawley down-draft furnaces. The upper manifold of each furnace is connected in three places to the lower tubes of the boiler. Circulation is then running at 1800 revolutions per minute and developing with star-connected generators 60-cycle three-phase current at 2300-4000 volts. To avoid vibration was the primary reason for installing turbines, but aside from that, it is extremely doubtful if the necessary engine capacity could have been put in place under the conditions of head room and floor space available. Even under the circumstances some ingenuity had to be exercised in making the exhaust connections, on account of the extended character of the pillar foundations. These were cut away sufficiently to allow the placing of a special rectangular casting connecting each turbine with the exhaust main.

Each unit has an oil-circulating system driven by worm gearing, by which the bearings are lubricated and which is also used to actuate the throttle valve under control of the governor. There is also installed an independent motor-driven oil of dry steam at half load, 40 pounds at full load and 41 pounds at 25 per cent. overload. It has been the practice to carry just sufficient load on the turbines to furnish the demand for steam on the heating system, and up to the present time there has not been enough demand to carry an economical load for long periods.

The accompanying boiler test, taken under ordinary working conditions, shows that, with an economical load on the turbines, a kilowatt-hour can be delivered at the switchboard for 4.23 pounds of coal, and this figure, it must be remembered, is obtained while operating against 22 pounds absolute back pressure.

The turbines exhaust into a 24-inch main which leads to the tunnel of the Central Heating Company. On this main is a 24-inch Crane relief valve with risers extending to the roof. There was no room which would permit of a 24-inch outlet

TEST OF ONE OF THE EDGE MOOR BOILERS.

Duration of test, hours	9
Heating surface, square feet (including Hawley furnace)	3,930
Superheating surface, square feet	1,504
Grate surface, square feet	2 Hawley furnaces 6'x6'x6" each
Barometric pressure	29 3
Steam pressure absolute	162 9
Temperature of steam, degrees Fahrenheit	415 4
Chimney draft in inches of water	0 6
Temperature of feed water, degrees Fahrenheit	180 3
Temperature of escaping gas, degrees Fahrenheit	450
Pounds of coal burned as fired	13,600
Pounds of coal burned dry	13,042
Pounds of refuse	1,970
Pounds of combustible	11,072
Per cent. of refuse to dry coal	15 1
Coal burned per hour dry, pounds	1 449
Total pounds of water evaporated (apparent)	116 6[illegible]
Degrees of superheat	[illegible] 6
Factor of evaporation (including superheat)	1 1[illegible]
Total water actually evaporated f. and a., 212 degrees, pounds	12[illegible] 41[illegible]
Total water actually evaporated per pound coal f. and a., 212 degrees, as fired, pounds	9 44
Total water actually evaporated per pound coal (dry) f. and a., 212 degrees, pounds	9 84
Total water actually evaporated per pound combustible f. and a., 212 degrees, pounds	11 [illegible]
Rated horsepower	4[illegible]
Horsepower developed during test	41[illegible]
Kind fuel used	Youghiogheny [illegible]
Total B.t.u. per pound of coal	13,[illegible]
Per cent. efficiency of boiler	7[illegible] 1

Approximate analysis: Moisture, 4.1, volatile matter, 28.7, fixed carbon, 56.7, ash, 9.6, sulphur, 1.7.

being installed, and it was finally found necessary to utilize a narrow space in one of the elevator shafts. As shown in Fig. 6, a special casting was made fitting the relief valve and having four connections. Twelve-inch spiral pipe was run from these connections to the roof and here by the use of more special castings the pipes were run into two 16-inch Cross exhaust heads.

ELECTRICAL INSTALLATION

Practically all of the electrical output of the station is used on lighting service, either as 2300-volt three-phase current or on the Edison three wire 220-volt system. Alternating- and direct-current busbars connect with the other two stations and the plants operate in multiple both on the alternating-current and direct-current sides, using for the latter service two [illegible]-kilowatt Allis-Chalmers motor-generator sets and a storage battery of 320 chloride cells. Each motor-generator set consists of a [illegible] three-phase synchronous motor driving a [illegible]-kilowatt direct-current generator at [illegible] revolutions per minute and delivering current at 220-250 volts. The units are started from the direct-current busbars.

Each set has a generator panel carrying a Westinghouse edgewise ammeter, voltmeter, double-throw main switch, a Thomson recording wattmeter, alternating-current voltmeter, a direct-current field meter and power-factor indicator. There is a booster panel controlling a 150-kilowatt General Electric 1200-ampere booster for charging the storage battery. Two battery panels are provided with edgewise Weston ammeters and cell switch indicators and controlling apparatus. Twenty-four three-wire direct-current feeder panels, Fig. 7, are installed, with edgewise Weston ammeters on each wire of the three-wire system. There are no circuit breakers between the load and the direct-current side of the motor generators, but on the alternating-current side automatic circuit breakers are provided. Six lighting panels with a double set of busbars control the circuits in the building, each circuit having a double-throw switch so that it may be thrown on either the direct- or alternating-current side of the system.

FIG. 7. SWITCHBOARD

The storage battery consists of 320 [illegible] chloride cells of 1500 ampere-hours capacity, divided into two sets having 20 end cells each. It is charged during the day and discharged on the peak load which comes between five and six in the evening.

Although ordinarily furnishing direct current, the motor generators on the alternating-current and direct-current sides [illegible]

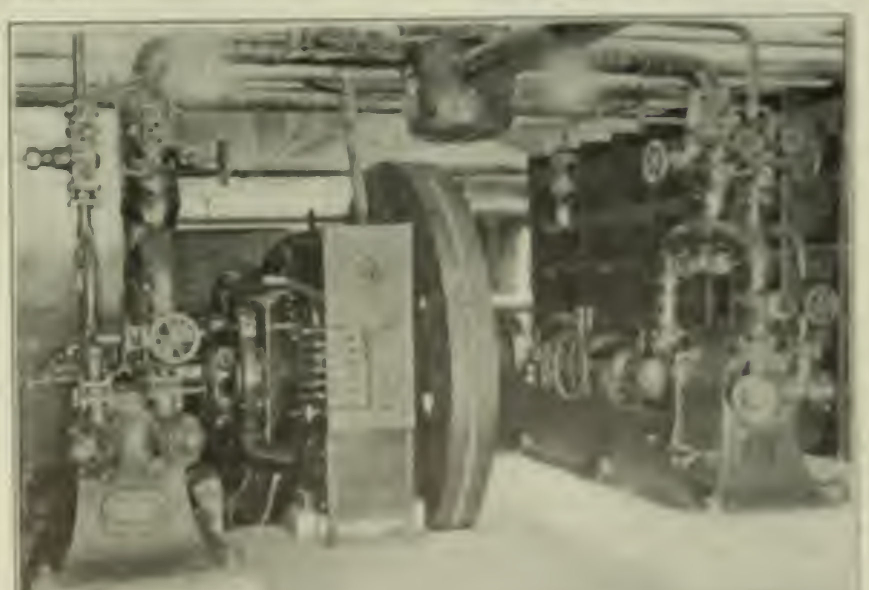


FIG. 8. [illegible] MACHINES

Minor Apparatus

To cool drinking water in the building, a 25-ton Vilter refrigerating machine has been installed and is driven by a variable-speed Crocker-Wheeler motor, direct connected to the shaft. Waukesha water is brought in tank cars to the building and turned into two 10,000-gallon cement tanks in the basement. The expansion coils of the refrigerating machine are located in these tanks, and the exchange of heat is direct, without the intermission of a brine system. Two Yoeman motor-driven centrifugal house pumps circulate the water. The refrigerating equipment, shown in Fig. 8, is much larger than necessary for its present use, but it is the intention in the future to supply refrigeration to outside parties. Foundations are installed for a similar unit of the same size.

Other modern devices characteristic of a first-class office building are a vacuum cleaning system, the vacuum of which is obtained by a steam aspirator; and a Lamson pneumatic tube system for the transfer of papers, etc., from one department to another, this service being maintained with two 150-cubic foot Christensen motor-driven air compressors. A Stromberg auto-telephone system combined with the Bell system is installed for intercommunication and for outside calls. The building is heated with the Paul system of vacuum return, and for fire service there is provided a 6-inch single-stage Lawrence centrifugal pump driven by a General Electric 85-horsepower motor running at 750 revolutions per minute.

The plant as a whole is satisfactorily fulfilling the special purpose for which it was intended. It was designed and installed under the direction of C. J. Davidson, chief engineer of power plants.

The Use of Wooden Rings in Water Mains

By William Kavanagh

In laying large pipe intended for conveying water the employment of wooden rings, shaped to suit varying angles and inequalities between elbows, tees, etc., and also to act as lengthening pieces between fittings and flanges, will be found to be very important. In general, large pipe cannot be handled with the same facility as small pipe, it being practically impossible to force heavy pipe into line should fittings be tapped angularly or out of true, and in some cases the nipples or lengths of pipe will screw up farther into the fittings than anticipated, shortening the pipe. Sometimes lengths of pipe or nipples will be found bent, either through handling or because of some defect of construction, and when large pipe is to be connected and erected at a place remote from a shop having tools large enough to cut and thread it, the ingenuity of the pipefitter is taxed to remedy such troubles.

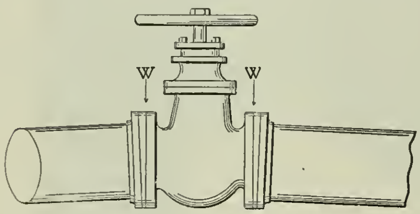


FIG. 1

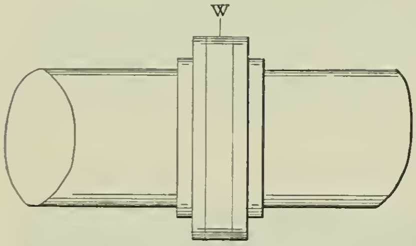


FIG. 2

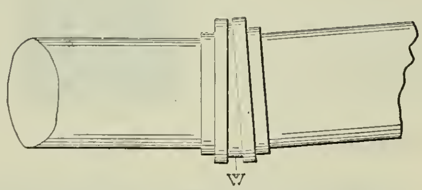


FIG. 3

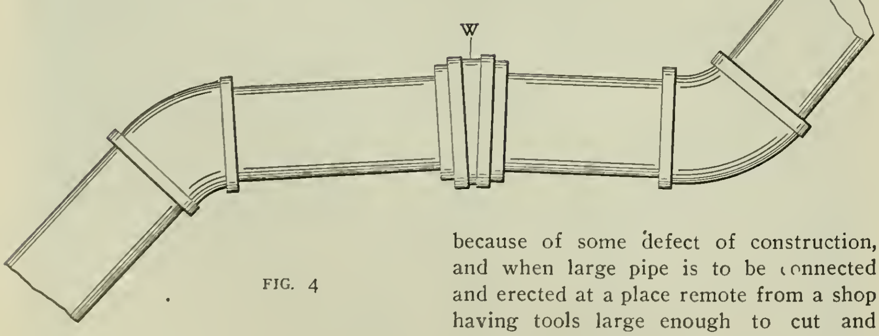


FIG. 4

Not long ago numerous difficulties were overcome, in the erection of a large water main intended for conveying water under a pressure of 150 pounds per square inch, by the employment of wooden rings shaped to suit requirements. The size of the pipe was 14-inch, and its installation through various winding passageways and crooked, narrow places called for the use of numerous short pieces of pipe, together with the usual flange unions, valves, tees and elbows. Whenever it was found expedient, a wooden ring was used. The ring was first shaped, then drilled and fitted to suit the bend or alinement of the fittings. After this, a rubber gasket was fitted to each side of the ring, or wedge, and the whole inserted in the desired position and bolted in place. Whenever the thickness of the wooden ring exceeded a certain amount, the length of the bolts had to be increased, and when the angle of the bend became acute the diameter of the bolts had to be decreased, in order to pass them through the holes.

Fig. 1 shows how the nipples approached the main stop valve and the application of the wedge-shaped wooden rings to fill out deficiency of alinement is shown at *W W*. Fig. 2 shows how a wooden ring *W* was employed to overcome deficiency of length. Here the nipples screwed into the fittings farther than was expected and the distance was made up by increasing the thickness of the ring, which in this case was 2 inches, a rather large amount to stretch a piece of 14-inch pipe. Fig. 3 shows how two nipples approached each other, having a flanged-union connection. It was found impossible to spring the nipples sufficiently to enable the bolting up of the union and at the same time have it face properly. The use of the ring *W* compensated for this deficiency.

Fig. 4 shows how the nipples and flanged union from two 45-degree elbows appeared when connected. The elbows and nipples lay close along a heavy stone floor, making it impossible to manœuver the elbows so as to have the union face properly. A wedged-shaped wooden ring, similar to that in Fig. 3, was employed, and it filled the requirements nicely. Fig. 5 illustrates the use of the wedge-shaped wooden ring between two 90-degree flanged elbows. Here it was found impossible to cant or swing the nipples so as to enable the correct facing of the elbows and permit of bolting them together. The use of the ring *W* was all that could be desired and it facilitated the connection of this part of the line more rapidly than if the heavy stone wall, over which the pipe had to run, were cut away.

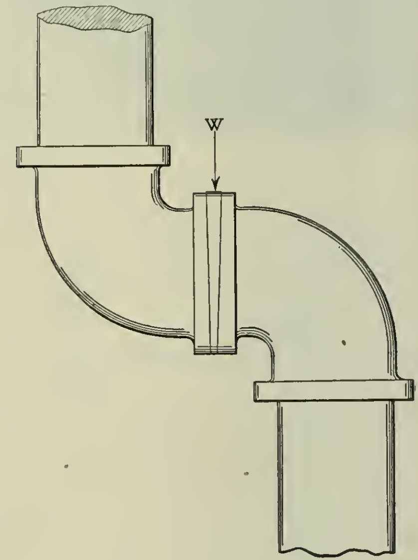


FIG. 5

In all cases the joints in which the wooden rings were used were water tight and satisfactory in every respect.

A New Binding Agent for Coal Briquets

Consul George Eugene Eager, of Barmen, Germany, gives the following details regarding the advantages of briquet making by the use of sulphite pitch (zelpech), with a preliminary statement concerning the making of coal briquets with tar pitch in general:

Only fifty years ago the dust of coal was considered to be entirely useless, but since then a great change has taken place and at present in Rhenish Westphalia the Ruhr coal district alone produces 3,000,000 tons of such briquets each year. The same increase is shown in the other European coal districts, i.e., Silesia, Belgium, England, etc.

Up to the present, coal-tar pitch (so-called brai) has been used for making coal briquets, and its production in the past ten years has increased about 100 per cent. Most of the coal-tar pitch is produced in England and Germany, the latter country only being able to produce for its own consumption, while England supplies the remaining consumers, i.e., America, Russia and Belgium. As stated, the coal-tar pitch production is limited, and consequently in the United States and Russia only comparatively few briquet manufactories are to be found.

The coal-tar pitch is an excellent binding agent for baking and coking coal, especially bituminous; it burns easily and gives the briquets hardness for long-distance transport, but various qualities of good briquet material cannot be bound with it, thus making its common availability impossible. Its numerous disadvantages are as follows: It produces very much smoke and has a very disagreeable odor; it cannot stand high temperature, and becomes soft and difficult of use in hot or extreme weather; the dust and fumes of coal tar, being corrosive, are very injurious to the skin, eyes and lungs of the workmen employed, causing diseases of these organs. The low temperature at which it ignites, although an advantage when used with soft bituminous coal, becomes a great disadvantage when the attempt is made to use materials that burn less easily. The coal tar becomes soft and burns much more rapidly than the coal flowing out of the briquet, leaving the coal to fall to pieces in dust and remaining unconsumed.

NEW MATERIAL FROM WOOD CELLULOSE

For this reason it has been impossible to briquet anthracite, semi-anthracite, or coke gravel with coal tar pitch, it being unable to resist the heat and pressure of the blast furnaces; therefore a binding agent which overcomes all of the difficulties mentioned ought to have the most brilliant prospects for the future.

This long-sought-for binding agent has been found in the "sulphite pitch." The material is obtained in the process of manufacturing sulphite cellulose. The wood is put through a washing process in lye by which the fiber is cleaned of all resinous ingredients, it being pressed out from the wood pulp. Thus far this material has been entirely useless. Through a cooking process it is reduced to a highly glutinous substance called "sulphite pitch."

The sulphite pitch possesses many qualities which show its excellent advantages as a binding agent. It is intensely glutinous and possesses a high binding power. In the ordinary briquet of bituminous coal from 7 to 10 per cent. of coal tar is used to give it the proper hardness, and with the use of sulphite pitch the same results can be obtained by the use of 5 per cent. There are qualities of coal and ore that can easily be made into briquets with from 2 to 3 per cent. of the sulphite pitch.

Sulphite pitch burns without smoke or odor and is an ideal fuel for the household as well as for industrial purposes. In cities where the smoke nuisance has heretofore prevailed the use of briquets made with this sulphite pitch will form a solution of the smoke question. Trials have already been made with coke briquets made with this new process in blast furnaces and on torpedo boats, with the most sanguine results. The former tests not only showed a saving of 20 per cent. coal, but the iron showed almost an entire freedom from sulphur. In its trial on the torpedo boats it not only proved a perfect fuel, but the entire absence of smoke proved its advantage over other fuels in time of war. Ocean liners, warships, railway engines and factories could all use this fuel to advantage and not only economize in the amount of fuel necessary, but would relieve the cities from the smoke nuisance.

AVAILABILITY OF MATERIALS

Sulphite pitch does not soften under heat and burns at a high temperature. It can be ground to any consistency or can be produced directly in any form of powder; it can be had in every country where there are cellulose mills and it is very cheap, while the coal-tar pitch, which is rare and expensive. Many attempts have been made to briquet anthracite, semi-anthracite, coke gravel, or dross, even with a very high per cent. of coal tar, but without success. These disadvantages all disappear with the use of the sulphite pitch. Anthracite briquets for household use (egg form for American stoves) manufactured with sulphite pitch burn smokeless and odorless; therefore, they are not only an excellent substitute for the anthracite coke, but are even superior to them.

Recent trials to briquet coke gravel and dross the remainder of coke (gasworks cinders) with tar pitch have proved failures, but the situation changed immediately as soon as sulphite pitch was used as the binding agent, and the results show a briquet that can be considered a perfect substitute for coke. Practical trials of these briquets in both blast and cupola furnaces have shown that the briquets do not fall to pieces even under the highest temperatures, but keep while gradually shrinking. On account of their consistence they sway deeply into the melting zone of the furnace, thereby positively contributing materially to the melting effect. Fine ore, bog iron ore, brown ore, manganese ore, pyrite, furnace cadmia (flue dust from blast furnaces), and other ores can all be made into briquets by the use of sulphite pitch and successfully melted in the furnace. All trials of these materials with coal-tar pitch have failed, because the binding agent burned away at a lower temperature, leaving the material in dust as before. With sulphite pitch it is possible to briquet furnace cadmia so that it can be melted in a blast furnace. This alone means a great saving to the iron industry.

CONSTITUENT ELEMENTS—PROCESS OF MAKING

In general, sulphite pitch consists of the following substances: Coke, 25 to 35 per cent.; volatile matter, 50 to 60 per cent.; ashes, 8 to 12 per cent.; water, 10 to 15 per cent.

The latest chemical tests have proved that the percentage of ashes can be materially reduced. Through the origin of sulphite pitch its ashes contain sulphur up to 20 per cent., or 2.5 per cent. of the sulphite pitch. The sulphur, however, is tied up to iron and lime, which latter substances are always present in abundance, so that the sulphur remains in the ashes and cannot do any damage. It is true that sulphite pitch can be dissolved in water, and that briquets made from it are not waterproof; but this is of no great importance, as in most cases a waterproof briquet is not needed. The sulphite-pitch briquet is, however, more waterproof than the lignite briquet, the making of which has become a flourishing industry. The sulphite briquet is not hygroscopic and can be made absolutely waterproof, if it is necessary, by a simple special treatment.

It is not supposed that sulphite pitch will in any way interfere with the coal-tar pitch in its use for soft bituminous coals, but the superiority of sulphite as a binding agent for the harder coals and cokes, also iron dust and other ores, opens up a new and very important industry. Already a large coke-briquet factory has been built in Langenberg near Barmen-Elberfeld, and the entire output of the factory was sold out at once. Another large factory is in process of construction in Aix la Chapelle [illegible] and [illegible] Europe.

Guide to Small Station Switchboard Design

General Instructions and Suggestions for Station Managers for Laying Out Switchboards for Small Alternating- and Direct-current Plants

It frequently happens that the switchboard equipment of a small station must be almost if not entirely superseded by a new switchboard in order to meet the requirements of increased load and unexpected changes in the character of the load. In many such cases, the work of laying out the new switchboard devolves upon the operating head of the plant because the owners consider it too small to justify the employment of a consulting engineer. To meet such cases, the General Electric Company has formulated general fundamental instructions and suggestions which will be found most helpful to station managers confronted with the conditions mentioned. Because of the highly useful character of this material we reprint herewith that portion of it which relates to alternating-current stations of 2300 volts and direct-current power plants of 575 and 275 volts.

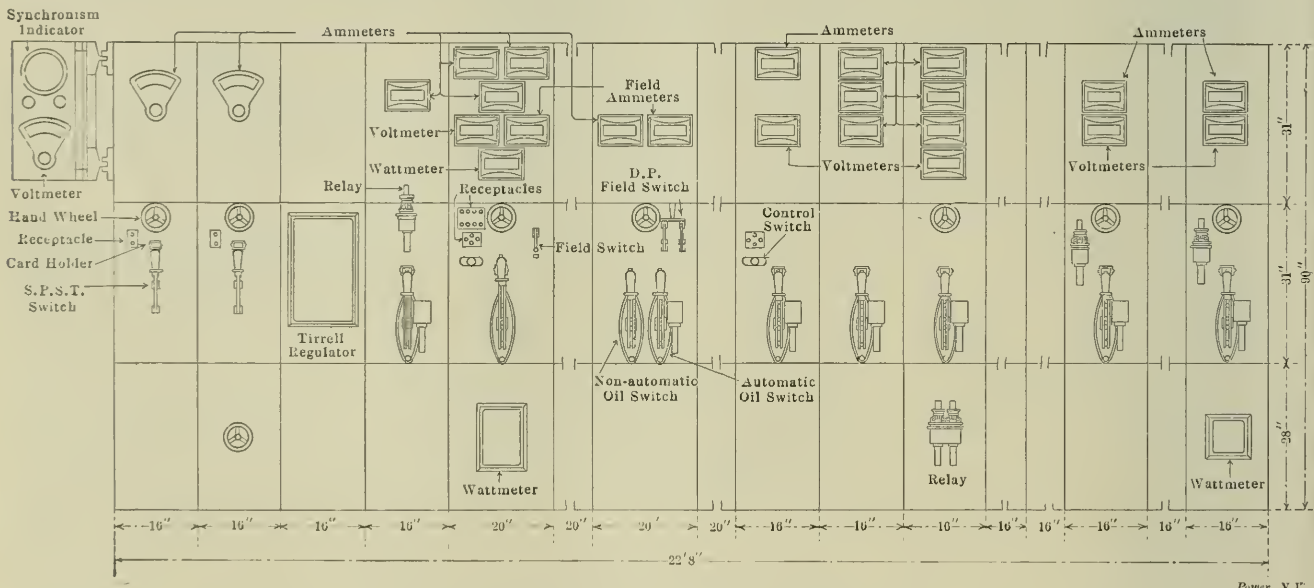


FIG. I. FRONT VIEW OF 2300-VOLT SWITCHBOARD

2300-volt Alternating-current Switchboards

Exciter Panels

The exciter panels should preferably be arranged for the control of only one exciter from each panel for the reasons that the panel and the exciter can be considered as a unit, and can be disposed of together if any change is made in the equipment; a more symmetrical arrangement can be made of the instruments and other devices, and the switchboard can usually be laid out with a fewer number of sizes of panels.

The equipment recommended for exciter panels is as follows: One ammeter, one field rheostat handwheel, one single-pole, single-throw switch and one two-point potential receptacle. Negative and equalizer switches should be mounted on or near the machines. A fuse on a base behind the panel may be added, if desired.

The best plan, as a rule, is to use only one voltmeter for the exciters, and mount this on a bracket at the end of the switchboard. If a voltmeter is used for each exciter, it may be mounted on the corresponding exciter panel; a potential receptacle will then be unnecessary.

Induction-motor Panels

When exciters are driven by induction motors, it is necessary to provide a panel for the control of the motor. The equipment should consist of one ammeter, one triple-pole single-throw automatic oil switch with bell-alarm switch, and one inverse time-limit overload relay. If a Tirrill regulator is installed, there will usually be room for it on this panel.

This arrangement is used also because the induction-motor panel is usually placed between the exciter panels and the generator panels. If for any reason the induction-motor panel is not so placed, it is better to use a separate panel for the regulator.

Generator Panel

The standard equipment of a three-phase generator panel is as follows: Three ammeters, one polyphase-indicating wattmeter, one voltmeter, one field-circuit ammeter, one single-pole single-throw field-circuit switch with discharge clip, one handwheel and chain mechanism for field rheostat, one four-point synchronizing receptacle, one eight-point potential receptacle and four-point plug, one triple-pole single-throw nonautomatic oil switch, two current transformers and two potential transformers.

A synchronism indicator is recommended in all cases. The best place for it is on a swinging bracket at the end of the board.

If the generators are rated in current output, as is customary with some builders, it is advisable to install ammeters on these panels in order that it will be possible to ascertain at any time exactly what current each machine is delivering. All three-phase systems are more or less unbalanced; therefore, in order to obtain correct readings, it is necessary to install an ammeter in each leg of each generator circuit.

Indicating wattmeters are important, as it is not possible to determine by any other means the division of load between two alternating-current generators running in multiple. The ammeters cannot differentiate between the idle component and the work component of the current from a machine, and are therefore of no use in determining the division of load.

Field-circuit ammeters are useful, but not absolutely necessary. They serve as a check on the generator in case of trouble, and are valuable when testing for trouble.

Voltmeters are, of course, used to read the voltage of the machine before it is connected in multiple with any other. They are also used to indicate the potential of the busbars. The eight-point receptacle on the panel is provided to connect the voltmeter to any of the phases.

The field-circuit switch is equipped with a discharge clip, in order that the inductive discharge which occurs when the switch is opened can be dissipated through a resistance without injury to the machine or any of the other apparatus.

The synchronizing plug is used to connect the generator to the synchronizing busbars leading to the synchronism indicator. The General Electric Company has always recommended synchronizing between machines, and for this reason two types of plug are furnished with its switchboard equipment, one marked "Machine running," and the other "Machine starting." If a synchronism indicator is used, the proper connections will be made by means of these plugs, so that the synchronizing indicator will show whether the starting machine is operating too slow or too fast.

Usually the rheostat is too large to mount on the back of the panel. The handwheel can be mounted on the panel and connected to the dial switch on the rheostat by means of a sprocket wheel and chain or bevel gears, etc., or in some cases the dial switch of the rheostat can be placed on the panel and connected to the resistance by leads. The latter arrangement is objectionable on account of the great number of leads and the expense. If rheostats are placed at any considerable distance from the switchboard, it is better to operate them electrically and mount simply the control switch on the panel.

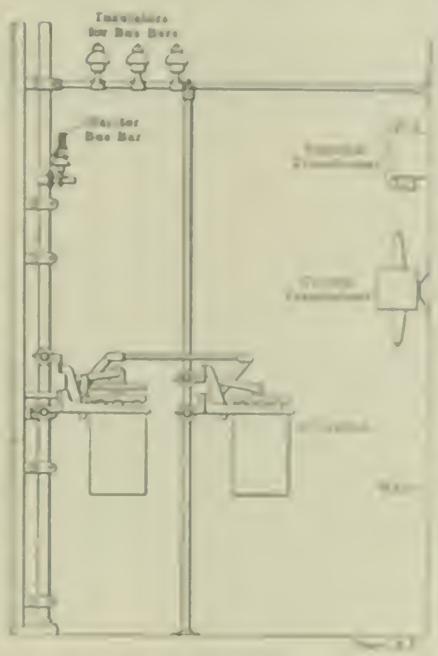


FIG. 2. SECTION THROUGH SYNCHRONOUS-MOTOR PANEL

Many engine builders furnish means to adjust the governors of their engines, and it should be ascertained in each case whether such a device is to be furnished, and the type of motor used, in order that the proper switch can be mounted on the panel.

No automatic protection is recommended for alternating-current generators for several reasons. If automatic switches are used, there is great danger of shutting down the plant at the time of putting machines in parallel if the machines are not exactly in synchronism when they are connected together. If a short-circuit or overload occurs on any feeder, the generator switches are liable to open at the same time as the feeder switches, causing a shutdown. Most alternating-current generators are so designed that they are not injured by momentary short-circuits.

Synchronous-motor Panels

When motor-generator sets are used for furnishing either Edison three-wire direct-current service, or 550-volt railway or power service, the synchronous-motor panels should be equipped with one main ammeter, one field ammeter, one double-pole single-throw field switch with discharge clip, one rheostat handwheel and chain mechanism, one triple-pole double-throw automatic oil switch (automatic on one throw only), with bell-alarm switch, one triple-pole single-throw non-

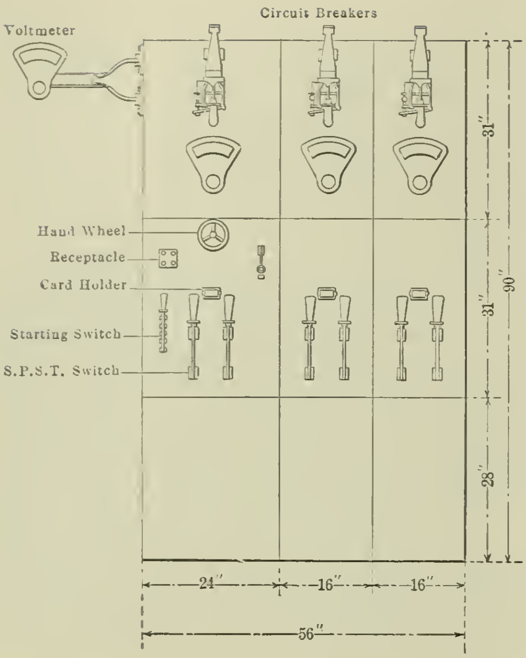


FIG. 4

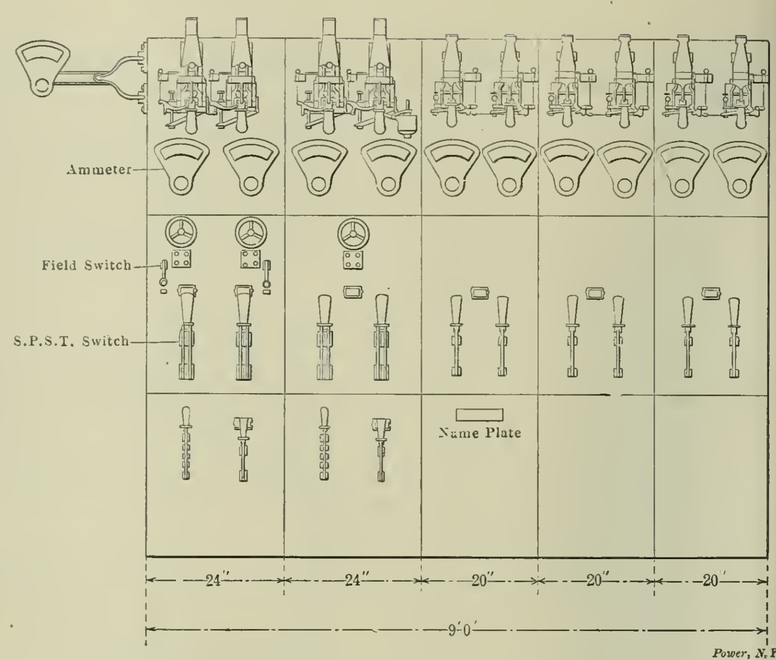


FIG. 5

FRONT VIEW OF DIRECT-CURRENT SWITCHBOARDS

automatic oil switch for compensator, and two current transformers.

If the synchronous motor sets are started only from the direct-current side, the main switch should be single-throw. If, however, they are started from the alternating-current side, the main switch should be made double-throw, in order that the motor can be connected to the starting taps on the compensator and then thrown over to the line by the switchboard operator.

When the sets are started from the direct-current side, it is necessary to synchronize and to add a voltmeter and potential transformer to the panel for reading the potential when synchronizing.

The arrangement of the field rheostats on these panels should be similar to the arrangement of the rheostats on the generator panels.

Rotary Converter Panels

Where rotary converters are used the alternating-current panel for the converter should have the following equipment, assuming direct-current starting: One main ammeter, one voltmeter, one synchronizing receptacle, one triple-pole single-throw automatic oil switch, with bell-alarm switch, two current transformers, and one potential transformer.

When rotary converters are used for furnishing Edison three-wire service, it is customary to install a regulator on the alternating-current side of the rotary, in order to be able to control the potential of the direct-current service. This regulator is usually motor-controlled, and in such cases a double-pole double-throw control switch should be mounted on the panel. The voltmeter is not necessary if no potential regulator is used.

Three-phase Feeder Panels

Three-phase feeders are frequently used for lighting, but are more generally used for power service. The equipment of each three-phase feeder panel should consist of three ammeters, one triple-pole single-throw automatic oil switch with

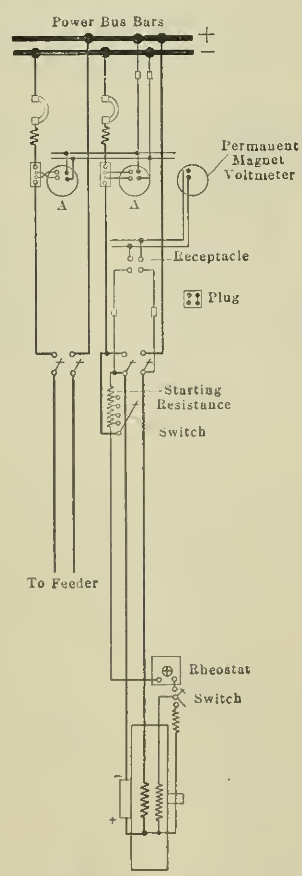


FIG. 6

bell-alarm switch and two current transformers.

If three-phase feeders are used to supply lamps as well as motors, the preferable method for operating the lighting circuits is to connect the lamps to one phase of the three-phase feeder and apply a regulator to this phase; this will afford complete control of the lighting. The usual equipment of a panel for controlling a circuit of this kind is as follows: Three ammeters, one voltmeter, one voltmeter compensator, one handwheel for the control of the regulator, one triple-pole single-throw automatic switch, with bell-alarm switch, four current transformers and one potential transformer.

If the regulator is located at a considerable distance from the switchboard, it is preferable to operate it electrically, and a double-pole double-throw control switch, instead of the handwheel, should be mounted on the panel. If the regulator can be placed close to the panel, however, it can be connected to the handwheel on the panel by means of either a sprocket wheel and chain, or by beveled gears.

Single-phase Feeder Panels

If single-phase feeders are used for lighting, the equipment should comprise one ammeter, one voltmeter of the compensating type, one double-pole single-throw automatic oil switch with bell-alarm switch, one current transformer and one potential transformer.

In case regulators are used, the same arrangement should be made on this panel for the control of them as is outlined for the three-phase panels.

Relays

The General Electric Company has developed what is known as the diaphragm-type relay, which operates on the inverse time element principle; that is, it can be adjusted to operate in a predetermined time with certain currents. If so adjusted, the time of operation is inversely proportional to the amount of current, and approaches an instantaneous value in case of a short-circuit. The use of this relay is recommended on all feeder circuits, alternating current rotary converter panels and synchronous- or induction-

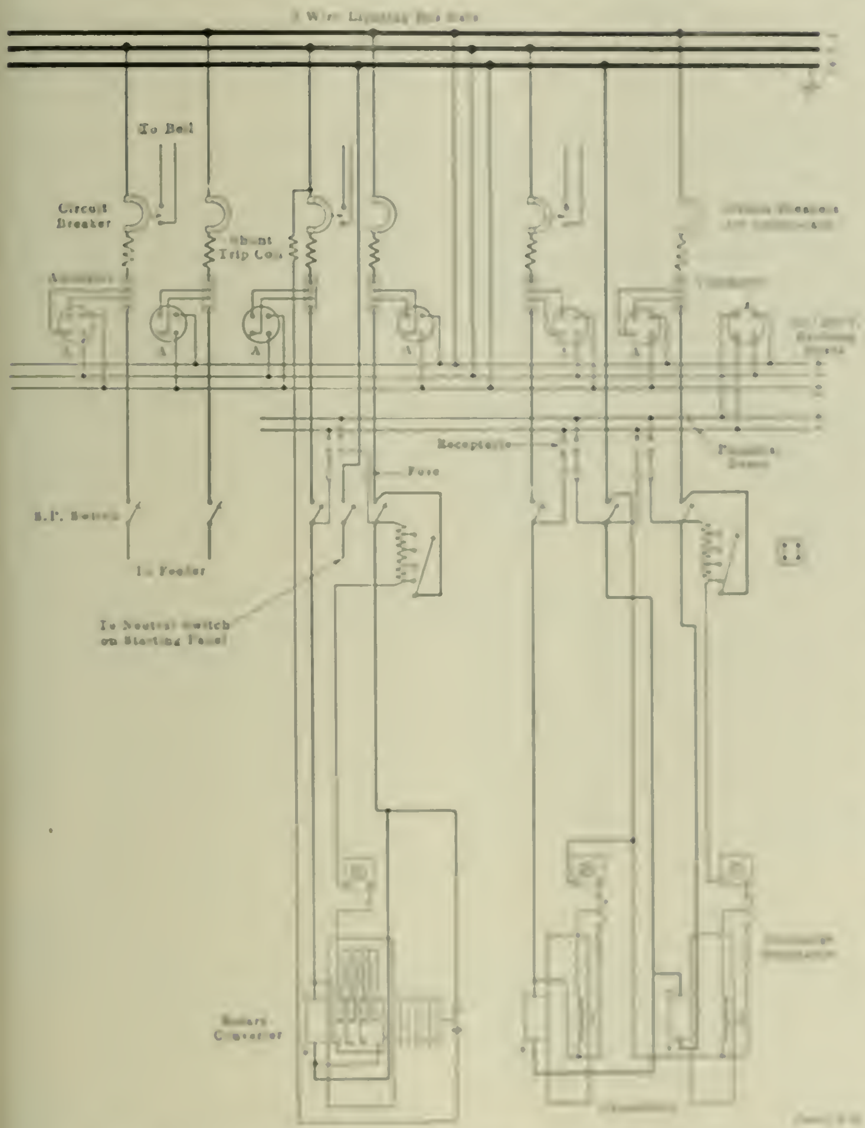


FIG. 7. DIAGRAM OF CONNECTIONS OF ALTERNATING-CURRENT SWITCHBOARDS

motor panels, as it prevents the shutting down of the circuit by a momentary overload, yet will disconnect the circuit practically instantaneously in case of short-circuit or similar trouble.

Ground Detectors

It is desirable to use an electrostatic ground detector connected to the busbars. This can be mounted on a stationary bracket at the top of the switchboard, or on a swinging bracket at the side of the switchboard. The bracket at the top is preferable, as it places the instrument beyond the reach of the station attendant and removes all high-tension apparatus from the switchboard proper.

Arrangement of Apparatus

There are many possible arrangements of the oil switches, current and potential transformers, busbars and connections. The best arrangement to employ depends on the design of the station and the proposed location of the switchboard. With the arrangement shown in Fig. 1 the busbars are mounted on a pipe framework at the top of the panel and the oil switches on the panel-pipe supports. The use of remote control switches makes a preferable arrangement, as the connections can then be made in a position so as to make the backs of the panels more accessible for testing, or for any changes or repairs which are found necessary.

Under no conditions should the current and potential transformers be mounted on the back of the panel, because with such an arrangement the panel would be covered by the connections to and from the transformers, and thereby made inaccessible. In some cases the connections would be so crowded as to make the switchboard unsafe. The preferable location for these transformers is in the leads from the generators beneath the floor, if the leads come in from below, or on the wall in case they come from above. Transformers connected to the feeder circuits should be mounted on the wall if the feeders go out above, or beneath the floor if they go out underground.

Fig. 3 is a rear view of the switchboard in Fig. 1, showing the connections between the various instruments and operating devices.

Direct-current Switchboards

Fig. 4 shows a direct-current switchboard arranged for 575-volt power service. The panel shown at the left of the drawing is exactly the same whether used with a rotary converter or a generator driven by a motor or an engine, excepting that no field switch is needed for converter panels. The equipment of this panel should be one circuit-breaker with bell alarm switch, one ammeter, one handwheel and chain mechanism for the rheostat, one single-pole single-throw field switch with discharge clip, one four-point potential receptacle and two single-pole single-throw lever switches.

One voltmeter should be mounted on a swinging bracket placed in some convenient location.

If machines are equipped with speed-limit devices it is customary to provide low-voltage release or shunt trip coils on the circuit breakers.

If the generator is a part of a motor-generator set and is to be arranged for direct-current starting, a [illegible] starting switch should be mounted on this panel. If the generator is driven by an alternating-current motor, the alternating-current panel already described should be used for the control of the latter.

Feeder Panels

The equipment of the feeder panel should consist of one single-pole circuit-breaker with bell-alarm switch, one ammeter and two single-pole single-throw feeder switches. If desired, one of these switches can be omitted, the remaining switch being connected to one side of the circuit and the circuit-breaker to the other.

250-Volt Three-wire Switchboard

Fig. 5 shows two direct-current generator panels, one is for the control of two low-voltage generators operated on the three-wire system, and the other is the direct-current panel for a rotary converter. The panel for controlling the two direct-current generators would be exactly the same for motor-driven machines and should have the following equipment: Two circuit-breakers with interlock and bell-alarm switch, two ammeters, two handwheels for field rheostats, two single-pole single-throw field switches with discharge clips, two four-point potential receptacles for voltmeter plugs, three single-pole single-throw lever switches and one four-throw starting switch (for motor-driven generators). If the two generators are engine-driven, of course the starting switch can be omitted.

The direct-current rotary converter panel should have the following equipment:

Two circuit-breakers with interlock, shunt trip coil and bell-alarm switch; two ammeters, one handwheel for the field rheostat, one four-point potential receptacle for the voltmeter plug, three single-pole single-throw lever switches and one four-point starting switch.

It is generally preferable to start either a rotary converter or a motor-generator set from the direct-current side, as this causes much less disturbance of the system, which of course is important in lighting work.

The panels described are arranged for shunt-wound generators and converters as these machines are usually employed for lighting. If, however, compound-wound machines are used, equalizer busbars should be placed at a convenient point and the equalizer switches located either on the machines or on pedestals near the machines.

In the case of the two compound-wound machines supplying the three-wire system, it is necessary to have the series-field winding of the machine which operates on the positive side of the system connected in on the positive side of the machine. The machine operating on the negative side of the system should have its series-field winding connected in on the negative side of the machine; the circuit-breakers should be connected in the leads running to the neutral busbar. The reason for this is that the neutral is usually grounded, and as only one circuit-breaker is furnished for each machine, it is advisable to have this connected on the side of the machine which is grounded, in order to properly protect the machine against a ground in the leads from the machine to the switchboard, or on the machine itself.

A voltmeter should be mounted on a swinging bracket, as indicated in Fig. 5.

Feeder Panels

The feeder panels shown in Fig. 5 are each arranged for one three-wire grounded circuit. These panels should be equipped with two circuit-breakers with interlock and bell-alarm switch, two ammeters and two single-pole lever switches. There may be installed on one of these feeder panels a six-point receptacle, in order that the potential can be read between each leg of the system and the neutral when the rotary converter is running alone. There may also be installed a four-point receptacle for reading the potential across the outside of the three-wire service when only the generators are running. Figs. 6 and 7 show the proper connections for Figs. 4 and 5, respectively, as viewed from behind the switchboards.

Bridgewalls in Theory and Practice

By W. H. Wakeman

The chief engineer of a large manufacturing plant believed that the hot gases resulting from the partial combustion of coal could not be thoroughly consumed unless they were caused to pass through a narrow passage on their way to the chimney; therefore, when he installed two new 72-inch boilers he had the bridgewalls built in the form of an inverted arch, corresponding to the form of the shell, and the space between the top of this wall and the boiler shell was 3½ inches. See Fig. 1. Through this space all of the products of combustion passed on their way to the chimney and, according to the idea of this chief engineer, they became thoroughly mixed and burned during the process.

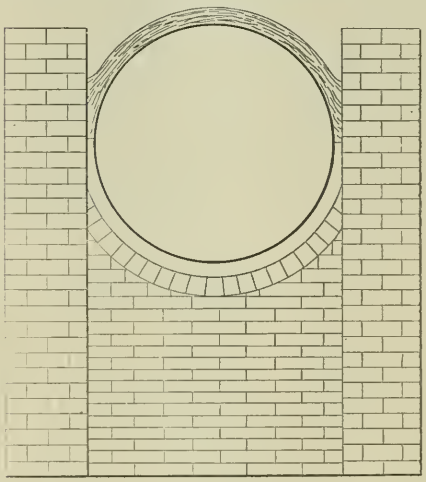


FIG. 1

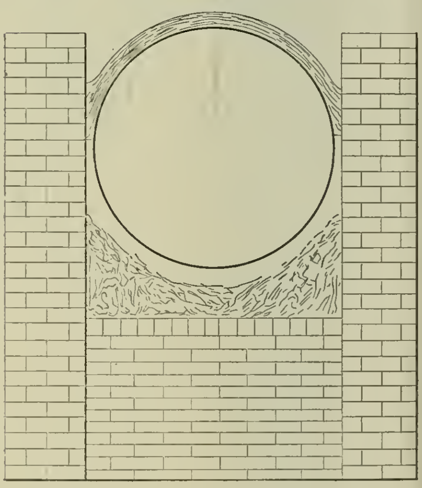


FIG. 2

Fortunately the chimney of this plant created a very strong draft, otherwise the boilers would not have generated steam enough to supply the demand when a full load was on, as the following calculation shows: The internal diameter of a 3-inch tube is practically 2.8 inches, and the area is 6.157 square inches; therefore, the combined area of 120 tubes is 738 square inches, and it is safe to assume that the area of the passage for hot gases should not be less than this at any point between the boiler and the chimney. If the space above the bridgewall extends around one-half of the circumference of the shell, its area is

$$3.5 \times 108 = 378$$

square inches, or almost exactly one-half the area of the tubes; consequently, the draft is less than it would be if this space were twice as large, although the length of this contracted passage is short, which is a point in its favor. The temperature must be very high at this point, but the boilers were not damaged by it as long as they were kept clean.

There were 18 other boilers in this plant supplied with bridgewalls that were straight and level on top, with a space above them about 12 inches high at its lowest point. This chief engineer claimed that when these bridgewalls were clean, thus making the full area of the passage effective, the efficiency of the boilers was reduced, because the hot gases were not completly consumed on their way to the chimney. His remedy for this evil was to allow soot and ashes to collect at this point, as shown in Fig. 2, and he would not allow this to be removed.

The real object in building a bridgewall is to hold the fuel in its proper place; therefore, it should be high enough for this purpose, and anything more is a waste of labor and material.

Bridgewall Too Low

The fronts of a pair of boilers that I had charge of for five years were designed so that the grates were about 20 inches below the shells. As Lehigh nut coal was burned in these furnaces at this time, a bridgewall 12 inches high above the grates was sufficient to hold the coal, even when the fires were banked; but, later, bituminous coal was adopted, and when this was shoved back to the bridgewall and the mass covered with fresh fuel to keep it from making steam during the night, the bridgewall was too low, as it was difficult to keep coal off it. To remedy this difficulty I had it raised 4 inches by setting firebrick on edge, as illustrated in Fig. 3.

This reduced the space from the bridgewall to the shell from 8 to 4 inches, but it did no harm. One of these boilers leaked badly at the girth seam near the bridgewall, and although the seam was chipped and calked several times in a workmanlike manner, it soon leaked again. Thirteen new rivets were put in and headed down while hot, thus causing them to hold more firmly when cold on account of shrinkage of the iron, but the leak was in evidence again within a few days. This would have proved conclusively to some engineers that the con-

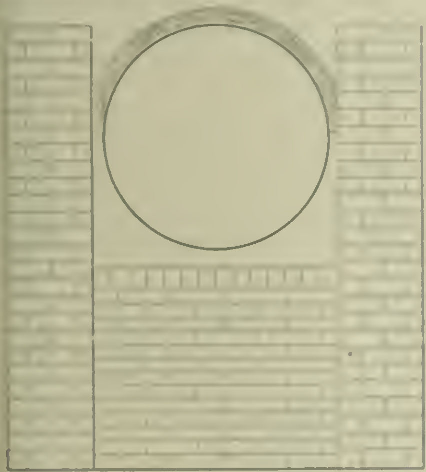


FIG. 3

centration of heat at this point was the cause of trouble; but this did not convince me, because I knew that the internal surface of the shells was practically clean at these points.

These boilers were fed through the blowoff pipe with water that was heated nearly to the boiling point by a good exhaust steam heater, but when this arrangement of piping was discarded and internal feed pipes installed the leaks disappeared and never returned. This experience shows that it is unsafe to decide on the cause of trouble of this kind without thorough investigation.

BRIDGEWALL TOO HIGH?

No objection was made to this high bridgewall by the boiler inspector as long as I remained in charge of the plant, but when visiting the place a few months after taking charge of another plant, I found the bridgewall cut down as illustrated in Fig. 4. It was reported that this was done by order of the boiler inspector, who objected to the high bridgewall because it resulted in the concentration of too much heat at this point.

Since then I have read the opinion of a careful writer on this subject, who points out in an earnest manner what is a fact to him beyond dispute, namely, that a bridgewall should never be cut down in this way, because nearly all of the hot gases will rush for this part of the passage and the result will be a ruined boiler. If either or both of these conclusions were correct, as illustrated in Figs. 3 and 4, it is certain that when a boiler is set as shown in Fig. 1, it would soon be rendered unsafe for use, yet, this is not true in everyday practice; hence my conclusion that a bridgewall is designed to hold the fuel in place and should be strictly so considered. If this part of a boiler shows signs of overheating, it is probably due to other causes.

Fig. 5 shows what was left of a certain bridgewall after wood had been

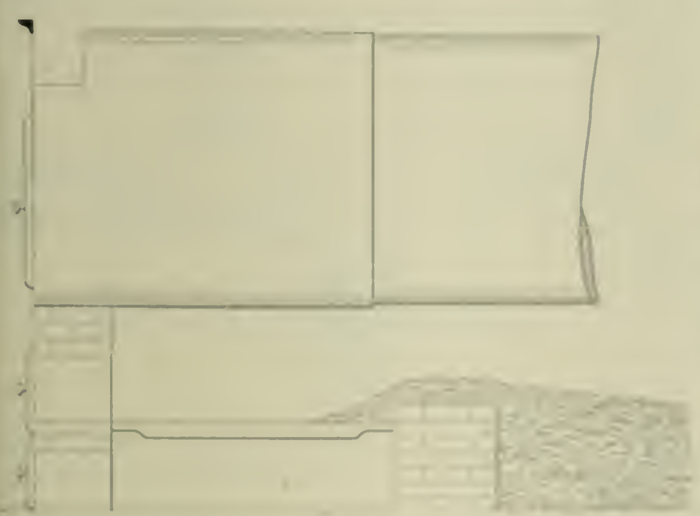


FIG. 5

burned in the furnace for several months. Heat is not concentrated at the point directly above this bridgewall, yet if the internal surface of the plate were covered with cylinder oil it would be overheated and rendered dangerous. The fuel burned in this furnace is not kept in place by the bridgewall for anything short, and while this plan admits of burning long wood and thus saves the labor of cutting it into shorter pieces, there is nothing else to recommend it. On the other hand, when an engineer allows his bridgewall to get into this condition and is satisfied to use it without improvement

he will probably be contented with slipshod conditions elsewhere in the plant, to the detriment of first-class service. If this bridgewall should be properly maintained as shown in Fig. 3 and the wood cut into suitable lengths to enable the fireman to keep the grates evenly covered at all times, it would result in saving much fuel, and be more satisfactory on other accounts.

Fig. 6 illustrates a properly built bridgewall with ample space behind it for combustion to be completed. I know of no

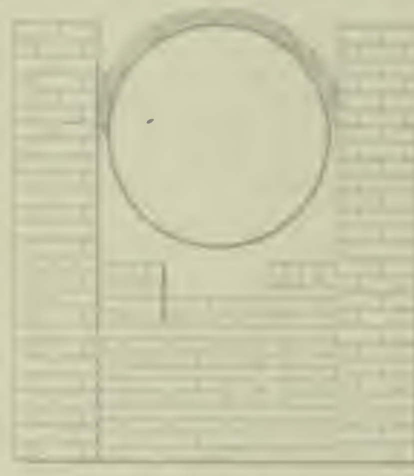


FIG. 4

FIG. 6

better plan, after thirty years' experience along this line, and I therefore consider it as best [illegible]. The heavy dotted line represents the plan outlined by some engineers, as they claim that when the sharp bend comes to be turned, the products of combustion pass over the bridgewall more readily, as the currents of heat; but it is doubtful if this view be correct, because I have never discovered evidence to prove that it is [illegible] the gases to come over [illegible] of a square bridgewall [illegible] what is commonly called a [illegible].

Draining High-Pressure Steam Lines

Why Water Should Collect in the Steam Piping, Its Effect on the System and Methods of Draining it Back to the Boilers or to Atmosphere

BY WILLIAM F. FISCHER

Probably the greatest source of danger to engines of the reciprocating type is the liability of water collecting in the steam-piping system, which unless stopped by a separator eventually finds its way into the engine cylinder in "doses" or "slugs" carried over with the steam flow. This is particularly dangerous in high-speed engines, owing to the small clearance space at each end of the cylinder.

Water Hammer

Pipes are usually proportioned so that the steam travels at the rate of about one mile a minute, or in some cases much faster, hence if a slug of water is picked up by the steam and carried along with it, an accident is apt to occur, either by the rupture of an elbow at a change in the direction of the flow, or by the water entering the engine cylinder. Although in some cases the quantity of water in the steam mains may not be sufficient to cause serious damage, it may, however, cause disagreeable knocking and hammering, which causes vibration, and in time causes the joints to leak. This knocking and hammering, so common in steam-heating plants, is what is known as "water hammer." Professor Thurston has experimentally shown that the pressure produced by water hammer may be as much as ten times, or more, that which the pipe, fittings and valves were originally expected to sustain in their regular work, and this fact is borne out in practice by the number of accidents traced to this cause alone.

Radiation and Pipe Covering

The presence of water in steam mains is due to the condensation of steam in the pipes, and in some cases to priming or foaming of the boilers, where water at times is carried over with the steam in large quantities. Heated surfaces naturally lose heat when brought into contact with a cooler surface or element, thus between two bodies near each other and at different temperatures there exists a tendency toward temperature equalization by radiation, conduction and convexion. A pipe carrying steam at a temperature of from 212 degrees and upward coming in direct contact with the surrounding atmosphere, the temperature of which seldom exceeds 100 degrees, is naturally a cause for rapid radiation of heat from the surface of the pipe to the atmosphere. This rapid radiation of heat causes condensation in the pipes, and is also a direct loss of the heat units derived from the fuel and stored up in the steam, and for this reason should be prevented as far as possible by covering all live-steam lines with a good nonconductive pipe covering.

Condensation and Superheat

Condensation may be divided into two parts: "static" condensation, which occurs when steam fills the pipe, but is not flowing through it, and "dynamic" condensation, which takes place when a valve is opened permitting the steam to flow. It

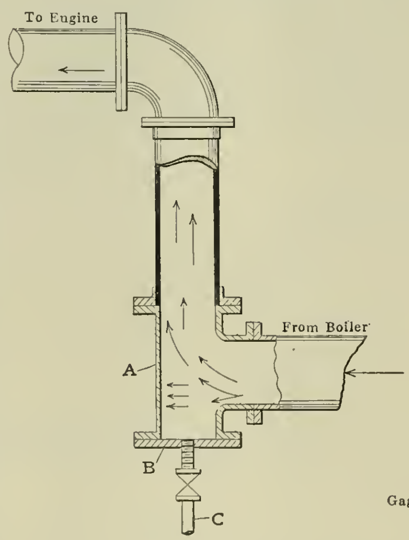


FIG. 1. A CONSTRUCTION OFTEN USED

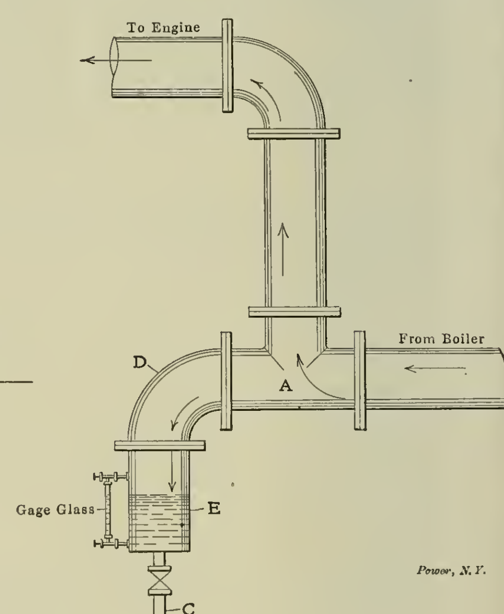


FIG. 2. A BETTER ARRANGEMENT

has been found to all practical purposes that the amounts of condensation are almost equal in both cases.

In modern plants with the use of superheated steam and the proper pipe covering, the condensation losses are reduced to a minimum as long as there is a rapid transference of steam from the boilers to the engines, but there are nearly always certain lengths of idle pipe in the system in which there is no flow; here the steam is bound to condense while the pipes are kept alive, and if they are shut off, there is danger of water forming in them when they are again opened to the steam. Before any water of condensation can form with superheated steam, the surplus heat units or superheat must first be extracted from the steam, or, in other words, the superheated steam must first be reduced to saturated steam at the same pressure, or less, before any condensation occurs.

Initial Condensation

Water has a large capacity for absorbing heat, and when allowed to accumulate in the steam mains has a tendency to condense part of the steam flowing therein. Any steam thus condensed, though perhaps in small amount, must be replaced by the boiler, and the extra steam generated for this purpose alone will amount to considerable money in fuel in a year's time. Initial condensation in an engine cylinder is a good example of this.

Water lying in the cylinder, or swept in by the steam, chills the cylinder walls, which in turn condense part of the steam entering at the next stroke of the piston. Consequently a greater amount of steam must be admitted to the cylinder than would otherwise be required to do the work. This initial condensation causes a corresponding drop in pressure at the engine throttle, and causes pounding and disagreeable knocking in the engine cylinder, as the water is slapped back and forth at each stroke of the piston.

Water in Steam Pipes and Its Effect

The presence of water in the steam mains also causes unequal straining in the piping and at the joints, as it tends to reduce the temperature of the lower side of the pipe as the water is swept along. Some boilers, when heavily fired or forced beyond their rated capacity, especially quick steamers and those having insufficient steam space, have an aggravating habit of throwing over large quantities of water into the steam header. This priming or foaming is also caused by impurities in the feed water, or is sometimes due to the presence of oil in the boilers. Then again, a sudden reduction of pressure in the steam main, such as is likely to occur when an extra engine is quickly cut into service, or to a sudden increase in the load, causes a corresponding reduction of pressure at the boilers, liberating the heat stored in the water. This heat flashes part of the water into steam, and in doing so, causes violent ebullition, and part of the water is entrained and carried over with the rapidly flowing steam to be deposited in the main steam header.

If this water is drained off as fast as it forms, no danger can possibly result from it, but if allowed to accumulate to any extent, the effective pipe area is gradually decreased to such an extent that when a heavy load is thrown on the station the resulting rush of steam toward the engines is bound to set the water in violent motion, projecting it with great force against a fitting or blind flange, and a rupture may result. Pockets or low spots in the piping where water can collect should be avoided, or if impossible to do away with them entirely, they should be dripped to insure keeping them free of water at all times.

Steam connections from the boilers frequently enter the main header at the bottom. This practice should be avoided as it leaves a pocket for the condensation from the header to drain into when either of the boilers is shut down. If it is attempted to run the water of condensation against the steam flow, water hammer is likely to occur, unless the pipe is exceptionally large and the velocity of the steam much below the average, as in heating plants, etc. The steam lines connecting the main steam header with the boilers should enter the header at the top or on the side, and should drain toward the header. All steam lines to the engines should be taken from the top of the header where possible to do so, and should drain toward the engine separator.

Drip Pockets

Tapping a small pipe connection into the bottom of fittings on high-pressure steam mains for drainage purposes is not to be recommended as the steam flowing past a small opening sweeps the water over with it. Drip pockets of large cubical capacity should be used, having an opening or inlet equal in diameter to the steam main to which they are connected, on sizes up to 12 inches inclusive. For pipe above 12 inches in diameter, there is no advantage in increasing the size of the drip pocket, as the capacity of a 12-inch drip pocket is ample to handle all drips from the larger size pipe. These drip pockets provide an opening sufficiently large to catch the water before it is carried past them by the steam, and will also take care of any water carried over with the steam from the boilers should they prime.

All drip pockets should be fitted with gage-glass water gages operated from the floor so the valves can be quickly closed without danger of scalding the operator should the gage glass break. These gages show at a glance the hight of the water in the pocket at all times, also indicating whether the trap or drip return system is operating properly. In all cases it is a good plan to attach a drip pocket at each end of the main steam header, to keep up the circulation and relieve the header of condensation when either of the end boilers is shut down for cleaning or repairs. The greatest flow of steam is necessarily toward the largest outlet in the header, consequently the piping should be dropped through a drip pocket at this point, as water will be swept toward this outlet with the steam flow from each end.

Long lines of piping should be dripped at least every 150 to 200 feet. A tee and 3 or 4 feet of pipe, capped at the end with a blind flange drilled and tapped for a drip connection, is a good substitute for a cast drip pocket, but should be fitted with a gage glass, as mentioned already. Drip lines under different pressures should never be run into one line, but each should be trapped separately.

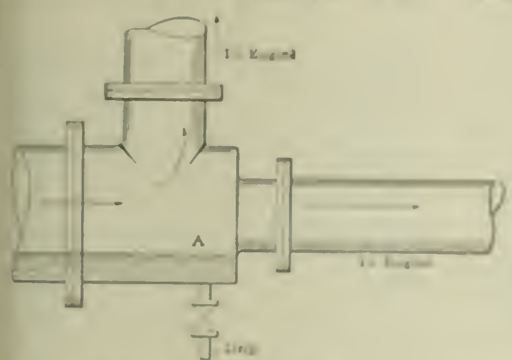


FIG. 3. REDUCING TEE

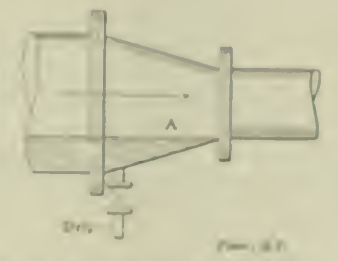


FIG. 4. REGULAR TYPE OF REDUCER

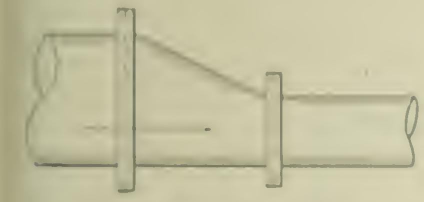


FIG. 5. ECCENTRIC REDUCER

FIG. 6. ECCENTRIC FLANGE

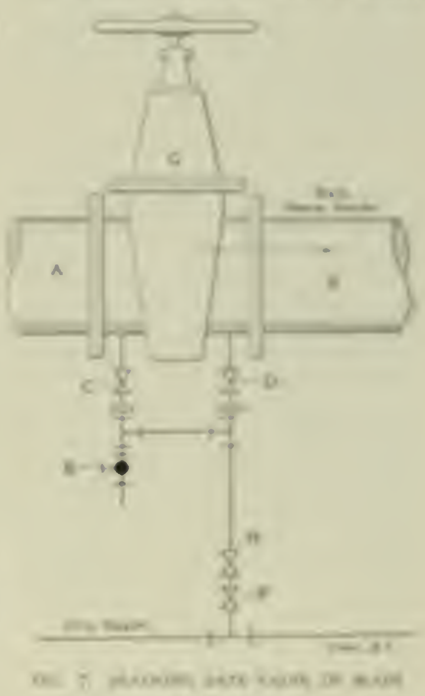


FIG. 7. PLACING GATE VALVE IN MAIN STEAM HEADER

Running Pump from Drip Header

A steam-driven pump for the purpose of boiler feeding, etc., will operate about as well on a mixture of steam and water as it will on dry steam; therefore the water which has been drained into a drip header may be directly beneath it, and the steam connection to the pump taken directly from the drip header. If the pumps are run continually while the main steam line is in service, they tend to keep up circulation and keep the line free of water. If the pumps are shut down, however, there should be another means of removing the water of condensation automatically, either through a trap, gravity return system, steam loop, pump and receiver or other suitable means.

Water drained off through the steam cylinder of a pump should not be again returned to the boilers unless filtered to remove the oil it contains. This holds good for all exhaust-steam drips after passing through an engine or pump cylinder where oil is present. A swinging check valve should be installed in each drip connection between the steam main and drip header, to prevent steam or water from backing up in any section of the steam main while out of service. Since the amount of condensation to be handled by drip pipes is practically an unknown factor, no general rule can be given for proportioning them. The designer must use his own judgment in this, as well as many other matters relating to the design of the piping system.

Draining Water Pockets

Fig. 1 shows a construction very often used in draining the end of a steam line where steam is taken from the top of the header. The line rises through a tee *A* vertically, with one end capped by a blind flange *B* drilled for a drip connection *C*. With this arrangement of the piping, the water of condensation is swept along the header at high velocity by the steam flow, and upon striking the back of the tee is suddenly arrested and broken up into fine particles or drops, some of which are caught up again by the steam and carried up past the elbow and into the engine cylinder unless stopped by a separator. Fig. 2 shows an arrangement of piping

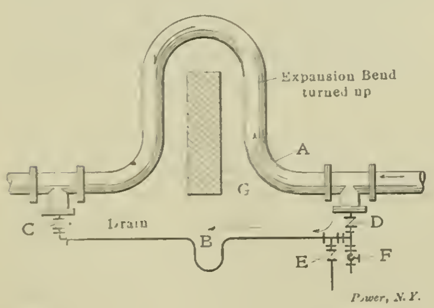


FIG. 9. DRAINING AN EXPANSION LOOP

much preferred to that shown in Fig. 1. The tee *A* is placed horizontally in the line, with the outlet looking up and a drip pocket *E* connected to the extreme end of the line through the elbow *D*. With this arrangement the water of condensation is swept along to the end of the line, falling through the elbow into the drip pocket *E*, where it is drained off through the drip line *C*.

In Fig. 3 is shown a section of a high-pressure steam line provided with a reducing tee. If the steam flow is in the direction of the arrows, a water pocket is formed in the line *A*. If the water which will collect here is not drained off as fast as it forms, a heavy flow of steam will sweep it over to the engine. Fig. 4 shows a line reduced on the run through a concentric reducer of the regular type. The results are the same as in the previous case. Figs. 5 and 6 show how this water pocket may be avoided by the use of an eccentric reducer, or an eccentric flange,

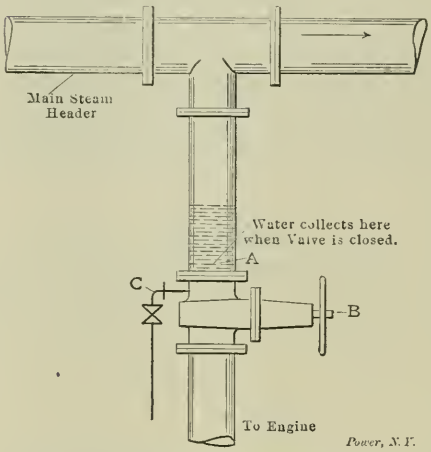


FIG. 8. WHEN STEAM IS TAKEN FROM BOTTOM OF HEADER

in place of the fittings shown in Figs. 3 and 4. The eccentric reducer is to be preferred to the flange in all cases, but the cost will be greater.

In cutting out a section of piping for repairs, or to renew gaskets, etc., workmen are sometimes scalded when breaking joints, due to some pressure still remaining in the line after the main valves are closed. When the bolts are loosened the water of condensation in the dead section gushes out, scalding the face or hands of the workman. The dead section should be well drained before opening the joints.

Fig. 7 shows a gate valve *G* placed in a steam main and dividing it up into sections *A* and *B*. This valve is dripped at each side of the gate or disk, through the drip valves *C, D* and *F*, and check valve *H* into the drip header. Globe valve *E* is for an open bleeder connection. If section *B* is shut down, the drip valve should be closed. The water of condensation forming in the live section *A* is drained off into the header through valves *C, H* and *F*, or if the steam were flowing in the opposite direction and section *A* cut out of service, drip valve *C* should be closed and section *B* drained through the valves *D, H* and *F* into the drip header.

With this arrangement of the drip piping and valves, the line may be used as a bypass around the main valve *G* to equalize the pressure in the dead section, or to warm it up gradually before opening the main valve, thus preventing knocking and pounding in the line due to water hammer. To use the piping as a bypass, valve *F* should be closed, and valves *C* and *D* opened to admit steam from one section to the other. When the main valve *G* is open and steam flowing, drip valves *C, D* and *F* should remain open to drain the line at this point.

When shutting down either section *A* or *B* for repairs, the dead section of the piping can be cleared of steam and water by opening the bleeder valve *E* and blowing out the pressure. For example, if section *A* were shut down, valves *D* and *F* should be closed, and drip valve *C* and bleeder valve *E* opened to the atmosphere, or *vice versa* with section *B* shut down. The check valve *H* is to prevent the water in the drip header from backing up into either section of the steam main when out of service, should the attendant forget to close the drip valves *C* and *D*. All the valves in the main line may be dripped in this manner satisfactorily.

When steam is taken from the bottom of a main, as shown in Fig. 8, the water of condensation collects at *A* when valve *B* is closed. The valve should be tapped above the seat for a drip connection at *C*. This drip line should be connected to a trap or into the drip header.

When installing an expansion loop or bend, it is sometimes impossible, for want of sufficient space, to place it horizontally as it should be, or, again, it is sometimes necessary to carry a steam line over an obstruction, as shown at *G*, Fig. 9. With

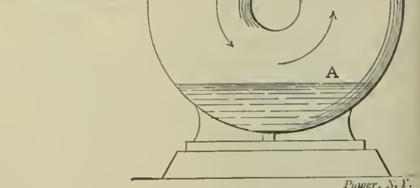


FIG. 10. CAST-IRON EXHAUST ENTRAINER

the bend turned up as shown, a water pocket is formed in the line at each end of the bend. A drip line should be placed as shown and bent at *B* to take up the expansion. The steam flowing in the direction of the arrows, travels up and over the expansion bend *A*, while the water travels along through the drip line below through valves *D* and *C*. A bleeder valve is provided at *F* and a connection to the main drip line or to a trap is made through the valve *E* in case it is required to drain the water off at this point. Valves

D and *C* should always remain open while the line is in service, to insure the water of condensation being carried on with the steam flow past the pocket at the inlet side of the bend at *A* in case the trap does not work properly or in case valve *E* is closed.

The drainage from any part of the steam-piping system is valuable on account of the water and the heat it contains, and should be returned to the boilers again by suitable means. Fuel is an important and expensive item of cost and any means of saving fuel is a means of increasing the earning capacity of a plant, large or small. Sometimes the saving due to returning high-pressure drips to the boilers in small plants is not sufficient to warrant the expenditure for the necessary apparatus to do so. This is a point to be determined by the engineer familiar with the existing conditions.

Low-pressure Drips

Condensation from exhaust-steam lines always contains more or less oil, and for this reason should be filtered before returning to the boilers, as the presence of oil in the boilers causes burning of the plates and sagging. As a general rule this condensation is collected in a drip line and led off to the sewer, trench, condenser overflow tunnel or other convenient points, as in most cases it does not pay to attempt returning these drips to the boiler.

Fig. 10 shows an exhaust entrainer for removing the water of condensation from exhaust pipes in condensing systems. It consists simply of a double elbow which provides a pocket at the foot of the riser into which the drip water from the engines may drain, and is so arranged that the exhaust steam must pass over the surface of the water at *A*. The action of the exhaust steam is to entrain or pick up minute particles of water and carry them upward to the condenser, whatever the hight of the latter. The particles are so infinitesimal that the loss of vacuum under any ordinary condition cannot be detected. These entrainers being provided with a substantial foot, serve as a support for the exhaust riser. They are chiefly used in connection with barometric condensers or condensers of a similar type.

Exhaust-steam mains under vacuum cannot be drained direct to the atmosphere while the condenser is in operation, as the minute a drip valve is opened, in place of the water flowing out, air rushes in and breaks the vacuum. There are several other methods, however, of draining exhaust-steam lines under vacuum, such as through a vacuum trap, tilt pump and receiver, etc., which it is not the writer's intention to discuss here.

Wet versus Dry Compression

By Joseph H. Hart

To the average operating engineer at the ammonia compression system the terms wet and dry compression are more or relative and have no special significance. He knows that there are several methods of operating refrigerating machines in regard to temperatures, load and back pressures and he has as a general thing his own little theory in regard to best conditions of operation. He also knows in a general way that various types of machines and various manufacturers are committed especially to the wet-compression, whereas others utilize the dry-compression type, and that in the wet-compression system the operation of compression is accomplished by carrying frost back on the suction pipe to the inlet valve of the compressor and in some cases completely covering the compressor with frost. The meaning of these two terms, however, and their significance from a scientific viewpoint, and the various factors which go to determine the relative efficiency of the two types are matters practically unknown.

Now, in order to understand what is meant by these relative terms, it can be said in a general way that all ordinary compression is dry compression and yet the two terms are often used with a more general significance. Thus, air compression can be either dry compression or wet compression depending upon the presence or suspension of water vapor in the air during compression. In the other significance air compression is always dry compression and wet compression is impossible with that material except under conditions only obtainable in the physical laboratory. It can be said [illegible] in ammonia compression that the terms wet and dry compression have to do with the latter significance and are [illegible] connected with the presence or absence of water vapor in the material.

Now, dry compression in this latter significance of the term is accomplished whenever a gas is compressed. Wet compression only [illegible] when a vapor is compressed. The difference in the meaning of the words gas and vapor is all important. A vapor is a gas near the temperature of condensation of the material. Another definition can be stated as follows: A gas is a vapor above the critical temperature. The critical temperature of a substance is the temperature above which a gas cannot be liquefied no matter to what [illegible] the compression; only [illegible] it will always remain a gas and possess all the properties of the [illegible]. A gas follows Boyle's law and Charles' law so [illegible] variation of pressure, volume and temperature [illegible]

[illegible] the product of the pressure and volume is a constant quantity and this constant according to Charles' law is directly proportional to the absolute temperature of the material. Thus keeping the pressure [illegible] constant the [illegible] in direct proportion to the absolute temperature of the gas. These laws do not hold for vapor, however. The product of the pressure and volume is not a constant [illegible] of either one in the case of vapors, even though the temperature is kept constant. It is this peculiar property of vapors and gases which is the ultimate basis of the relative efficiency of wet and dry compression.

Ammonia Compression Characteristics

Ammonia compression is complicated still more than the compression of an ordinary vapor by the fact that the compression [illegible] of a temperature immediately in the vicinity of the temperature of condensation and often passes through this temperature during the process of compression. In dry compression the work done on the gas in compression is at least evident in an increase in temperature. The quantity of heat produced is an exact equivalent to the work done on the gas [illegible] in this compression that the compressor often operates at its maximum efficiency with [illegible] indication of work, and the transformation of this work into heat lowers very greatly the efficiency of the compression, due to the rise of temperature of the gas with a resulting increase in the amount of effective pressure required for compression. Thus the object in compression is to compress the gas and remove the heat of compression as fast as produced. It is impossible to do this with any great facility and the result is that the heating effect is often cumulative. What is known as cylinder reheating is due to the fact that the cylinder walls become heated on the compression and upon the opening of the inlet valve again for a second charge the incoming gas is at once heated by contact with the hot cylinder walls. This reheating effect gives the result of an increase in the initial pressure of the gas during compression.

The same [illegible] a portion of the gas [illegible] back through [illegible] is a decrease in the density of the gas at constant pressure, or what is considered to be leakage [illegible] with a [illegible] in the capacity of the ammonia compressor [illegible] of a compressor [illegible] the capacity of an ammonia compressor [illegible] of ammonia gas compressed [illegible] operating [illegible] city of the compressor diminish greatly but the heating effect continues and results in an increase in average pressure throughout the stroke and a lower efficiency of compression as well.

The jacket of the average ammonia compressor is hopelessly inadequate in the performance of its duty in the cooling of this unit. The heating effect of compression is largely a skin phenomenon limited at high speeds to the intense heating of a thin layer on the interior of the cylinder walls and cooled by recharging before conduction to the water jacket has had time to get in its effect. The old De Lavergne type of compressor, utilizing an auxiliary oil circulation through the compressor, was designed for the purpose of producing an internal water jacket in its effect and for the elimination of clearance evils as well. That the net result was an increase in complexity in the operation of the compressor, with a loss rather than increase in efficiency, is now an accepted conclusion.

Today compressors in which this phenomenon occurs are the common existing type and are the factors which limit the speed of operation and are the greatest limitations on efficiency of the process. The average air compressor is essentially of this type and the evil effects due to reheating and clearance are merely augmented by the presence of water vapor as existing in normal air. Thus, the removal of the water vapor from air presents a form of dry compression, whereas its presence constitutes wet compression, and the effect of water vapor in its influence on efficiency is the determining factor in the two cases. Air and ammonia under these circumstances are two typical gases and dry compression is the resulting phenomenon which occurs in the operation of the compressor.

Now, in the operation of the ammonia compressor it was found possible by injecting a little ammonia liquid into the cylinder on each stroke to keep the material cool throughout the entire period of compression. This does not mean that the heat is not produced. The same, or at least a definite, amount of heat equivalent to the work done is produced on each stroke of the piston. This heat, however, does not result in an increase in operating pressure as it does in the case of gas compression, due to two reasons. One is that the resulting increase in pressure due to heating effect would not be as great in the case of a vapor as in a gas and the other is due to the fact that the heat as fast as produced is absorbed by the vaporization of a portion of the ammonia liquid present in the cylinder. Thus the utilization of this device results in the elimination of two evils, with the production of two additional ones.

Reheating Effect Eliminated

The reheating effect, with consequent diminution in density of the incoming charge and of capacity in the cylinder for the same, is totally eliminated by keeping the cylinder walls cold, but the capacity of the cylinder is reduced in turn by the volume of the ammonia liquid injected per stroke, and the work is increased by the fact that the piston operates against the vapor which is produced by vaporization from the ammonia liquid present in the cylinder when the latter is heated by the heat produced by compression. Thus, the saving is more imaginary than real and is a question of relative efficiencies merely. In dry compression every ounce of ammonia gas which passed through the cylinder was ultimately used for the production of available refrigeration. On the other hand, in wet compression a portion of the ammonia liquid available for the production of refrigeration becomes no longer available for this purpose, since it is evaporated in the cylinder and the heat of vaporization used to produce cooling in the compressional charge during compression rather than in commercial cooling where desired. Thus, the ammonia which passes through the compressor or through the condenser is no criterion or measure in the wet compression system of the amount of refrigeration produced.

While the preceding conditions represent the ideal phase of the wet compression it is not accomplished by any means in practice except under abnormal conditions and is not believed to be the most efficient process. The significance of wet compression is complicated by the fact that there is no real dividing line between the two types. The exact point where the vapor ceases to be a vapor and becomes a gas is dependent upon its critical temperature but this temperature does not enter in many developments. Thus, in air compression the critical temperature is so low that throughout the entire cycle of air changes the critical temperature is never even approached. On the other hand, the critical temperature of ammonia gas is relatively so high that almost throughout the entire stroke it is never approached from the other side.

Again, in ammonia compression matters are complicated by the introduction of what is known as saturated vapor. A saturated vapor is a vapor in contact with its own liquid. Increase in pressure or temperature on such a mixture results in variations in the amount of vapor present, since variations in pressure under such conditions results often in a variation in density without effect upon the pressure or apparent volume. Real wet compression in ammonia is the compression of a saturated vapor throughout the stroke; that is, ammonia liquid is present throughout the entire period of compression. The density of the vapor increases greatly on account of the further production of extra vapor from the liquid during the process. If the liquid injected at the beginning of the stroke is only sufficient to keep the vapor saturated throughout a portion of the stroke, that is, if the heat produced is more than enough to vaporize all the liquid present, then the stroke is no longer absolute wet compression. It is a mixture of wet and dry compression, with the variation between the two not occurring immediately at the complete evaporation of the liquid.

Thus, some wet-compression systems exist in which practically no liquid is injected. The vapor is practically at its condensation point and saturated at the beginning of the stroke, a fine mist of the liquid only being present. This explains the reason why there exists such a variation in possible compressions. In actual practice the conditions occurring inside the cylinder are largely evident from external conditions. The property of ammonia gas is largely a function of the temperature, especially at a given suction pressure. Hence the different phases of dry and wet compression can be readily attained by varying the temperatures of the charge. If the frost is carried back to the inlet valve of the cylinder practically partially wet compression is occurring. If the frost is carried completely over the cylinder so that the water jacket has a layer of ice on its surface, it can be assumed that a portion of liquid ammonia is injected on each stroke, or that the vapor is so saturated with ammonia mist that it behaves in this manner. However, it is possible, with extremely cold condenser water to have this compression occur under these conditions without normal wet compression in the strictest sense of the word. However, such temperatures of condenser water would be extremely abnormal.

The efficiency of a compressor is a function not only of temperatures but also of speed. The result is that the average operating engineer should attempt to get a maximum speed out of his compressor with minimum steam consumption and minimum temperatures on the ammonia gages. Available refrigeration is in every case directly proportional to the work done and hence the speed, if the pressures are the same in the two cases, and it is the generally accepted opinion today that ammonia compressors operate best under normal condenser-water temperatures when the frost is carried back on the suction pipe to within a few inches of the inlet valve of the compressor and the attempt made under these circumstances to speed up the compressor to the extent that the water jacket gets fairly hot or at least is warm to the touch. The frost will invariably slide in one direction or the other without regular attention but it represents undoubtedly the point of maximum efficiency in the operation of the plant.

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Hydraulically Operated Valves for Curtis Steam Turbines

The speed of the steam turbine is controlled for different loads by successively opening and closing valves, thereby putting into use more nozzles which admit steam to the first wheel. These valves are of the poppet type, each being closed by a helical spring. The valves are all duplicates and are opened in rotation by cams mounted on a shaft, each cam having an angular lead over that preceding it. The cam shaft is actuated by the piston of an hydraulic cylinder, causing the valves to open so that throttling occurs on opening or closing a valve before the next one opens or closes, thereby regulating the amount of steam admitted for any load.

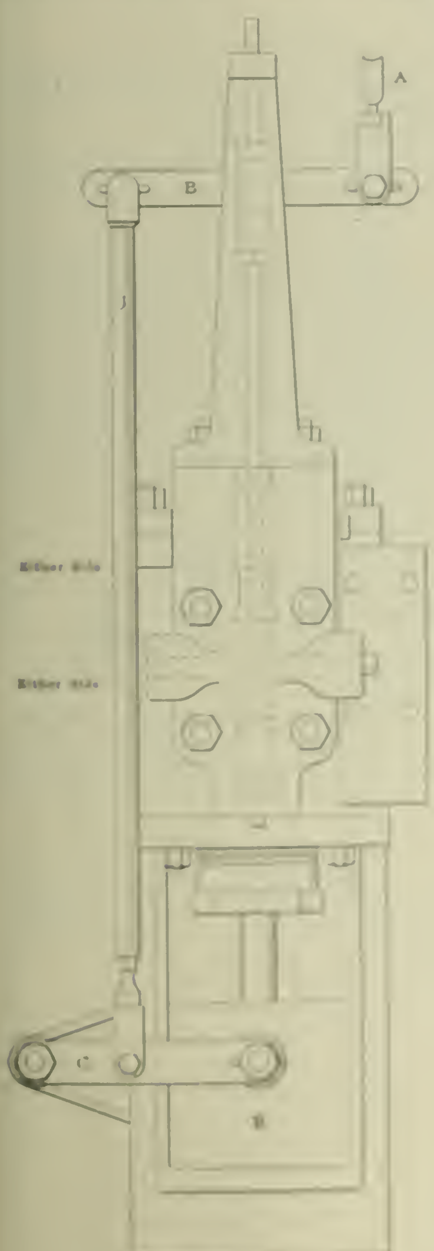


FIG. 1

FIG. 2

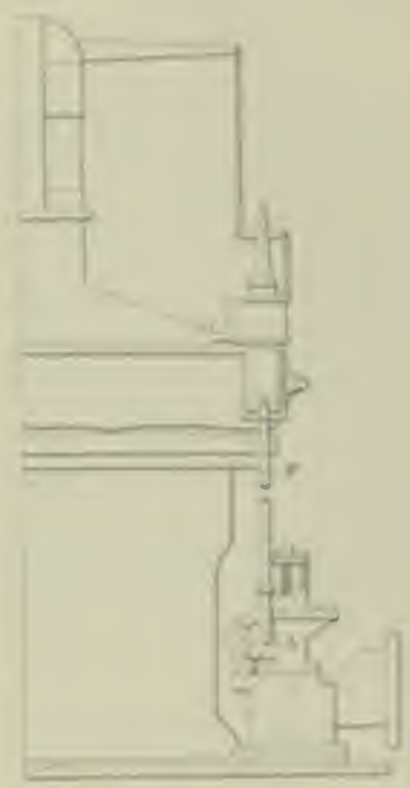


FIG. 3

Referring to Fig. 1, the rod A is actuated by the governor, the lever arms B and C being so arranged that the piston D, Fig. 3, will stay in a fixed position to correspond with any position of the rod A, Fig. 1, as the crosshead E, [illegible] connected through a connecting rod F, Fig. 3, to the cam shaft [illegible] therefore there will be a fixed position of valves open for any position of the governor. While the turbine is running at a fixed speed the piston valve will occupy a central position closing both ports, G and H, Fig. 2. If the speed decreases the governor will move the rod A, Fig. 1, down, opening the port G to the discharge port and port H to admit liquid under the piston, thus opening more valves and thereby increasing the speed. In turning, the piston [illegible] the rod J, Fig. 1, upward and moves the valve B to its central position again.

On a good working machine, a [illegible] valve will drop of its own weight to the [illegible] connecting the rods A and J from the lever B. I have experienced some trouble [illegible] this valve [illegible] thereby affecting its work. It is necessary that the connections between the valves and governor be free from friction and no binding at any joints, and the liquid must be clean and free from grit for good service.

William Butler.

Somerville, Mass.

Pressure Required to Lift a Check Valve

Referring to a letter appearing on page 201 of the January 26 number, entitled, "Pressure Required to Lift a Check Valve," I do not agree with Mr. Helms in the following respects:

For instance, Mr. Helms describes a conical poppet double-seat valve so proportioned that the pressure on the front of the valve may equal the pressure on the back of the valve at the moment of opening, the pressure per square inch being the same in each case. This valve, as illustrated by Mr. Helms, is shown in Fig. 1. A recess is cut or cast circumferentially around the valve disk at *a a*, and the fluid pressure is led into this recess through ports *b b*.

Mr. Helms states: "It is evident that if the area of this recess represented by 0.7854 $(d_1^2 - d_2^2)$ is equal to the projected area of the seat, 0.7854 $(d^2 - d_3^2)$, the valve will open when the pressure per unit area on the front is equal to the pressure per unit area on the back of the disk, since the areas exposed to the action of the fluid pressure are equal on both sides." The weight of the valve disk itself is, of course, neglected in this case.

The point I wish to make clear is this: By referring to Fig. 1 it will be seen that the fluid pressure acting vertically in the recess *a* on a circumferential strip of width *Y* acts up, and reacts down in the recess, and is thus balanced as shown by the arrows and their direction. This pressure, being balanced, has no tendency to lift the valve from its seat. In this case the tendency is to rupture the valve disk itself. Probably this can be better understood by referring to Fig. 2. Here the valve disk is represented as a piston *A* fitted into the cylinder *B*. The diameter of the piston D_4 equals D_4 in Fig. 1. The piston is recessed at *a a*. The dimensions D_4, *Y* and d_2 are equal in both cases.

As before, the fluid pressure is led into ports *b b*. Here it is quite evident that any pressure admitted to recess *a* through port *b* has no tendency to lift the piston, as the forces are balanced vertically. If this is true in both cases, Fig. 1 and 2, there is only the area of a circumferential strip of width *x*, Fig. 1, as the effective area of recess *a*.

The pressure acting up against the strip *x*, reacts down against the sides of the conical valve seat, tending to separate the two bodies. The projected area, or area of strip *x*, equals 0.7854 $(d_1^2 - D_4^2)$. This, it would appear, represents the effective area of the recess acted upon by the fluid pressure, and not the area 0.7854 $(d_1^2 - d_2^2)$, as given by Mr. Helms.

As the sum of the areas, 0.7854 $(d_1^2 - D_4^2)$ and 0.7854 d_3^2, does not equal the area 0.7854 d^2, or in other words, as the area of the front of the disk plus the area of the circumferential strip *x* does not equal the area of the back of the disk, the pressures per square inch will not be equal on both sides of the valve at the moment of opening. Thus, with a valve

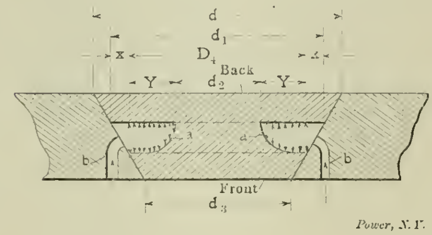


FIG. 1

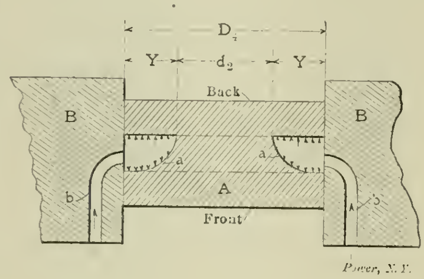


FIG. 2

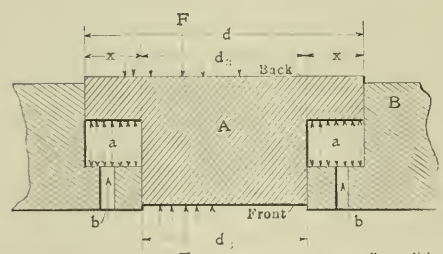


FIG. 3

of this type the pressure per square inch on the front, or under side, will necessarily have to be somewhat greater than the pressure per square inch on the back, or upper side, in order to raise the valve disk from its seat. This is, of course, providing the valve disk makes perfect contact, metal to metal, with the seat, and is not separated by a thin film of the fluid, in which case, neglecting the weight of the disk, the difference in pressure necessary to cause the liquid to flow through the opening should be sufficient to unseat the valve.

If the weight of the valve disk is taken into consideration, the pressure on the under side must necessarily be somewhat greater in order to hold the disk open. Ordinarily, the kinetic energy of the flowing liquid should be sufficient to do this if the disk is not of great weight.

If the valve was arranged as shown in Fig. 3, and the pressure per square inch equal, front and back, the total force *E*, acting up, will equal the total force *F*, acting down, as the areas acted upon by the fluid are equal, both front and back, inasmuch as $d_3 + 2x = d$.

Mr. Helms also makes the following statement: For valves having a circular cross-section the pressure will be equal on both sides at the moment of opening, neglecting the weight of the disk, when the valve is proportional as expressed by the following equation:

$$d_2 = d_1^2 + d_3^2 - d_2^2.$$

This is evidently an error, as the formula should read

$$d^2 = d_1^2 + d_3^2 - d_2^2$$

or

$$d = \sqrt{d_1^2 + d_3^2 - d_2^2}\ .$$

However, if the foregoing reasoning is correct, this formula will not hold good for the valve in question.

William F. Fischer.

New York, N. Y.

Under the above caption, F. C. Helms, on page 201 of the January 26 number, says: "It is evident that if the area of this annular recess, represented by 0.7854 $(d_1^2 - d_2^2)$, is equal to the area of the seat, 0.7854 $(d^2 - d_3^2)$, the valve will open when the pressure per unit area on the front is equal to the pressure per unit area on the back, since the areas exposed to the action of the fluid pressure are equal on both sides. For valves having a circular cross-section, the pressures will be equal on both sides at the moment of opening (neglecting the weight of the valve), when the valve is proportioned as expressed by the following equation: $d_2 = d_1^2 + d_3^2 - d_2^2$."

The letters refer to the dimensions shown in Mr. Helm's article. The above equation is evidently a misprint, and from the previous discussion I judge it should read: $d^2 = d_1^2 + d_3^2 - d_2^2$.

What I take exception to is his statement regarding the annular recess. He evidently expects to balance the poppet valve by this recess. Mr. Helms falls into an error when he says the valve is balanced when $d_1^2 - d_2^2 = d^2 - d_3^2$.

To explain this, I have enlarged that part of his illustration, as shown in Fig. 1. This shows the recess when pressure is admitted to the recess through the port *B*. The effective area of the recess that helps to lift the valve is 0.7854 $(d_1^2 - d_4^2)$.

To make this clear I have drawn reacting forces at *C* that include all forces in the effective area given above. At *A* I have drawn reacting forces that include all that do not fall in the effective area. As will be seen, the forces at *C* will react and help lift the valve, while those at A will neutralize each other and act as so much dead water.

It will be seen, then, that to fully balance the poppet valve by Mr. Helms' method would require $d_1 = d$ and $d_4 = d_3$ which is a condition not to be considered.

Partially balanced valves have been built on the double-beat principle, see Fig. 2, which is a modification of the idea suggested by Mr. Helms. Let D_1 and D_2 be the diameters of the larger and smaller seats of a double-beat valve, and P the effective pressure of the fluid in pounds per square inch. Then the force required to open the valve equals $0.7854\ (D_1^2 - D_2^2)\ P$, neglecting the width of the seats and the weight of the valve.

FIG. 1

From this it is evident that by making the difference between D_1 and D_2 small, the force required to open the valve will be small, and consequently the extra pressure required to open the valve will also be small.

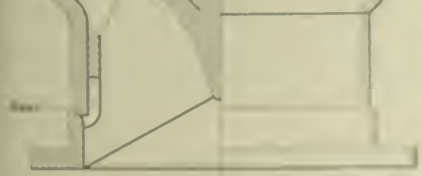


FIG. 2

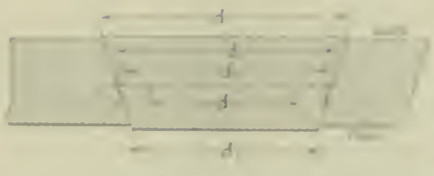
The double-beat valve shown in Fig. 2 was designed by A. F. Nagle, and is now pumping water under an effective pressure of 52 pounds per square inch. The valve is worked automatically by the water. The seats have a [illegible]-inch bearing surface, and are made of bronze.

JOHN B. SPERRY.

Aurora, Ill.

On page [illegible] of the January 26 number is shown a sketch of poppet double-seated balancing valve which I think would fail to balance in actual practice. To illustrate the point I take exception to I submit a sketch similar to the one mentioned.

Mr. Helms states that "it is evident that if the area of the annular recess represented by $0.7854\ (d^2 - d_1^2)$, is equal to the area of the seat, $0.7854\ (d_2^2 - d_3^2)$, the valve will open when the pressure per unit area on the front is equal to the pressure per unit area on the back, since the areas exposed to the action of the fluid pressure are equal on both sides." This statement is wrong, as he has not taken into consideration the effect of the pressure acting on the area of the surface represented by $0.7854\ (d_4^2 - d^2)$, see sketch, which acts in a downward direction opposing the pressure tending to lift the valve. The pressure acting toward lifting the valve should be obtained by $0.7854\ (d_1^2 - D^2)$, and is shown graphically by the open triangle in the sketch herewith presented.



MR. CAREY'S SKETCH

T. CAREY.

Albany, N. Y.

Repairing a Crank Disk

Our main [illegible] Watertown simple engine, running at [illegible] revolutions per minute, began to pound badly and I lost no time in shutting down. When the engine came to a stop I found the crank disk cracked across its face, the crack passing through the lower part of the crank-pin hole and extending to within [illegible] inch of the outside edge of the crank disk.

As it would require a week or ten days to obtain a new disk, we decided to shrink on a band. A piece of [illegible]-inch steel was rolled and welded into a band and turned up in a lathe [illegible] inch smaller than the disk. After heating the band in an open [illegible] fire to expand it, we forced it on the disk, and as it cooled it drew the crack together so it could hardly be noticed.

After connecting the crank pin we started up, and the engine ran for [illegible] a week, when the crank pin showed signs of being loose in the disk. I took the pin out and [illegible] punched it all around and drove it in again. I put it in the [illegible] [illegible] [illegible] [illegible] of [illegible] any signs of loosening.

[illegible] but [illegible] the company decided to have a new disk put on. I had a new one cast [illegible] inches larger in diameter than the old disk, and as the old disk had a hole of [illegible] size in the center [illegible] a shaft hole, it allowed the new disk to be used. I [illegible] [illegible] than the old one.

When the new disk was ready I went [illegible] engine from the boiler and heated the disk as hot as possible with steam, which so expanded it that with the aid of four [illegible]-inch rods running back over the hub of the driving wheel it was pulled on [illegible].

SHOWING THE CRACK IN THE CRANK DISK

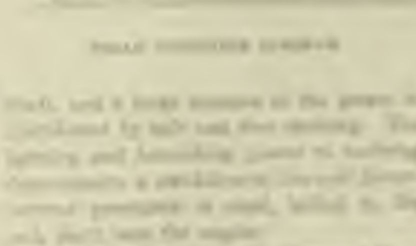
H. T. [illegible].

[illegible], Me.

Freak Indicator Diagram

The accompanying diagram is from an engine of a type sold by the C. H. Brown company about [illegible] years ago. The cylinder diameter is [illegible] inches, stroke [illegible] inches, revolutions per minute [illegible] and the steam pressure [illegible] pounds.

The engine is belted to [illegible] line shaft,



FREAK INDICATOR DIAGRAM

shaft, and a large amount of the power is distributed by belt and line shafting. The lighting and [illegible] ... [illegible] ... the engine.

It was [illegible] by other diagrams from the engine [illegible] [illegible] [illegible], but it was one of the [illegible] [illegible]. The engineer [illegible] all the [illegible] for a moment so that I could get my diagrams quickly, and then throw the generator on again before the motors had stopped. I got the crank-end diagram, but took the head-end just as he threw in the main switch and blew several fuses. I suppose there is some connection between the short-circuited generator and the freak diagram, but have been unable to decide where it lies.

EARL R. FILKINS.

Chicago, Ill.

An Obscure Electric Circuit Trouble

Not having seen any suggestion as to the cause of the arc-circuit trouble of Mr. Minton I would like to make a suggestion as to the probable cause and also explain some of the conditions which probably exist. To begin with, the arrangement of stepping down the voltage from the high-tension lines is not to be recommended, as the arc circuit is electrically connected with them, and the trouble in this case seems to be on that account. It is more advisable to have a transformer with a 11,500-volt primary and an 8000-volt secondary. This would insulate the transmission lines from the arc circuits. The arrangement now is an auto-transformer with an 8000-volt tap.

What I think caused the trouble was a ground on the one leg of the high-tension lines which the auto-transformer is not connected to, and also the high-resistance ground in the underground wires where the lead cable is split and the rubber insulation is deteriorated. As noted, when the stab switch on the regulator side of the arc circuit was inserted, the regulator moved to its extreme position; this could only be expected, as there were but forty lamps burning. It had to act that way to hold the current down. On inserting the stab switch on the opposite side of the circuit, the meter reading there was only four amperes, and to account for this, I think that the current divided at the ground in the underground wire, taking two circuits to the generator; the one circuit which took four amperes went by the way of the lamps and the 2000-volt tap of the auto-transformer, and the remainder of the current went by the way of the grounded arc circuit to the grounded high-tension leg.

It was said that the resistance to ground on the arc circuit was one megohm, but although this ohmic resistance is high, the dielectric strength of the insulation may have been very low, so that when the arc circuit was thrown on the current kept arcing through the small holes in the rubber to the ground, this enabling the ground circuit to form. The discharge of the lightning arrester at the instant of the closing of the arc circuit was due to the ground leg of the high-tension line and also the surge of current through the regulator and the forty lamps. This, of course, happened before the regulator or lamps had a chance to act, thus practically causing an instantaneous short-circuit on the transmission line.

The reason the circuit acted the same way when transferred to the switches of No. 2 circuit was on account of the cause of the trouble not being removed. But when the transformer was changed to a different source of supply, the circuit acted O. K. This proved that the former supply circuit was grounded. An arc circuit can be operated if only one ground exists on the circuit, but it is advisable to get rid of it as soon as possible.

It was not necessary to put a solid ground on the circuit where the cable was grounded to find out if there was a ground between the last lamp and the transformer, because if there was one, it would soon burn itself free or burn up the primary of the transformer, for in a case such as this the 2000-volt primary would be placed across a 11,500-volt circuit. But the solid ground helped out in such a way that it caused two good circuits through the lamps, and instead of the load being on one phase it was thrown across two of the three phases. The circuits formed were as follows: One circuit flowing through the regulator and the forty lamps to ground, the regulator holding the current down so that the lamps would burn; the other circuit was through the primary of the transformer and the other seventy lamps, the voltage per lamp in the latter circuit being greater than normal by about 20 volts at least. If this circuit burned all right, it is probable that the high-tension voltage is less than stated in the sketch. The reason the regulator started to burn after placing a solid ground on the lamps, was because the resistance of the first circuit through the regulator, forty lamps, the solid ground and the grounded high-tension leg was reduced considerably, this overloading the regulator more in this case than before the circuit was solidly grounded.

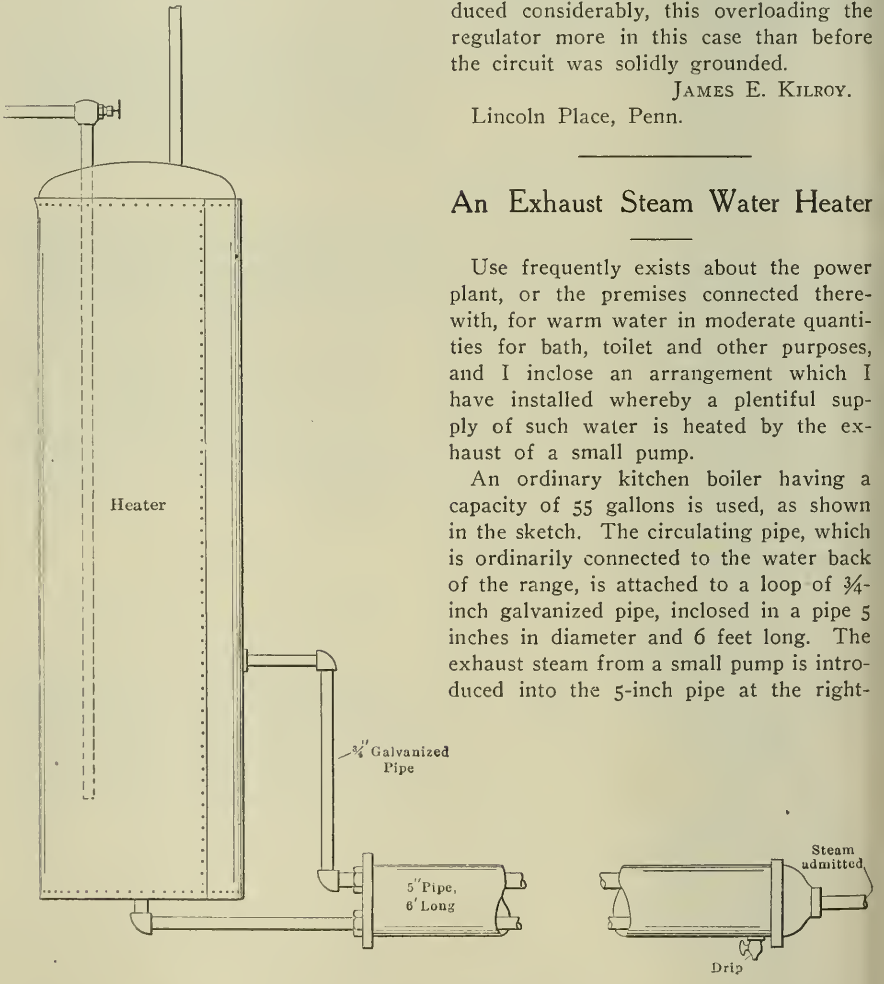
JAMES E. KILROY.

Lincoln Place, Penn.

An Exhaust Steam Water Heater

Use frequently exists about the power plant, or the premises connected therewith, for warm water in moderate quantities for bath, toilet and other purposes, and I inclose an arrangement which I have installed whereby a plentiful supply of such water is heated by the exhaust of a small pump.

An ordinary kitchen boiler having a capacity of 55 gallons is used, as shown in the sketch. The circulating pipe, which is ordinarily connected to the water back of the range, is attached to a loop of ¾-inch galvanized pipe, inclosed in a pipe 5 inches in diameter and 6 feet long. The exhaust steam from a small pump is introduced into the 5-inch pipe at the right-hand end and escapes from a pipe at the other end, as shown, a drip being provided at the lowest point to carry off the water of condensation. The loop is thus always surrounded with exhaust steam, which by heating the water inside produces a circulation, keeping the contents of the boiler sufficiently warm. However little may be drawn from the boiler, its temperature can never rise above the boiling point at atmospheric pressure, and hot water and not steam will come when the tap is opened.



AN EXHAUST-STEAM WATER HEATER

J. A. LOYER.

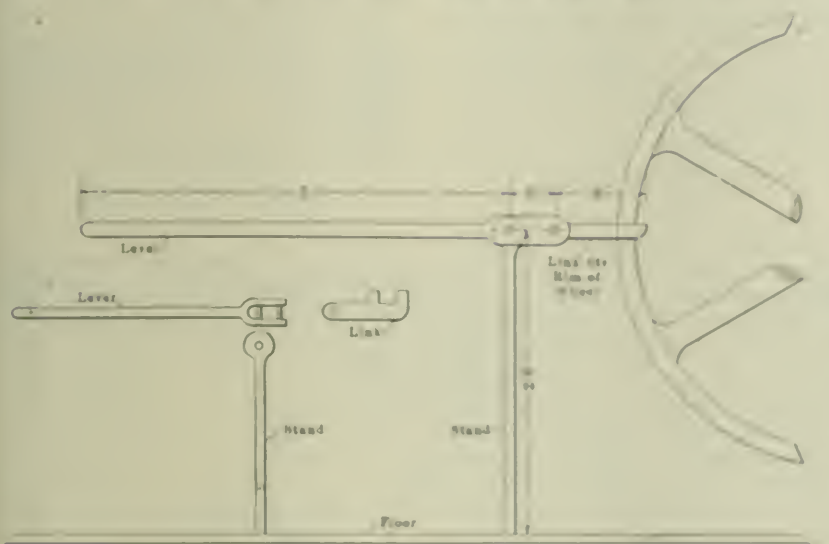
Montreal, Can.

An Engine Turning Device

The sketch shows an engine-turning device I used in one of my plants. It is simple and works well. When one lifts up the lever the link will slide down and grip the rim for a new pull. The illustration shows its construction.

E. A. YOUNG.

Isabella, Tenn.



AN ENGINE-TURNING DEVICE

More Frequent Internal Inspection

The editorial under the caption "More Frequent Internal Inspection" deserves more than passing notice. In considering the value of a boiler inspection two facts should always be borne in mind: First, there are boiler inspectors and boiler inspectors, and they are not by any means all alike. The personal equation plays a very important part in their work; second, the boiler inspector sees the thing from a different viewpoint. He is interested in risks, the boiler owner is interested in economy. It was with the thought of recouping possible loss that the owner in the first place took out a policy. So there you are.

The man who places too much reliance in the boiler-inspector's report is very likely to wake up some morning a sorry man. And this does not presuppose that the inspector did not do his work conscientiously, either. Perhaps he has. Perhaps he has discovered that the tubes are coated with scale, and so states in the report. But the risk is good, and he is not particularly concerned whether you are burning a wee bit more coal because of the scale, and so he says: "Oh, there isn't enough to bother with." Take his word for it, and you'll pay for it in hard cash. But it is to be remembered that there are plenty of cases where scale is present and the inspection has not revealed it. A few concrete cases may be cited.

About four years ago a boiler-tube cleaner was sent on trial to the Petersburg electric-light plant, Petersburg, Ill. The cleaner was tried, ten wheelbarrow loads of scale were taken out "and the boilers were considered by the inspectors to be in good shape," the president reported.

In the May 7, 1908, issue of *Electric Traction Weekly* there was published a paper by A. M. Allen, a consulting engineer. Following is an excerpt:

"As an example, the writer knows of a plant having four 150-horsepower return-tubular boilers, operating twenty-four hours per day, which were pushed to their utmost to furnish the necessary steam, and the insurance inspector's after their examination reported the boilers as being clean. At about this time an enterprising salesman arrived with a tube cleaner which he induced the management to try. This was put through the tubes and scale taken out by the bushel, the result being that they are now operating their plant on only three of the boilers."

Take another case: Last July, a boiler-tube cleaner was sent to the Clinton prison, Dannemora, N. Y., for trial. Among other things, Mr. Gilbert, superintendent of industries of the institution, in his report stated: "I removed [illegible] pounds of scale from our No. 1 boiler, and directly after an inspector's report of 'clean boiler' I took out [illegible] pounds of scale from our No. 2 boiler."

These concrete cases prove nothing if they don't prove that it pays to investigate boiler conditions yourself regardless of what the inspector's report is. You have done a distinct service by touching on this matter.

H. E. GARSWORTH.

Buffalo, N. Y.

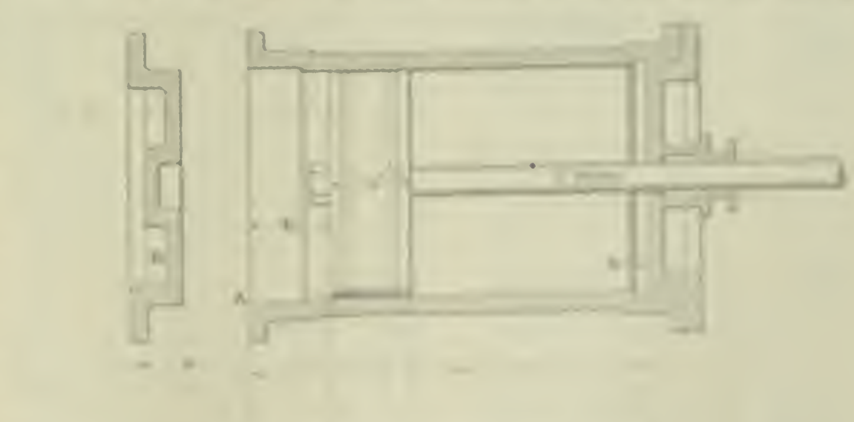
Method of Adjusting Pistons

To adjust a piston for clearance in a large engine requires considerable hard work. The following is an idea I picked up some time ago that makes it an easy job:

Presuming the piston is out of the cylinder, take a 2x1½-inch stick a little longer than the cylinder and, placing it inside against the front head, make a mark at the end of the cylinder at *A*. Say we have an engine with a 27-inch stroke, piston head 12 inches thick, false head 5 inches thick and the cylinder from *A* to *B* 44½ inches. Lay off these measurements on the stick and you have ½ inch *b-b*, which represents ½ inch clearance on each end. When putting the piston in place, adjust it so that the distance from *A* to *C* is [illegible] and clearance will be equal on both ends of the cylinder.

CHARLES J. [illegible].

[illegible], Mass.



METHOD OF PISTON ADJUSTMENT

Two Loose Nuts

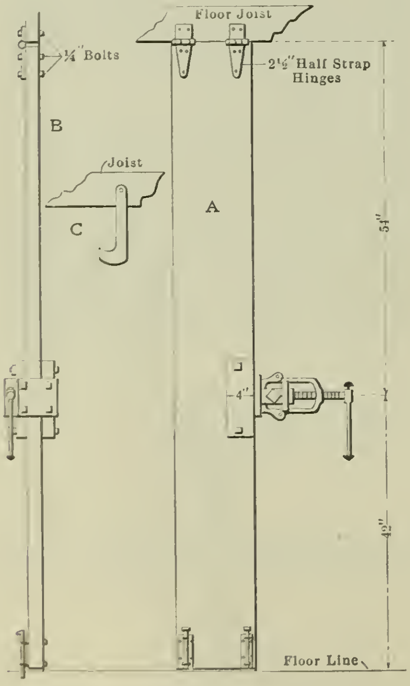
On page 306 of the February 9 number, Mr. Wakeman has a sketch of a Corliss engine, showing the exhaust valves covering the port leading from the cylinder to the valve. This is not correct, as the pressure would force the valve from its seat, resulting in a leaky engine. The valve should cover the port leading to the exhaust chamber; then the pressure would have a tendency to force the valve to seat tight. Also, where will the cylinder head go to when the crank reaches the dead center?

E. L. Dean.

North Wilbraham, Mass.

Movable Pipe Vise Support

At *A* is shown a front elevation of the device complete; *B* is a side elevation and *C* a detail of the hook for holding the support out of the way when not in use.



A MOVABLE PIPE-VISE SUPPORT

In *A* it will be seen that the pipe vise is mounted on an ordinary 2x12-inch plank, 8 feet long, and at a suitable hight to be convenient to work at. The plank is hinged at the top by means of two ordinary half-strap hinges to the floor joist or an overhead timber. At the bottom of the plank are two 6-inch door bolts which enter plates inserted in the floor and hold the device firmly in a working position.

The vise is bolted to two pieces of 2x4-inch stock, 12 inches long, which are in turn through-bolted to the upright 2x12-inch plank, thus forming a very firm support for the vise with comparatively light material.

The hook shown at *C* is a simple piece of flat steel suitably bent or forged and attached to any suitable overhead support.

When the vise is not in use the floor bolts are raised and the plank lifted until the hook catches it, thus leaving the floor entirely clear for any purpose desired.

Edwin Kilburn.

Spring Valley, Minn.

Lighting Problem

In the issue of February 2, under the head of "Lighting Problem," F. L. Rolph asks for criticism and remarks on a wiring diagram. The connections shown are feasible. Care, however, must be taken to make the leg of the incandescent circuit, which is also a part of the arc-light circuit, of sufficient capacity so that there is no material drop of potential, thereby lowering the drop on the incandescent circuit. Each incandescent lamp should have a shunt box or coil, so that the burning out of one lamp will not put out the others, nor increase the voltage across the others; or some other device must be used so that when the lamp burns out the circuit will not be interrupted and additional resistance will be introduced in the circuit to make up for the loss of this lamp.

With reference to commercial circuits, unless it is possible to divide the load fairly evenly between the circuits, I should recommend the use of three wires on each side in order to make this division of load possible, and thereby keep the regulation fairly close.

Henry D. Jackson.

Boston, Mass.

Why Some Engineers Do Not Read

When I read a letter recently under the above heading it directed my thoughts back to my first experience in engineering, under a chief. Being deeply interested along engineering lines, I procured some books and began to study at home. Then I enrolled as a student in a correspondence school. Finally I secured a job as fireman in a light and power plant in a town of about 13,000 inhabitants.

Thinking that I was now fairly on my way for advancement, I studied harder than ever and began to read technical papers, and could see the benefit gained by so doing. But unfortunately I was under a chief who condemned books and papers and claimed that there was nothing in them. He said that he "had a head that told him things," etc., but I went ahead just the same, received a promotion and finally secured the management of a municipal plant in a neighboring town, a position I never could have held without study. I still read Power and The Engineer, especially the practical letters, and derive much benefit from it.

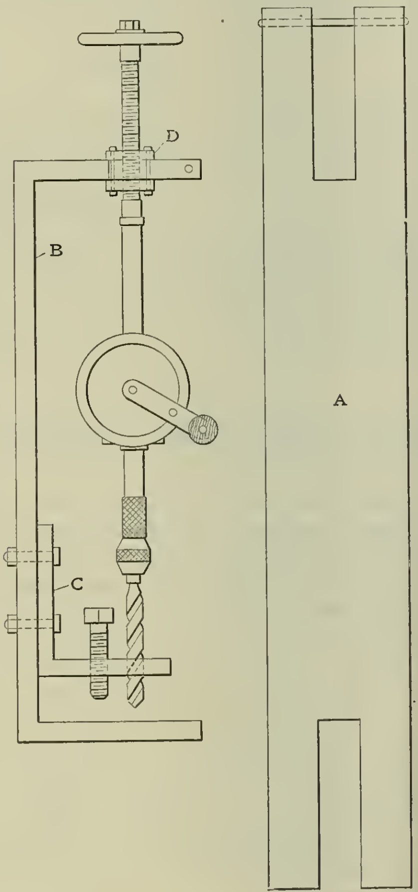
After a few inexcusable delays our friend, whose head told him everything, was asked to resign. He then got into a little plant in a town of about 600, but after a few months he had that plant shut down, and he was looking for another position. It pays to read technical papers.

E. H. Cavanaugh.

Altamont, Ill.

Using a Breast Drill

The accompanying sketch shows how a breast drill can be used to good advantage. Having to drill a great many holes, I fitted up the drill in the manner shown.



USING A BREAST DRILL TO ADVANTAGE

I took a piece of ⅜x2-inch cold-rolled steel *A*, and after sawing slots in both ends, bent it as shown at *B*. Next I took a piece of the same stock and sawed a slot in it and then bent it at right angles, as shown at *C*, and bolted it to the frame piece. A couple of set screws were provided to clamp it to the work to be drilled. I then took two ½-inch nuts and sawed them out to fit the slot, as shown at *D C*.

A 1-inch shaft was then turned out with a head and one end threaded to fit the nuts. The other end was turned down to fit a collar, which in turn fitted the shoulder of the breast drill. A pin prevents the nuts from sliding out of the frame.

G. A. CLEVELAND.

New Haven, Conn.

Flue Gas Sampler

Sampling tubes for collecting the flue gases for analysis with the CO_2 automatic recorder, or with other analyzing instruments, have always given more or less worry to the operator. If they do not become stopped up with soot, there is always the question as to whether an average sample is being obtained.

After using the American Society of Mechanical Engineers' flue-gas sampler, as described in volume 21 of the *Transactions*, page [illegible], for some time, it was discarded on account of soot and small particles of ash collecting in the small tubes and solidifying to such an extent that they could not be removed by blowing through with steam, thus closing the openings, the advantage of this design being thereby destroyed, as the sample was no longer an average one.

While we had better success with a single ½-inch pipe, reaching across the stack, with a number of ⅛-inch holes drilled in the under side, throughout its length, with the end capped, there was always the doubt as to whether a proper sample of the gas was being taken.

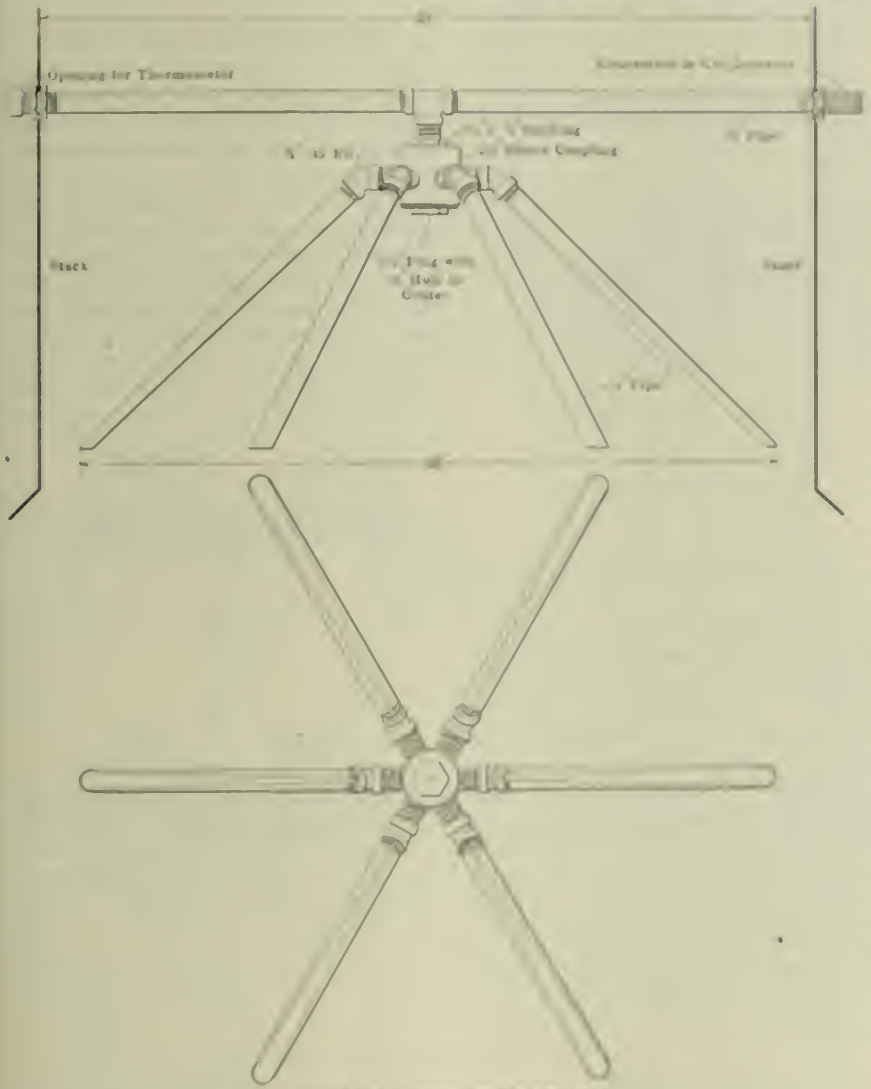
The line sketch herewith shows the design of sampler now in use. This sampler is made up entirely of pipe and standard fittings, and is so constructed as to collect gases from all parts of the stack and mix them in a mixing chamber before going to the recorder, the sampler being placed in the stack just below the damper.

The mixing chamber is a [illegible]-inch sleeve coupling, with a plug in its bottom having a [illegible]-inch hole in its center. In the top of this sleeve is a [illegible]-inch bushing and a ½-inch nipple to which the sampling tube is connected by means of a tee. The sampling tube extends across the stack, forming a hanger for the entire apparatus, and at the same time giving an opening in which a [illegible] thermometer can be inserted. Six holes are drilled in the mixing chamber and tapped for ½-inch pipe, to which are attached six legs, as shown. The pipes forming the legs have a slotted opening on the under side, decreasing in width toward the mixing chamber, making a slot the width of which at any point is proportional to the distance from the center.

This sampler has given good results after nine months' use, and up to the present shows no signs of clogging with soot and ash. The line on the chart is much more regular than the line obtained from the use of the single-tube sampler and resembles the line obtained from the use of the A. S. M. E. "[illegible]" sampler.

O. L. [illegible]

Annapolis, Md.



DETAILS OF A FLUE-GAS SAMPLER

Rope Drive for Governor

In the issue of January 26, E. McLaren comments on the governor drive mentioned in a previous number. Answering his letter, I would say that the rope drive previously mentioned not only reduces the liability of losing the driving power due to a possible break but, what is more important, there is much less liability of slippage, even should the ropes become oily. Each rope as it passes over the sheave is firmly held, or I might say wedged, into a V-shaped groove, and each rope is alone capable of driving the governor, so that the slippage, even under very unfavorable conditions for a belt drive, is almost negligible with the rope drive.

Mr. McLaren mentions "[illegible]," which I take to mean gripping of the governor spindle due to heating caused by friction. In a properly built governor the fits are made such that this is almost impossible. The friction of the governor is very small and if it is properly oiled it can easily be turned by hand. Under ordinary conditions the small belt is a more than sufficient drive, though far less reliable than the rope drive.

[illegible] bearings are not necessary in a properly designed governor. Most modern governors support the spindle on two hardened steel [illegible], or on a brass bushing between the steel bottoms. In the latter case a lot [illegible] is provided [illegible] to take up the wear of the brass.

One of the objects of my [illegible] letter was to point out the "safety-stop" [illegible]. The term "safety stop" is a [illegible] [illegible]; the attachment is a "[illegible] [illegible]" with a [illegible] [illegible]. [illegible] would be [illegible] [illegible] [illegible], especially where there is [illegible] [illegible] [illegible]. [illegible] [illegible] and the right side of the belt [illegible] [illegible] [illegible] McLaren's suggestion [illegible] [illegible] [illegible] [illegible] would [illegible] [illegible] [illegible].

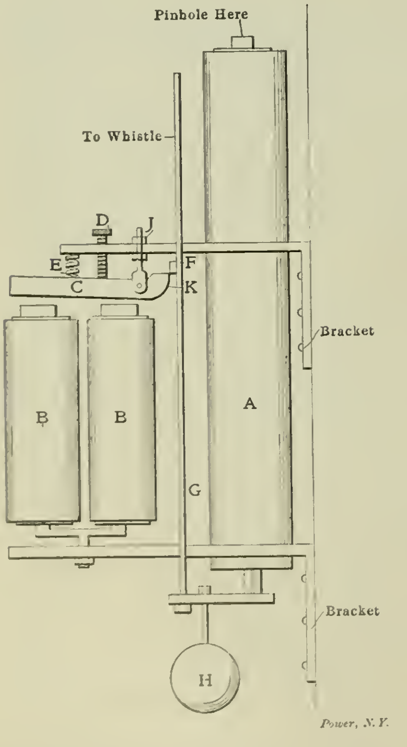
[illegible]

[illegible]

Automatic Device for Sounding Whistle Alarm

The accompanying sketch illustrates a device which is connected in series with an annunciator on the battery side of our fire-alarm system for the purpose of automatically sounding the whistle in case of fire. The magnets *B B* are connected in series with the annunciator, and in case an alarm is turned in from any station about the works the armature *C* is drawn downward, thus operating the catch *K* and releasing the rod *G*, which is drawn down by the weight *H*, the weight being sufficient to pull the whistle.

The descent of the rod is regulated by the dashpot *A*, which prevents it from descending with a jerk. When the circuit is opened again the armature is lifted by the spring *E*, which is just strong enough to raise and support the weight of the armature. The rod and weight are then raised by hand ready for the next call. The air gap between the armature and the magnets is regulated by the set screw *D* and hanger *J*.



DEVICE FOR SOUNDING WHISTLE ALARM

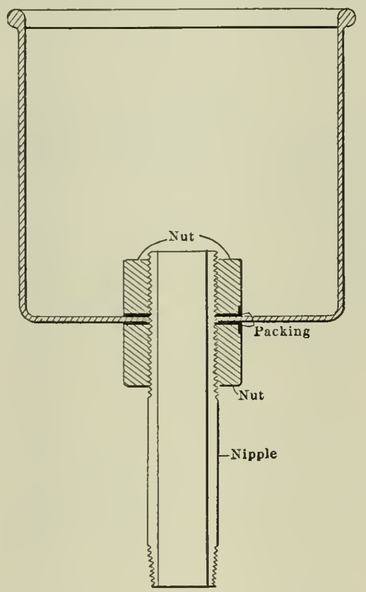
The parts *F* and *K* are made of hardened steel, the armature of soft iron, and the rod and hook, at the bottom, are made of steel; the dashpot, hangers, set screw and brackets are made of brass. The magnets were taken from an old alarm bell. This device works very well and is substantial. The system is tested at regular intervals to insure its being in working order.

L. U. Hawkins.

Reading, Penn.

Piping Vessels Without Threading or Soldering

Following is a kink in piping vessels that cannot be tapped or soldered: A hole is cut in the vessel, through which a piece of pipe of the size to be used is passed. A long screw nipple is secured by two locknuts. One nut is removed and the other screwed down to the shoulder of the long screw, with the counter-



PIPING A PAN, BUCKET OR OTHER VESSEL

bored side facing the long screw end of the nipple. After passing the long screw end of the nipple through the hole in the vessel from the outside, screw the other locknut on with the counterbored side toward the bottom of the vessel. Then wind a piece of lampwick or other packing around the nipple on both sides of the vessel, between it and the locknuts, and screw them up tight.

Piping can be run from the end of the nipple to any desired place. We use this joint in running pipes from oil tanks to various parts of machines and engines, and find it very satisfactory.

F. E. Fick.

Govans, Md.

Transformer Connections

In the issue of February 2, under the head of "Transformer Connections," R. S. Carroll asks if, having two transformers connected in open delta across phases *1* and *2*, it would be necessary to install the lighting transformer across phase *3*; also what effect it would have on the regulation.

Since without the lighting transformer the circuit would be balanced, it would make no difference on which phase the lighting transformer was installed, as this would be the only unbalancing feature of the circuit. The effect on the regulation, therefore, would be dependent on the size of the wire used on the phase on which the lighting transformer was installed, and the loss in this wire. Since the lights are used when the motors are not, the regulation would be entirely dependent on the regulation of the transformer and the size of the wire. The motor-circuit regulation would be dependent, also, on the same conditions.

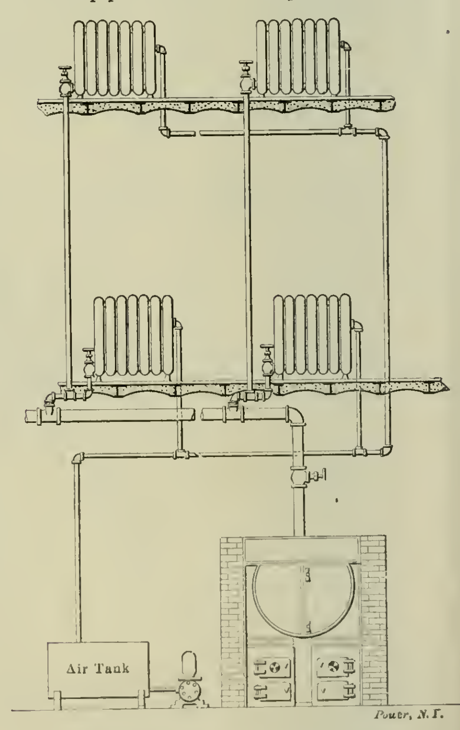
Henry D. Jackson.

Boston, Mass.

Substitute for Air Valves

The accompanying illustration shows the arrangement of my heating plant and my method of preventing water hammering in the pipes and radiators. All air valves have been removed and instead I have connected a small ⅜-inch air pipe running parallel with the steam pipe. This air pipe extends from the various radiators to the basement and connects to an air tank after combining in one 1-inch pipe.

In the morning I open the valve on the 1-inch pipe and leave it open until I get



ARRANGEMENT OF HEATING PLANT

4 or 5 pounds of steam on the boiler, when the valve is closed. I keep up steam until about 11 a.m., by which time there is considerable condensed water in the air pipe at the lower end, and there has also formed a strong vacuum between this water and the radiator. The vacuum in the air pipes will draw the vapor out of the boiler and the radiators will remain hot all day. I can steam up any time during the day and there is absolutely no water hammering. I have 82 radiators in

the building, and in cold weather the air valves would generally freeze, keeping me running around opening up air valves instead of attending to the boiler. I put in 1736 feet of air pipes, arranged as shown. At the air tank is a belt-connected pump driven by a gasoline engine for removing the condensed water.

N. H. JOHNSON.

Sleepy Eye, Minn.

Babbitting a Large Main Bearing

In response to a hurry-up call, a machinist was sent to babbitt a main bearing. The engineer had neglected the bearing during the night run and from some cause or other, the babbitt had melted, so that the shaft was wearing down into the iron of the bottom box before the engine was stopped.

A piece of sheet iron a little longer than the bottom box was bent, as shown at *A*, Fig. 1, and fastened to the box by means of clamps, leaving an opening of ½ to ¾ inch for the babbitt. Another piece was bent as shown at *B* and fastened to the quarter box, allowing room for the babbitt metal. The boxes were stood on end on an iron plate and the bottom well sealed with clay to hold the babbitt. A little tallow from a candle was scraped into the cavity to prevent an explosion, and the boxes poured. When cool, the sheet-iron forms were removed and the babbitt well hammered with a ball-peen hammer.

The boxes were then assembled as shown in Fig. 2 (end view) and Fig. 3 (side view). The pieces *C C* are of hardwood, the bottom ones being of the required thickness to bring the center of the box to the same hight as the center of a lathe. The bolts *D D* hold the bearing together and also clamp it to the lathe carriage. The pieces *E E* were made of hardwood, and high enough to enable the cutter to clear the pieces *C C*. Care was taken to have the distance across from the outside faces of the wedges *F F* the width of the opening in the frame. A boring bar was placed in the lathe. The boxes were then set, bored out, oil grooves cut, and the surface scraped.

E. G. HARRIS.

Burlington, Ia.

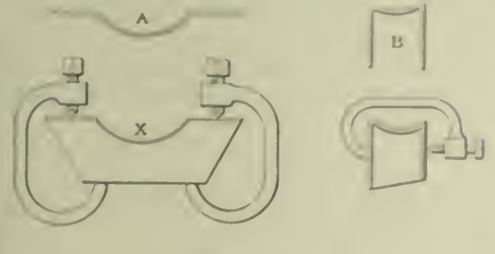


FIG. 1

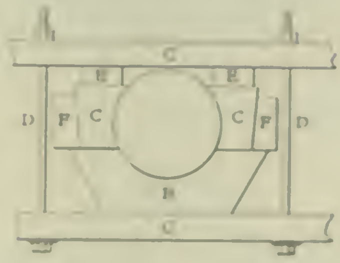


FIG. 2

FIG. 3

Dashpot Does Not Seat

In endeavoring to answer the query of Elsworth Davis under the above caption, on page 200 of the January 26 number, I will say that it is very difficult to suggest the cause of the trouble from the meager particulars given. Requests for information in reference to matters of this kind should be accompanied with some details, such as type of dashpot, the make of engine, whether of old or late design, etc. For instance, the dashpot and plunger of the old Hamilton-Corliss, and the later engines of this same make, are entirely dissimilar.

The old Hamilton, as well as other Corliss engines made at this time, employs a type having two plungers in one, the smaller having a cup leather on it, and this has for its office the formation of the vacuum for pulling down the plunger after the knock-off cam has caused the release of the die from the block. The upper plunger is much larger, and has a leather riveted on its under side. This leather has a small flap valve working over a small port bored in the plunger. The object of this plunger is to cushion the plunger on its descent to prevent it from slamming or striking the bottom of the dashpot. As the plunger rises this little flap valve opens and allows the air chamber to fill with air, and in the air chamber of the dashpot proper there is an air-exhaust regulating valve. When this is properly set it will allow all of the air to escape except just enough to cushion the drop of the plunger. When the plunger has risen and the block is released, allowing the plunger to drop, the little flap valve closes, so that the air admitted through it cannot escape through it, and hence can escape only through the regulating valve.

Now the trouble may be caused by the cup leather having become worn out, or having become defective from any other cause, so that the necessary vacuum is not formed under it. Or, what is more likely, the leather on the cushioning plunger, or the plunger itself, may have become worn and defective, or the little flap valve may be defective. This last is the most frequent cause of the trouble. If it has become defective it makes it impossible to regulate the [illegible].

I have had this trouble when the dashpot would work all right when using the starting bar, and would work good and bad by turns when running. The only sure way to locate the trouble is to dismantle the dashpot, having acquired a knowledge of the functions of each part and the conditions each part must be in to perform its functions properly. If this does not lead Mr. Davis to a solution of the problem, my advice would be to take it up with the builders of the engine, giving full particulars. The times I have been helped by the builders of engines are many. They are the best friends of the ambitious engineer.

WILLIAM W[illegible].

Lincoln, Neb.

On page 200 of the January 26 number, Elsworth Davis tells of his trouble with a dashpot not seating with a light load on the engine. If he had stated what kind of dashpot it was, whether leather packed or otherwise, what kind of engine and what load and how fast the engine ran, perhaps readers would more clearly understand the nature of the trouble.

I have had the same kind of trouble, but the dashpots were of the leather-packed type. Every time the leather got the least bit worn he would leak in and partially destroy the vacuum in the dashpot, and the dashpot would not seat until the load forced it down.

There are several things that will cause this trouble: low [illegible] compression, too high speed with low boiler pressure, too high [illegible] pressure, or [illegible] causing the dashpot to [illegible]. The latter usually caused the trouble I had.

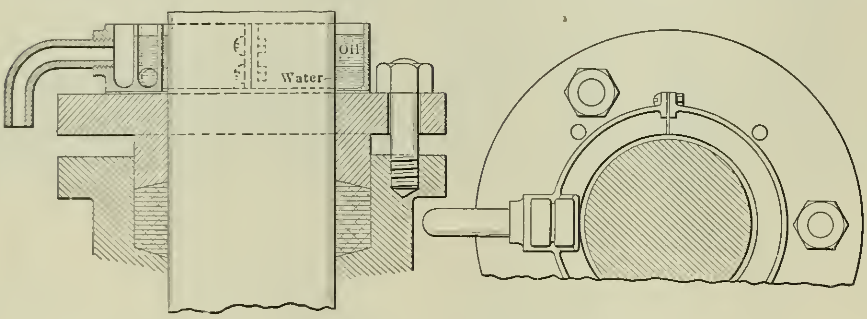
Mr. Davis says that he working the [illegible] by hand the dashpot works easily. Perhaps he does not move the [illegible] as far as it would when the engine is running. That will make a great difference, as the governor and knockoff cams are not in the same position when worked as they would be while running.

C[illegible] W. [illegible].

[illegible], Neb.

Method of Lubricating Elevator Plungers

While the plunger elevator is being discussed in the columns of Power, I submit a sketch showing a method I have used to lubricate the plungers of elevators, pumps, accumulators, etc. I found that oil keeps a plunger in better condition than grease, but is easily washed away by leakage from the stuffing box. To prevent this, I attach a collar to the plunger and gland, which retains the oil and acts as a separator, permitting the water to escape through the drip. The plunger in moving up or down carries the oil on its surface, thus keeping the plunger free from gum or corrosion and also preserving the packing. Should any water leak by the packing, it will pass through the opening near the bottom of the ring and overflow to the drip pipe. The sketch shows the ring made in two pieces to facilitate its application.



METHOD OF LUBRICATING ELEVATOR PLUNGERS

W. H. O'Connor.

Newark, N. J.

The "Contraflo" Condenser

In the article on "Development of the Surface Condenser," in the February 16 number, at the bottom of page 347 the statement is made: "In order that the air pump may extract the greatest quantity of air from the condenser, it is necessary to remove the vapor with which the air is mixed." A clearer statement would be as follows: In order that an air pump may extract the greatest quantity of air from a condenser its temperature must be low relatively to the temperature in the condenser, for to remove a given weight of air it is also necessary to remove the vapor with which it is mixed.

On page 348, in the first column, it is stated that "The sealing water, after passing through the air pump, is returned to the cooler, so that the same water is used over and over again." This statement is true as applicable to a dry system, where the water of condensation is not dealt with by the air pump, but by a separate pump. It does not apply to the design illustrated in the article, however.

Although the Contraflo Condenser Company, of London, is the manufacturer of this condenser, the Elwood Company is not the selling agent in the United States, but the representative to authorize the manufacture of the "Contraflo" condenser, under license, by any reputable builder of this class of machinery in the United States.

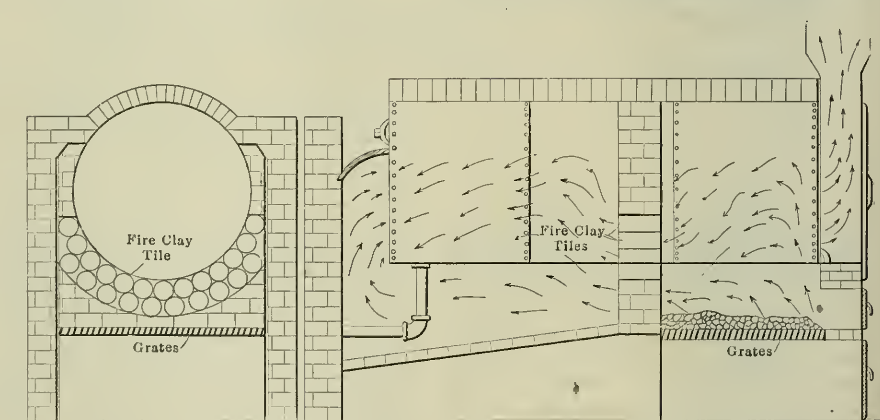
The Elwold Company,
W. R. Molinard, Manager.

Philadelphia, Penn.

Getting Complete Combustion

It seems to be the general opinion of most all authorities on smoke-consuming devices that the gases must be brought into contact with a white-hot arch of fire-brick before passing onto the shell and tubes, in order to get complete combustion.

In the ordinary boiler setting the main body of the gases passes directly from the grates over the bridgewall, along the comparatively cool surface of the shell and into the tubes, without any direct contact with the furnace walls, naturally resulting in a rapid cooling of the gases. These pass off in the form of smoke, which could be consumed if the proper amount of air was admitted to the furnace and divided into small streams, coming in contact with a surface hot enough to ignite the mixture.



END AND SIDE VIEWS OF FURNACE PROPOSED TO SECURE BETTER COMBUSTION

The sketch illustrates a method that could be applied with very little change or expense to any ordinary boiler setting to get this result. End and side views of the furnace are shown. The space over the original bridgewall is filled in to about the center line of the boiler shell, with fire-clay tile, the bridgewall being round to conform with the boiler curvature. This causes all gases to pass through the tile, which is at a white heat, before reaching the combustion chamber.

If necessary, in order to get the proper mixture of air before the gases enter the tile, air jets could be placed in the front of the bridgewall and a steam jet used to inject the proper quantity of air, although I think sufficient air could be admitted through the furnace doors and over the fire to get proper results, at the same time keeping the temperature of the door and surrounding wall down. The space between the bridgewall and boiler should be made large enough not to restrict the draft by the space taken up by the tile.

S. Kirlin.

Fort Smith, Ark.

Fixing Loose Crank Pins

I have read at different times how engineers have fixed loose crank pins by riveting the end over, center punching the pin around the end near the outside, or driving in dowel pins. One may in this town cut a keyseat in the pin and drive in a key.

Professor Sweet's scheme is, in my opinion, the best, that of drilling a hole in the center of the pin and driving in a taper tool-steel pin.

My scheme to cure a loose crank pin is to put in a new one. It is not much of a job to make a new pin, and if an engineer has not the ability to do it he has no business with a job of any importance. If a pin is loose in the fit, center punching, etc., will not make it tight.

John Dunn.

Streator, Ill.

Some Useful Lessons of Limewater

The Gases in the Air and the Part They Play in Combustion; Interesting Experiments to Prove That When Coal Burns It Forms an Acid

BY CHARLES S. PALMER

All that we have studied thus far is only an introduction to what that barrel of quicklime has to tell. We have seen that lime-like substances are found in hard water and that, sometimes, it is one of these same lime-like things which may be used to overcome this hardness; as though one should make one hand wash the other; or, following the old proverb, healing by "a hair of the dog that bit him." But this subject of hard water, while very real and practical, is not a separate thing by itself; it is connected with many other chemical facts and theories. We will make short excursions into some of these other fields, such as that of fire or water, or that of acids or alkalies.

Fire

In making our clearing before our imaginary cabin home, in the forest of ignorance and prejudice, one of the first things which we should know something about is the air, or the atmosphere, as it is also called. We know that the air has everything to do with burning, for if we want to make a fire burn in a stove or furnace all that is necessary is to keep the grate free from ashes, supply it with fuel, light it and give it free draft. Indeed, in some forms of power maker one can almost control the engine by regulating the doors and dampers. So it is almost self-evident that burning, in the common meaning, is dependent on the air draft.

Moreover, when coal or fuel burns there is some great change in the fuel. Most of it goes up the stack, except some 5 or 10, or, perhaps, 15 or 20 per cent. of ashes, but usually from 80 to 90 per cent. of the fuel vanishes in the work of furnishing heat and power. If one should look only at the fuel and the remaining ashes he would suppose that burning is a subtraction; and there was once common among scientific men a theory which called itself "phlogiston," that is, "fire stuff," and which supposed that burning is a subtraction, because they looked only at the fuel and ashes. But if we look with one eye at the fuel and the ashes and save the other eye for the waste gases which go up the chimney, then we find that burning is an *addition*, and not a small addition but a great addition. This is proved by burning fuel in closed apparatus and weighing everything which comes off it. In this way it is found that one ton of hard coal will send up the chimney, when well burned, between three and four tons of burnt gas, to say nothing of wasting heat on some nine or ten tons of a gas (nitrogen) which is in the air as neutral "filler."

If your attention has never been called to these curious facts, you have a good right to be skeptical as to the correctness of the figures. They are only general, but they are approximately correct; and you begin to think that our eyes must be half blind to let such vast quantities of substances slip by us unnoticed. There are many ways of getting at these interesting things, but one of the easiest ways is to ask this simple question: Is the air about us composed of one thing or of several things? You have heard all your life that the air is mostly made up of the two gases, nitrogen and oxygen; but if

FIG. 1

you have not taken this statement to the [illegible] of your careful attention, if you have not tested this statement with your own chemical apparatus, you can have but a faint notion of the wonderful meaning and the good business value which lie hidden behind the simple statement that the air is made up of nitrogen and oxygen. You know that there is more of the nitrogen than the oxygen, and yet that the oxygen is the active thing so far as burning is concerned; but you need to prove at least a part of this for yourself, in order to see what the fact is worth to you.

Two Things in the Air

Take a common wash or dish pan as shown in Figs. 1 and 2. By the way, you will be flattered to know that your wash dish is serving for what the books call a "pneumatic trough," which means a convenience for handling gases, a simple but great invention. Put an inch or two of common water into the dish. Get a wide-mouthed jar, say a common fruit jar. Find a wide, flat cork, which will easily pass through the mouth of the jar, without touching the sides, and float the cork on the water in the wash dish. Now find a little saucer-shaped dish to ride on the cork and to hold some easily combustible stuff, such as match ends, sulphur or phosphorus. The cork must be flat and well balanced with its cargo of stuff to burn, and sometimes it will be more stable if the wider end of the cork is at the bottom. You will find that you must get this point well fixed, as you have got to place the jar mouth downward over the cork and its cargo without disturbing the latter. Any saucer-shaped piece of tin or iron, as the round cover of a spice box, will do for the little dish; sometimes the saucers and plates of a doll's tea set serve first rate for such purposes, or the little dishes in a common box of water paints. You want to get the cork and its load well balanced, so you can slip the wide-mouthed bottle down over the cork. Then light the phosphorus or match ends, or what ever else you wish burned, and neatly put the bottle mouth downward into the water and over the burning cargo on the floating cork. As it burns, there will be an escape of several bubbles of air from the bottle, and you can explain this by the sudden heating of the air shut up in the bottle. But pretty soon the fire in the dish on the cork will burn more slowly, and finally it will go out. Meanwhile the cork with its cargo has risen up and into the jar as the watery [illegible] and inside the jar to take the [illegible].

Now note the air in the inside of the jar or bottle. If it is [illegible] some [illegible] will be partly absorbed by the water in the bottle, [illegible] the water will rise part way up the inside of bottle (Fig. 2). You must be patient [illegible] this experiment, [illegible] you will get [illegible] in handling [illegible]. You will [illegible] phosphorus from match [illegible].

drops of kerosene, you will not get as much absorption of the burnt fumes by the water. But in every case, with the burning of phosphorus you will get an absorption of the air in the bottle by the burning amounting to from one-fifth to one-third. The correct figure is about one-fifth; but you may drive off too much air at the start from the expansion from heating, before the real burning has gone very far; and this error in the experiment will show up as an apparent absorption of the original air greater than the real absorption and disappearance of the air in the bottle.

There are several sides to this experiment, and we will mention them here, so that you can be on the lookout for them:

First, the strong burning of the stuff in the little saucer, and the placing of the jar over this.

Second, as soon as the fire has gone out in the saucer and the water in the jar has finished absorbing the fumes from the burning, lift the jar quickly out of the water, first slipping a piece of cardboard over the mouth to keep the water that is in it from flowing out. Shake violently, using the cardboard cover, and set the jar right side up on the table. Note the amount of absorption of the original air in the jar.

Third, light a splinter of wood and thrust it quickly down into the air left in the upper part of the jar; the splinter is put out, as anybody should know it would be, because if the fire of phosphorus went out, wood or paper would not burn well in this same residual air. All the same, it is not a foolish thing to do, to test this same residual air with your splinter of wood. It sets you to thinking what it all means and you begin to note that there must be different kinds of gas as regards their ability to help burning. The gas oxygen that has gone off (it has gone into the water) helped the burning), and it amounted to only about one-fifth by volume of the whole air. The part of the air that is left will not help common burning, although it makes up some four-fifths by volume of the air; this remaining part is nearly all nitrogen. Just to set your mind at rest, you may like to know that there are three other things in the air in small quantities. These are some water vapor, some of your old friend carbonic-acid gas and a strange newcomer, called argon, the "lazy element," because it does not do anything but exist; that is, it does not make any definite compound with anything, but sometimes pretends to be like nitrogen as it is found in the air, about one part in a hundred by volume.

Fourth, put some litmus into the water at the bottom of the jar and note the action. Of course, you know enough by this time never to take one piece of litmus paper, nor one color, but *two* pieces; or, at least, one piece colored red at one end and blue at the other. You can take a bit of red litmus and let one-half touch a piece of soap to blue one-half. With both red and blue litmus you can catch both alkalies and acids. You will find that the water in the bottom of your jar turns the litmus red; that means that the burning has made something which went into the water and which has acid properties. If you used mostly phosphorus then the burning of the phosphorus has made one kind of phosphoric acid. If you used mostly sulphur in burning in the little dish on the cork, then the burning mostly made sulphurous acid, with some sulphuric acid. But in both cases, the burning with the oxygen of the air made things that are essentially acids. It was the great French chemist, Lavoisier, who found this out some hundred and forty or fifty years ago, about the time of the Revolutionary war; he showed that burning was an *addition,* and that the adding of the "burn-helping" gas (oxygen) in

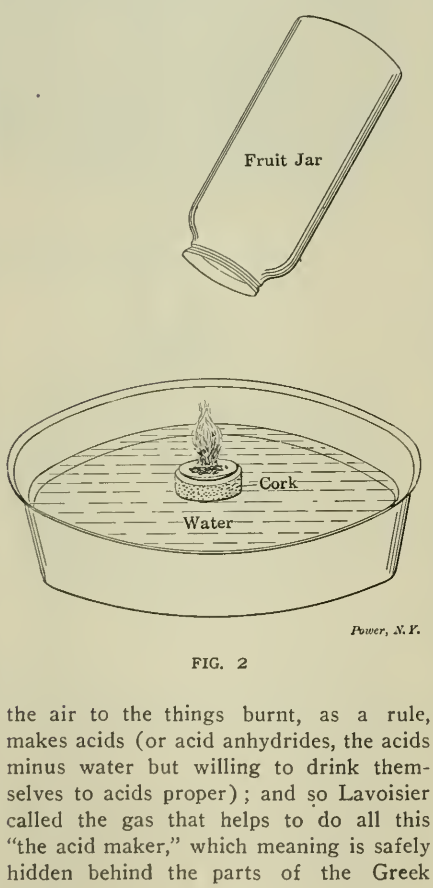


FIG. 2

the air to the things burnt, as a rule, makes acids (or acid anhydrides, the acids minus water but willing to drink themselves to acids proper); and so Lavoisier called the gas that helps to do all this "the acid maker," which meaning is safely hidden behind the parts of the Greek makeup, "oxy-gen." You will find out later that this claim of oxygen to make all acids, is not quite exact, but that there are acids which have no oxygen in them; but in every such case the acids have something which plays proxy for oxygen, so that in its broadest sense the name "oxygen," "acid maker," is not so bad for the "burn helper" in the air.

Repeat the Experiment Often

You must try this fundamental experiment of attacking the composition of the air over and over again and in every shape and method that your ingenuity can devise. Perhaps you can get some of the pure phosphorus to use, the kind that comes in yellow sticks and which must be kept under water to save it from burning up; or perhaps you can get a pinch of the so-called "red" phosphorus, a dark brownish-red powder, which is real phosphorus baked in a close vessel until it goes temporarily into this curious, sleepy form where it does not have to be kept under water to save it from burning; perhaps you can get some of this, to put in your little dish; but, whatever you do use, make it burn and make it take out all of the active oxygen from the air that it will, about one-fifth by volume at any rate. Usually you will get a larger apparent absorption, due to the aforesaid escape of some bubbles by heating.

You must keep your eye fixed on the several points: The good burning; the closing-in of the little saucer by the inverting of the jar; the absorption of part of the air in the jar and the testing of the remaining air; the testing of the water in the bottom of the jar. It all makes a part of the story of the composition of the air, but you will wonder how our friend limewater can help us out here. Well, that is an interesting question; and, in this chapter, we can only begin to show how limewater may have a great deal to do with the problems of burning.

Your thoughts will run somewhat as follows: It is all right to test such things as sulphur and phosphorus and match ends; but common coal is the thing which makes the bulk of fuel burnt, and we want to see what the air does to that, and how it does it.

The point which we are going to study is this: that coal burns first to carbon monoxide, CO, and this burns farther to carbon dioxide, your friend carbonic-acid gas, CO_2, or carbonic anhydride, the anhydride of true carbonic acid proper, H_2CO_3. Now the acids of phosphorus and sulphur and those strong-smelling things made from burning in the air, are readily absorbed by water; and they readily turn litmus red. But carbonic-acid gas is only feebly absorbed by water: it has not much taste and it does not act strongly on litmus; and so we are up against the question of trying to prove that when coal, or carbon, burns in the air, it does make its own form of acid, or acid anhydride, just as sulphur and phosphorus make theirs. You can begin to see how we are going to do this with the help of limewater; for you have already sucked the gases from glowing coal through some limewater, and you are fairly familiar with the acid properties of the gas from burning coal. But that special point will wait for another lesson: we want to get this point clinched, of the approximate amount of active "burn helper," oxygen, in the air.

There are one or two questions which may come up to your mind at this time.

One of them is this: What would happen if the air were pure oxygen? That is an interesting question, and you will make some experiments later with pure oxygen to show what would happen. But there are two forms to that question. One form is, what would happen if the nitrogen were taken out from the air and only the oxygen were left? That is one thing, but it would be quite another affair if the nitrogen were taken out from the air, and if its place were taken by so much more oxygen, that would be a condition of frightful possibilities, as you will see when you come to make pure oxygen.

One more question that I want you to think over between now and the reading of the next lesson is this: Why do you have to *light* a fire? Why doesn't it light itself? There is the fuel, there is the air, which you cannot see, but which you can feel, and it is waiting to take hold of your coal. But why does it wait until you kindle it, with all sorts of coaxing, from the match, through the shavings or paper, through the kindling wood, to the hard fuel; why all this preparation for what seems all ready to take place of and by itself? This question is worth some attention, the right answer will open your eyes to some things which no one can see, but which we must all believe to be true; it is the story of the chemical units, noted by those initial letters, and the groups into which those chemical units unite, groups which make up all kinds of material things which you see and feel every day. You are getting near the top of one of the foothills of science, and one of these days you will see the main range, and you can see all this from the window of your boiler room.

Credit for Low Pressure Turbines

In the February 2 number, page 241, L. Battu gives the credit of the conception and working out of the low-pressure turbine to Professor Rateau, mentioning J. W. Kirkland in a very complimentary way, but entirely ignoring W. L. R. Emmet, who at the International Electrical Congress, at St. Louis, in September, 1904, only a few months after Professor Rateau had presented at the Chicago meeting of the American Society of Mechanical Engineers the paper to which Mr. Battu refers, presented a paper containing the following, which shows that he had at that time a comprehensive idea of the advantages of the steam turbine for low pressure work:

Portion of Paper Read in St. Louis, in September, 1904, at a Meeting of the International Electrical Congress

Since, as has been stated, the best steam turbines so far developed give degrees of economy about equal to those of the best steam engines, and since the turbine, as explained, works in a larger field of available energy, it may naturally be inferred that the steam engine within its own range of action is more efficient than the steam turbine, and that to a certain extent is true. This fact naturally suggests a combination which undoubtedly has a large field of application, namely, the use of low-pressure steam turbines taking exhaust steam from existing reciprocating engines. It is probable that such combinations will only be a phase of the steam-turbine development, since it is highly probable that efficiencies as high as the best steam-engine efficiencies will soon be attained by turbines under all ranges of pressure and that it will become desirable for many economic reasons to discard reciprocating engines altogether.

The most advantageous conditions for the combined use of reciprocating engines and steam turbines will be found in existing steam plants where reciprocating engines are used to operate electric generators separately or in parallel. In such plants low pressure steam turbines can be installed and can be arranged to take steam directly from the exhaust pipe of engines without valves or governing mechanism. The turbines would be designed to give a very high efficiency with highly expanded steam and a condensing plant should be installed adapted to the highest degree of vacuum. The low-pressure valve stems and rod packings of the engines should be sealed with steam and other provisions should be made for the exclusion of air. The steam turbine should operate a generator adapted to connection in parallel with that driven by the engine.

A turbine designed for operation under these conditions would be an ideally simple affair and its maintenance and care would add little or nothing to the cost of station operation. There are many large stations in which the introduction of such turbines with proper condensing facilities would increase the output as much as 30 per cent., without any increase of the fuel consumption or change in the boiler plant. There are probably very few stations operated with reciprocating engines where the introduction in this manner of properly designed turbines would not increase the output as much as 20 per cent. In one case recently considered, 25 per cent. could be added to the output of the station without diminishing at all the work being done by the engines, that is, such an amount of work could be obtained with degrees of vacuum pressure entirely below those from which the engines are capable of deriving any benefit.

In such cases it would generally be desirable to design the turbine that under full load conditions it would take steam at a pressure of about 8 pounds absolute, corresponding approximately to the exhaust point in the low-pressure cylinder of the engine. The engine would then handle all the power which it could handle with maximum efficiency, and its own output would be only slightly reduced. The turbine would handle the power to which the engine was not well adapted. Under conditions of light load some economy might be effected by changing the cutoff conditions on the engine, but it would probably be better to leave all the conditions fixed and to allow the pressure on the turbine to vary as the load changed.

Such low pressure turbines would occupy a small space and there are probably few existing engine plants in which room could not be provided for their installation. The cost of installing such turbines with complete condensing facilities should not exceed $30 per kilowatt of capacity added to the station. This in itself is a small expenditure for an additional plant, even if we do not consider the fact that the use of this additional plant does not call for any increase in fuel consumption or in steam-generating apparatus.

The following table shows the approximate increase of output which can be obtained by using a low-pressure turbine with good vacuum worked in series with a good Corliss engine over that which could be obtained from the engine alone when used with the best vacuum. The engine considered would consume with atmospheric exhaust 18 pounds per indicated horsepower, and with a vacuum of 27 inches or better 14.7 pounds per indicated horsepower. In the turbine an efficiency is assumed which is justified by actual experiments, and which can easily be obtained in a simple machine of this kind.

Pressure of Steam Entering Engine, [illegible] Inches of Vacuum.	Per Cent. Gain Over Output of Engine When Worked with High Vacuum; The Turbine Exhausting to a Vacuum of 28 Inches.
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

These figures show an important possibility which should be realized in many existing plants, and they also illustrate forcibly the value of good vacuum in turbine work, since it shows the large amount of work available in these low pressure ranges by the use of turbines.

One square foot of heating surface is needed in a boiler for every 200 cubic feet of space in a church or hall. In a dwelling house, every 100 cubic feet of space requires 1 square foot of heating surface. Radiators should have 1 square foot of superficial area to every 8 square feet of glass in windows and 1 square foot for every 80 cubic feet of space to be heated. One horsepower in a boiler is generally sufficient for [illegible]

Safety Valves

The Mechanical Engineers Devote an Evening to Their Discussion; Lift as a Factor of Valve Capacity, and as Experimentally Determined

The February meeting of the American Society of Mechanical Engineers was devoted to the consideration of safety valves. Frederic M. Whyte, General Mechanical Engineer of the New York Central lines, introduced the subject, speaking particularly of the safety valve as related to locomotive boilers:

Frederic M. Whyte

The general practice in locomotive work has been to determine the size and number of valves to be used in an offhand way, and former practice has guided these determinations entirely. The capacity is indicated in an indifferent way expressed as a "size" referring to the diameter of something more or less certain, while the other dimension, the lift, which is necessary to give an indication of the capacity, is entirely ignored.

It will be comparatively easy to determine the capacities of valves, if the elaborate tests which have been already made, data from which will be presented in this discussion, have not already solved this part of the problem. More difficulty will be experienced in determining the quantity of steam to be discharged and the rate of release. Instead of indicating the capacity of the valve in a very rough way by the diameter of some opening, the method should be adopted of expressing the capacity in pounds of steam which the valve is capable of delivering at certain pressures. The capacity of the muffler need not be questioned except in extreme designs, but the indicated capacity should be that of the valve complete, with or without muffler according to the intended use of the valve.

In any kind of generating plant it ought to be quite sufficient if those immediately responsible for the quantity of steam produced know what is available. In stationary and marine work this is generally true and steam gages can be placed within view of those who should know what the pressure is at any time. Unfortunately, in locomotive work it has become perhaps desirable that others than those within view of the gage of the cab know something about the steam pressure, and inasmuch as the fireman is willing and sometimes anxious that they should know, he takes the only means at hand to inform them when he thinks that the results of his labors are good, and fires "against the pop" so that everybody within hearing or sight of the valve knows by the escaping steam that the fireman is doing his duty.

Assuming that such an indication of steaming conditions has grown to be a necessity, how can it be produced at the least expense? Two devices at least are available, the simmering valve, which will open slightly for two or three pounds about the normal maximum and then open full, just reversing this in seating, and the small pilot valve, which will open at two or three pounds pressure below the working valve. For the simmering valve, a seat must be used which will not cut under the wiredrawing action of the steam.

In locomotive practice it is not necessary that the valve capacity shall be equal to the maximum steaming capacity of the boilers, because the maximum steaming capacity is only at a time when steam is being used through the cylinders or blower to make the draft. Having fixed upon the per cent. of the generating capacity to be provided for in the valve, it will be necessary to determine the desirable unit capacity of the valves. Some States require that each locomotive boiler shall have at least two valves. Maintenance considerations indicate that these should be duplicates and therefore each has a capacity equal to one-half the required discharge capacity. If a number of boilers of different capacities are to be considered then the smaller ones will probably be provided with the same valves as the larger ones, for the purpose of duplication. There are some large boilers for which three valves may be necessary because the necessary capacity in two units might make the valves abnormally large for construction purposes. It is worth while also to consider whether undesirable results would come about from opening almost instantaneously an escape of steam from the boiler to the atmosphere. No suggestions are offered on this, but it is hoped that something bearing on the subject may be developed in the discussion.

L. D. Lovekin,

Chief Engineer of the New York Shipbuilding Company, said in part:

During 1903 I was asked to look into the rules and regulations as prescribed by the Board of Supervising Inspectors of the United States Steamboat Inspection Service concerning safety valves. This rule was established on grate surface without regard to the amount of coal burned thereon in a given time.

The rule as originally made served its purpose without trouble, but it must be remembered that this rule was made when such things as forced draft were almost unknown. Having in view the difference in the amount of coal now burned per square foot of grate surface, I prepared a new rule based on the well-known formula of Napier for the flow of steam through an orifice. The derivation of the formula is shown on page 473.

It will be noted that in preparing this work, the lift was based on 1/32 of the diameter of the valves, and while I consider this to be within good practical limits, I have found a number of safety-valve manufacturers who differ with me in regard to the lift. There is one thing certain, however, that whether the valve is restricted to 1/32 of its diameter or not, the net area of the opening should in my mind be at least equal to the tabled result indicated by the formula referred to.

I am not in favor of what might be termed an excessive lift of valve, such as one-fourth of the diameter, although some of our best recognized authorities in connection with the inspection of steamships still adhere to that list, the British Board of Trade being one of the foremost in this connection.

Unfortunately, when I presented the formula and table of safety valves to the board of supervising inspectors of steam vessels, they failed to state in their rules and regulations that the sizes of these valves were based upon the lift of the valve being equal to 1/32 of its diameter, and consequently left out a most important element. Under the rules of the board as they now exist in their printed forms it is quite possible to have a valve of the proper size in inches by said rules and yet be far below the actual requirements.

Having settled upon the proper diameter of a safety valve according to the formula, it will be evident that the clear area between the valve and its seat, due to having a lift equal to 1/32 of its diameter, is only about 1/11 of the area of the nominal diameter found by the formula. Therefore, it would seem that the inlet from the boiler to the safety valve should be equal in area only to the free area between the safety valve and its seat. This would reduce the opening in the boiler to about 1/11 of the area used at the present time.

Experiments in this line, however, have shown that a free entrance from the boiler to the safety valve is absolutely necessary to prevent chattering. Just exactly what relation this is I have not determined; in fact, it would depend entirely on the length of the nozzle or pipe connecting the safety valve to the boiler. In most cases safety valves are bolted either directly to the boiler or to a casting bolted directly to the boiler and which forms a seat for both the safety and stop valves, so that there would be very little to gain in reducing the inlet nozzle to a safety valve.

While dealing with the inlet side of a safety valve, I think it might be proper to bring out a feature seldom if ever discussed in connection with safety valves,

DERIVATION OF THE UNITED STATES BOARD OF SUPERVISING INSPECTORS' RULE FOR AREAS OF SAFETY VALVES

Napier's Rule for flow of steam through orifices.

Flow in pounds per second =

$$\frac{\textit{Absolute pressure} \times \textit{area}}{70}$$

(This corroborated by Peabody's experiments.)

P = Absolute pressure = gage pressure + 15
W = Pounds discharged per hour
A = Area of valve opening or orifice

Hence

$$W = \frac{P \times A}{70} \times 60 \times 60 = \frac{360 \times A \times P}{7}$$

For safety valve practice, cut this amount down 25 per cent., leaving 75 per cent.

Thus

$$W = 0.75 \times \frac{360}{7} \times A \times P = \frac{270 \times A \times P}{7}$$

Restrict the lift of valve to $\frac{1}{32}$ of its diameter = $\frac{d}{32}$

then

$$A = \frac{d}{32} \times \pi \times d = \textit{lift} \times \textit{circumference} = \frac{\pi \times d^2}{32}$$

Substituting this value for A as area of orifice

$$W = \frac{270}{7} \times P \times \frac{\pi d^2}{32}.$$

In a valve of diameter d the area =

$$\frac{\pi d^2}{4} = a.$$

To get W in terms of area of valve, substitute for d^2 its value in terms of a

$$d^2 = \frac{4a}{\pi}$$

$$W = \frac{270}{7} \times P \times \frac{\pi}{32} \times \frac{4a}{\pi} = 4.82 \times P \times a$$

In which value position W will represent the pounds of steam that must escape per hour, which must be equal to the pounds of water that the boiler can evaporate per hour.

To reduce this to a working basis consider these quantities per square foot of grate surface per hour.

W = Pounds of water evaporated per square foot of grate surface per hour.

P = Absolute pressure per square inch.

A = Area of safety valve per square foot of grate surface.

Hence

$W = 4.82 \times P \times a$, and $a = [illegible] \times \frac{W}{P}$.

From which a table of areas required per square foot of grate surface may be found by assuming the different values of W and P.

and that is the placing of safety valves upon the outlet end of dry pipes in boilers. These dry pipes, as is well known, usually consist of a pipe running along the upper part of a boiler and having slots cut into it so as to give an area equal to the full area of the pipe. In some cases which have come under my notice I have found the steam pressure within the boiler itself to be 200 pounds per square inch, while that of the outlet of the pipe was only 180 pounds, a drop of 20 pounds of pressure taking place due to wiredrawing the steam through the slots in the dry pipe. I have known of other cases where we have had 200 pounds of boiler pressure in connection with water-tube boilers and have purposely restricted the flow of steam through the dry pipe so as to cause a reduction in pressure of 10 pounds and thus obtain a slight degree of superheat. In this case, however, the valves were applied to the boiler drum and not to the dry pipe.

Some rules insist on the outlet area being equivalent to the full bore of the safety valve. This appears both unnecessary and unreasonable, for if we have only 1/11 of the area for the steam to pass through at the valve seat, we certainly do not require the full area in the outlet to pass on to the atmosphere. I would suggest that the area at the outlet from a safety valve should be equal to one-half the nominal area of the valve itself.

In the test on the United States cruiser "Tennessee," where we tried this scheme, we [illegible] with capped outlets [illegible] with one of the connecting ends [illegible] valves without [illegible] and although the steam pressure went up 20 pounds above the popping point, no trouble was experienced as a result of this outlet stoppage, thus proving beyond doubt that a combined area of outlet equal to one-half of the area of the safety valve, which is the way in which most of the United States battleships are equipped, is sufficient to prevent an excess of accumulation of pressure.

Philip G. Darling.

Mechanical Engineer of Manning, Maxwell and Moore, submitted a paper on "Safety Valve Capacity," the purpose of which is to show an apparatus and method devised to determine safety valve lifts, giving the results of tests made with this apparatus upon different valves, to compare a few of the existing rules or formulas governing valve size and to propose a rule giving the weight of a series of discharge of steam [illegible] based on experiments [illegible] special requirements, and results as indicate its general bearing upon valve requirements.

Two factors have mainly had a prominent part [illegible] determining the area of discharge and hence the relieving capacity; the diameter of the inlet opening at the seat and the valve lift. The former is the nominal valve size, the latter is the amount the valve disk lifts vertically from the seat when in action. In calculating the sizes of valves to be placed on boilers, rules which do not include a term for this valve lift, or an equivalent, such as a term for the *effective* area of discharge, assume in their derivation a lift for each size of valve. Nearly all existing rules and formulas are of this kind which rate all valves of a given nominal size as of the same capacity.

To find what lifts valves of standard make actually have in practice, and thus test the truth or error of this assumption that they are approximately the same for valves of the same size, an apparatus has been devised and tests upon different makes of valves conducted. With this apparatus not only can the valve lift be read at any moment to one-thousandth of an inch, but an exact permanent record of the lift during the blowing of the valve is obtained somewhat similar to a steam-engine indicator diagram in appearance and of a quite similar use and value in analyzing the action of the valve. See Fig. 1.

As appears in Figs. 2 and 3, the valve under test is mounted upon the boiler in the regular manner, and a small rod is tapped into the top end of its spindle, which rod connects the lifting parts of the valve directly with a circular micrometer gage, the reading hand of which indicates the lift upon a large circular scale or dial. The rod through this gage case is solid, maintaining a direct connection to the pencil movement of the recording gage above. This is a modified Edson recording gage with a multiplication in the pencil movement of about 8 to 1 and, with the chart drum driven by an electric motor, giving a horizontal time element to the record. The steam pressures are noted and read from a large test gage graduated in pounds per square inch, and an electric-spark device makes it possible to spot the chart at any moment, which is done as the different even pound pressures during the blowing of the valve are reached. The actual lift equivalents of the pencil hights upon the chart are carefully calibrated so that the record may be accurately measured to thousandths of an inch.

In testing, the motor driving the paper drum is started and the pressure in the boiler raised. The valve being mounted directly upon the boiler, then pops, blows down and closes under the exact conditions of service, the pencil recording on the chart the history of its action.

With this apparatus, investigations and tests were started upon seven different makes of 4-inch stationary safety valve and these tests were followed with similar ones upon nine makes of muffler locomotive valve, six of which were 3½-inch

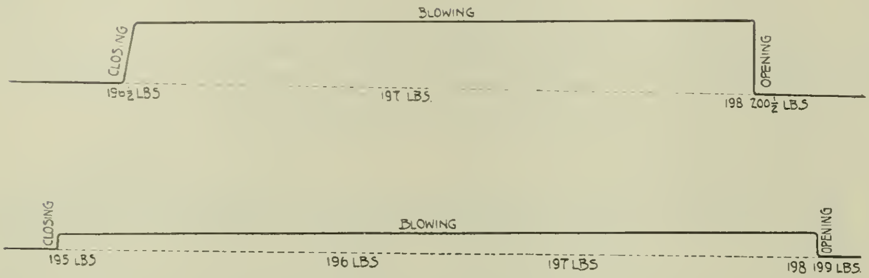


FIG. 1. TYPICAL HIGH- AND LOW-LIFT SAFETY-VALVE DIAGRAMS

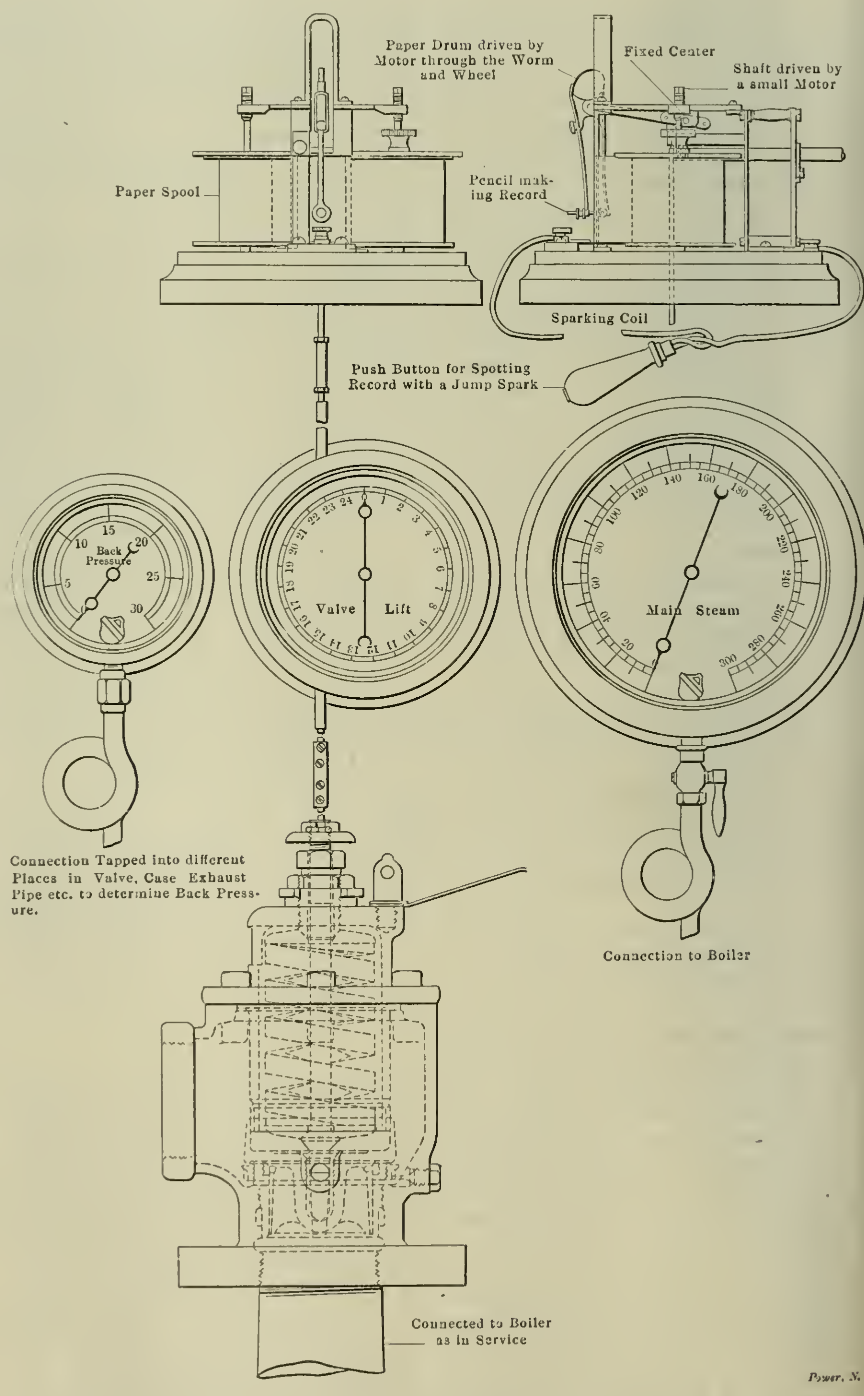


FIG. 2. OUTLINE DRAWING OF THE SAFETY-VALVE TESTING APPARATUS

l of the valves being designed for and sted at 200 pounds. The stationary-alve tests were made upon a 94 horse-ower water-tube boiler made by the abcock & Wilcox Company. The loco-otive-valve tests were made upon loco-otive No. 800 of the Illinois Central ailroad, the valve being mounted di-ectly upon the top of the main steam ome. This locomotive is a consolida-on type, having 50 square feet of grate rea and 2953 square feet of heating sur-

The results of the 4-inch iron-body stationary valve tests summarized are as follows: Of the seven valves the average lift at opening was 0.079-inch and at closing 0.044-inch, or, excluding the valve with the highest lifts, the averages were 0.07-inch at opening and 0.037-inch at closing. The valve with the lowest lifts had 0.031-inch at opening and 0.017-inch at closing, while that with the highest had 0.137-inch and 0.088-inch. Expressing the opening lifts as percentages of the

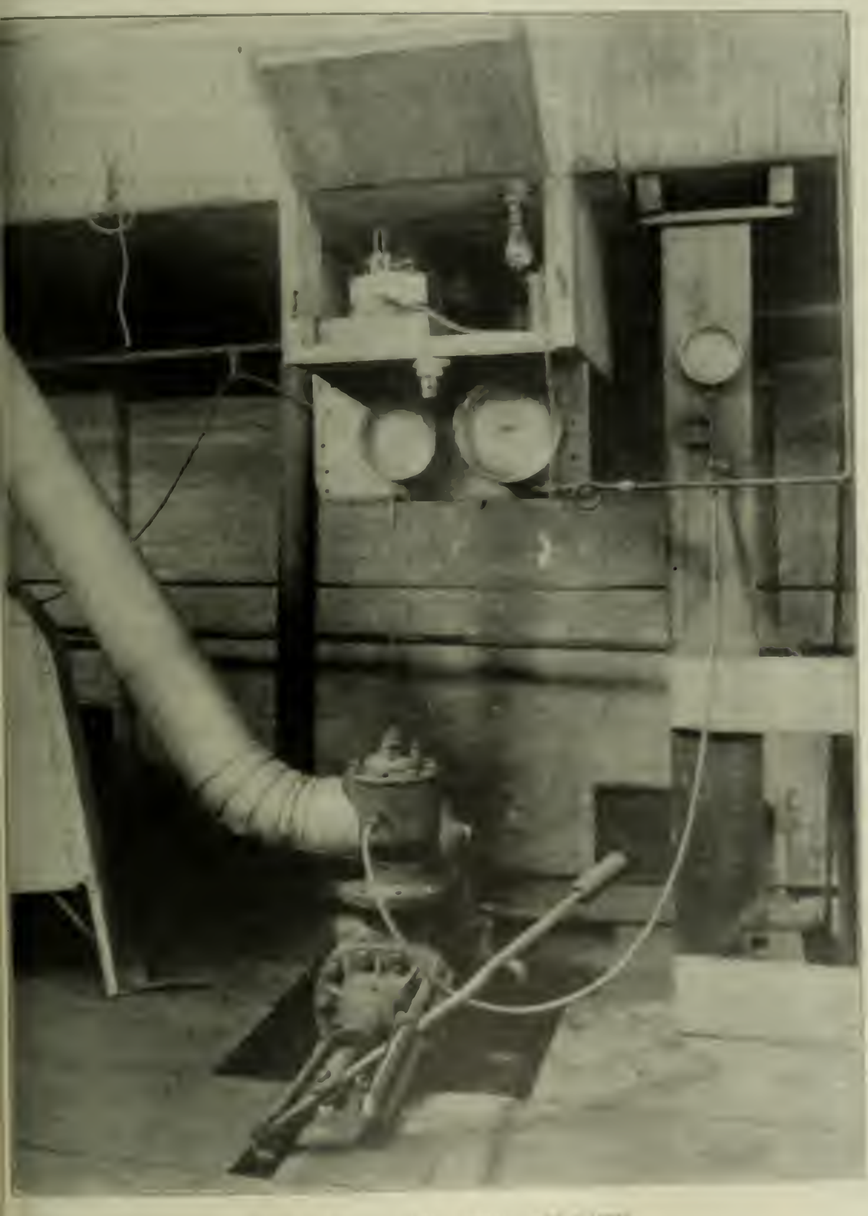


FIG. 3. PHOTOGRAPH OF THE APPARATUS

face. Although a great amount of additional experimenting has been done, only the results of the foregoing will be quoted in this paper. These lift records show (with the exception of a small preliminary simmer which some of the valves have) an abrupt opening to full lift and an almost equally abrupt closing when a certain lower lift is reached. Both the opening and closing lifts are significant of the action of the valves.

highest, the lowest had [illegible] per cent., the next larger [illegible] per cent., and the next [illegible] per cent. Of the [illegible]-inch [illegible] locomotive valves the summarized [illegible] are as follows: Average of the [illegible] valves [illegible]-inch at opening and [illegible]-inch at closing. Average, excluding the highest, [illegible]-inch at opening and [illegible]-inch at closing. The lowest lift valve had [illegible] inch opening and [illegible]-inch closing, the highest [illegible] [illegible] [illegible]

closing. As percentages of the highest the lowest lift valve was 36.4 per cent., the next larger 30.8 per cent., and the next 36.4 per cent.

The great variation—300 per cent.—in the lifts of these standard valves of the same size is startling and its real significance is apparent when it is realized that under existing official safety-valve rules these valves, some of them with less than one-third the lift and capacity of others, receive the same rating and are listed as of equal relieving value.

[After explaining the rule of the board of supervising inspectors, the derivation of which is explained in Mr. Lowden's remarks, Mr. Darling says:]

In the valves to which this rule is applied the following lifts are assumed to exist: 1-inch valve, 0.03; 2-inch valve, 0.06-inch; 3-inch valve, 0.09-inch; 4-inch valve, 0.13-inch; 5-inch valve, 0.15-inch; 6-inch valve, 0.19-inch.

Referring back to the valve lifts found by test, it is seen that the highest lift agrees very closely with the lift assumed in the rule and if the valve lifts of the different designs were more uniformly of this value or if the rule expressly stipulated either that the lift of 1/32 of the valve diameter actually obtains in valves qualifying under it or that an equivalent discharge area be obtained by the use of larger valves, the rule would apply satisfactorily to that size of valve. However, the lowest-lift valve actually has but ¼, the next larger less than ½ and the average lift of all but the highest-lift valve, which average is 0.07-inch, is but 50 per cent. of the lift assumed in the rule for these 4-inch valves.

Massachusetts Rule of 1909

$$A = \frac{W \times 70}{P} \times 11,$$

where

A = Total area of safety valve or valves in square inches.

W = Pounds of water evaporated per square foot of grate surface per second.

P = Boiler pressure (absolute).

One of the most recently issued rules is that contained in the pamphlet of the new Massachusetts Board of Boiler Rules, issued March 22, 1908. This rule is merely the United States rule given herewith with a [illegible] per cent. larger constant and therefore requiring that amount larger valves. The evaporation term is expressed in pounds per second instead of per hour, and the constants are given instead of [illegible] [illegible] when reduced to the form of the United States rule it gives:

$$A = 0.2074 \, W \, \frac{W}{P}$$

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the United States rule [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] done, shows that this rule assumes a valve lift of 1/33 of the valve diameter instead of 1/32 of the United States rule. This changing of the assumed lift from 1/32 to 1/33 of the valve diameter being the only difference between the two rules, the inadequacy of the United States rule just referred to applies to this more recent rule of the Massachusetts Board.

Philadelphia Rule:

$$A = \frac{22.5\,G}{P \times 8.62},$$

where

A = Area of safety valve in square inches per square foot of grate,
G = Grate area in square feet,
P = Boiler pressure (gage).

The Philadelphia rule now in use came from France in 1868, being the official rule there at that time, and was adopted and recommended to the City of Philadelphia by a specially appointed committee of the Franklin Institute; although this committee frankly acknowledged in its report that it "had not found the reasoning upon which the rule had been based." The area A of this rule is the effective valve opening, or, as stated in the Philadelphia ordinance of July 13, 1868, "the least sectional area for the discharge of steam." Consequently, if this rule were to be applied as its derivation by the French requires, the lift of the valve must be known and considered whenever it is used. However, the example of its application given in the ordinance, as well as that given in the original report of the Franklin Institute committee which recommended it, show the area A applied to the nominal valve opening. In the light of its derivation this method of using it takes as the effective discharge area the valve opening itself, the error of which is very great. Such use, as specifically stated in the report of the committee referred to, assumes a valve lift at least ¼ of the valve diameter, i.e., the practically impossible lift of 1-inch in a 4-inch valve.

The principal defect of these rules in the light of the preceding tests is that they assume that valves of the same nominal size have the same capacity and they rate them the same without distinction in spite of the fact that *in actual practice some have but one-third of the capacity of the others*. There are other defects as have been shown, such as varying the assumed lift as the valve diameter, while in reality with a given design the lifts are more nearly the same in the different sizes, not varying nearly as rapidly as the diameters. And further than this, the actual lifts assumed for the larger valves are nearly double the actual average obtained in practice.

The elements of a better rule for determining safety-valve size exist in Napier's formula for the flow of steam, combined with the actual discharge area of the valve as determined by its lift. In "Steam Boilers," by Peabody and Miller, this method of determining the discharge of a safety valve is used. The uncertainty of the coefficient of flow, that is, of the constant to be used in Napier's formula when applied to the irregular steam discharge passages of safety valves has probably been largely responsible for the fact that this method of obtaining valve capacities

SAFETY VALVE CAPACITY TESTS.

Run at the Stirling Works of the Babcock and Wilcox Co., Barberton, Ohio, Nov. 30, to Dec. 23, 1908.

Test Number.	Duration of Test.	Size and Type of Valve.	Adjustment Remarks.	Valve Lift.	Pressure.	Superheat.	Discharge per Hour.	Discharge Area. Note No. 1.	Remarks.
	Hours.			Inch.	Lb. per Sq.In.	Deg. F.	Lb. of Steam.	Sq.In.	
6	3	4″ R.F. iron stationary	Regular Adj., Exh. piped	0.0695	151.7	43.6	5,120	0.6226	No back pressure.
7	3	4″ R.F. iron stationary	Regular Adj., Exh. piped	0.139	145.4	45.1	8,600	1.255	Back pressure 2 lb.
8	3	4″ R.F. iron stationary	Regular Adj., Exh. piped	0.180	135.7	49.2	11,020	1.704	Back pres. 3 lb., max. pres.; lift > depth of seat.
9	3	4″ R.F. iron stationary	Regular Adj., Exh. piped	0.1045	149.4	41.9	7,290	0.9400	Back pressure 1 lb.
10	2½	3½″ locomotive. Form B	Regular Adj., without muffler	0.140	146.7	39.0	8,685	1.109	Tests 10-12 inclusive with an open locomotive valve.
11	3	3½″ locomotive. Form B	Regular Adj., without muffler	0.070	152.5	38.0	4,670	0.5493	
12	3	3½″ locomotive. Form B	Regular Adj., without muffler	0.105	150.3	41.2	6,780	0.8280	
13	3	3½″ locomotive. Form B	Regular Adj., with muffler	0.1395	146.3	38.1	8,400	1.106	Muffler valve in this following locomotive tests.
14	2	3½″ locomotive. Form B	Regular Adj., with muffler	0.140	52.2	51.3	3,620	1.109	Test at low steam pressure.
15	2½	Same, except with lipped feather	Regular Adj., with muffler	0.140	146.4	39.0	8,600	1.109	Different type of valve disk.
16	3	4″ R.F. iron stationary	Regular Adj., Exh. piped	0.140	138.5	42.3	8,770	1.265	No back pressure, repetition of test No. 7.
17	3	4″ R.F. iron stationary	Adj. ring one turn. 1/16″ above Reg. Posi.	0.140	142.0	50.1	8,900	1.265	Back pressure 3 lb., adj. ring position changed.
18	2	1½″ locomotive. Form B	Regular Adj., with muffler	0.107	140.8	23.0	2,515	0.4272	Tests 18-21 inclusive. Unsatisfactory as the valve was too small for the boiler used.
19	1	1½″ locomotive. Form B	Regular Adj., with muffler	0.060	151.2	None	1,550	0.2038	
20	2½	1½″ locomotive. Form B	Regular Adj., with muffler	0.075	146.3	None	2,025	0.2560	
21	2½	1½″ locomotive. Form B	Regular Adj., with muffler	0.075	147.7	None	1,975	0.2560	
22	1½	3½″ R.F. iron stationary	Regular Adj., Exh. piped	0.070	146.8	42.6	4,320	0.5493	No back pressure.
23	3	3½″ R.F. iron stationary	Regular Adj., Exh. piped	0.140	139.9	43.6	8,360	1.136	No back pres., lift > depth of seat.
24	3	3½″ R.F. iron stationary	Regular Adj., Exh. piped	0.105	141.6	48.7	6,300	0.8280	Tests 24-27 inclusive. No back pressure.
25	3	3″ R.F. iron stationary	Regular Adj., Exh. piped	0 130	140.1	48.4	6,370	0.8846	
26	3	3″ R.F. iron stationary	Regular Adj., Exh. piped	0.100	142.8	15.6	5,160	0.6770	
27	2	3″ R.F. iron stationary	Regular Adj., Exh. piped	0.070	142.4	29.5	3,705	0.4716	
28	3	3″ locomotive. Form B	Regular Adj., with muffler	0.130	138.4	48.7	7,060	0.8846	
29	3	3″ locomotive. Form B	Regular Adj., with muffler	0.090	139.3	43 9	4,950	0.6034	

Note No. 1.—The valves all having 45° bevel seats, these areas are obtained from formula: $a = 2.22 \times D \times l + 1.11 \times l^2$ except where as in tests Nos. 8, 18, 23, 25, the valve lift is greater than the depth of the valve seat, where the following formula is used: $a = 2.22 \times D \times d + 1.11 \times d^2 + \pi \times D \times (l - d)$. a = discharge area (sq.in.). D = valve dia. (in.). l = valve lift (in.). d = depth of valve seat (in.).

Note No. 2.—The four wings of the valve feather or disk probably reduce the flow slightly, but as these are cut away at the seat a definite correction of the exit areas for them is impossible. Further, the formula constants are desired for the valves as made.

has not been more generally used. To determine what this constant or coefficient of flow is and how it is affected by variations in valve design and adjustment, an extended series of tests have recently been conducted at the Stirling department of the Babcock & Wilcox Company, at Barberton, Ohio.

A 373-horsepower class K No. 20 Stirling boiler, fired with a Stirling chain grate, with a total grate area of 101 square feet, was used. This boiler contained a U-type of superheater designed for a superheat of 50 degrees Fahrenheit.

The valves tested consisted of a 3-, 3½- and a 4-inch iron stationary valve, and a 1½-, 3- and 3½-inch locomotive valve, the latter with and without mufflers. These six valves were all previously tested and adjusted on steam. Without changing the position of the valve disk and ring the springs of these valves were then removed and solid spindles, threaded (with a 10-pitch thread), inserted through the valve casing above. Upon the top ends of these spindles were placed handwheels graduated with 100 divisions, shown in Fig. 4 as applied to the locomotive valves, the spindle and graduated wheel being similar to that used with the stationary valves. By this means the valve lift to thousandths of an inch was definitely set for each test and the necessity for constant valve-lift readings with that source of error eliminated. In all 29 tests were run, fifteen were 3 hours long, four 2½ hours, three 2 hours and seven of shorter duration.

Tests numbered 1 to 5 were preliminary runs of but one hour or less apiece, and the records of them are thus omitted in the accompanying table which gives the lifts, discharge areas, average pressure and superheat, and the steam discharge in pounds per hour of each of the other tests. The discharge areas have been figured for 45-degree seats from the formula

$$a = 2.22 \times d \times L + 1.11 \times L^2,$$

where a equals the effective area in square inches, d the valve diameter in inches and L the valve lift in inches.

In tests 8 and 21, where the width of valve seat was 0.225-inch and 0.185-inch, respectively, and the valve was thus slightly above the depth of the valve seat the area was figured for this condition.

As previously stated the application of these results is in fixing a constant for the flow of Napier's formula as applied to safety valves. This formula (given in the derivation of the board of supervising inspectors' rule) may be stated as

$$E = C \times a \times P,$$

in which E equals the pounds of steam discharged per hour and C is a constant; E, a and P being given for the tests, C is directly obtainable.

Figuring and plotting the values of this constant indicates the following conclusions:

(1) Increasing or altering the steam pressure from approximately 95 to 150 pounds per square inch (tests 14 and 20) does not affect the constant, this merely checking the applicability of Napier's formula in that respect.

(2) Radically changing the shape of the valve disk outside of the seat at the huddling or throttling chamber, so-called, does not affect the constant or discharge. In test No. 15 the valve had a downward projecting lip, resulting in deflecting the steam flow through nearly 90 degrees, yet the discharge was practically the same as in tests 10 and 14, where the lip was cut entirely away, as in Fig. 4, giving a comparatively unobstructed flow to the discharging steam.

(3) Moving the valve-adjusting ring

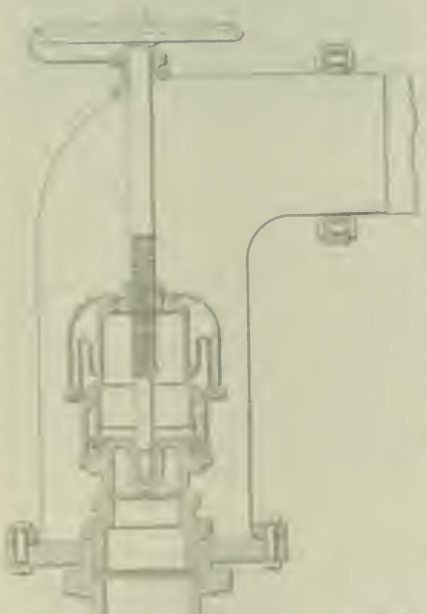


FIG. 4. VALVE DEVICES

through much more than its complete adjustment range does not affect the constant or discharge (tests 16 and 17).

(4) The addition of the muffler to a locomotive valve does not materially alter the constant of discharge. There is less than 2 per cent. difference between tests 10 and 13.

(5) Disregarding the rather unsatisfactory 1½-inch and 3-inch locomotive valve tests, the different sizes of valves tested show a variation in the constant when plotted to given lifts of about 3 per cent.

(6) There is a slight uniform decrease of the constant when increasing the valve lifts.

The variations indicated in the last two conditions are not large enough, however, materially to impair the value of a single constant obtained by averaging the constants of all the tests from those given. The selection of such a constant is necessary to correct with the other [illegible] conditions mentioned. The average constant is 47.5, giving as the formula

$$E = 47.5 \times a \times P.$$

The theoretical value for the constant of Napier's formula is 51.4, of which the above is 92½ per cent.

To make this formula more generally serviceable, it should be expressed in terms of the valve diameter and lift, and can be still further simplified in its application by expressing the area E (steam discharged or boiler evaporation per hour) in terms of the boiler heating surface or grate area. For the flat seated [illegible] 45-degree seats the effective discharge area is, with a slight approximation,

$$a = L \times \cos 45 \times \pi \times D,$$

in which L equals the valve lift, vertically, in inches and D the valve diameter in inches. Substituting this in the foregoing formula gives

$$E = 47.5 \times L \times \cos 45 \times \pi \times D \times P$$

or

$$E = 105.5 \times L \times D \times P.$$

The slight mathematical approximation referred to consists in multiplying the $L \times \cos 45$ by $\pi \times D$ instead of by the exact value $\pi \times D$ [illegible] L. To find directly the effect of this approximation upon the constant, the values for E, L, D and P from the tests have been substituted in the formula and the average constant redetermined, which is 105.1. The average lift of all the tests is 0.110-inch. Plotting the constants obtained from the formula in each test, as ordinates, to valve lifts as abscissas, allowing for the slight inclination referred to in condition (6), and plotting a line with this inclination through the obtained average constant, 105.1, shown at the 0.110 average lift, gives a line which at a maximum lift of 0.1-inch gives a constant of about 106. At lower lifts this is slightly larger. Therefore, 106 would seem to be the conservative figure to adopt as a constant in this formula for general use, giving

$$E = 106 \times L \times D \times P.$$

This transposed for D gives:

$$D = 0.00943 \times \frac{E}{L \times P}.$$

[illegible]

[illegible]

exists, place these constants on the safe side. The capacities of the stationary and locomotive valves, the lift-test results of which are summarized in the foregoing, have been figured from this formula, taking the valve lifts at opening and in pounds of steam per hour, and are as follows:

Of the seven 4-inch iron-body stationary valves, the average capacity at 200 pounds pressure is 7370 pounds per hour, the smallest capacity valve (figured for a flat seat) has a capacity of 3960 pounds, the largest 12,400 pounds; and of the six 3½-inch muffler locomotive valves at 200 pounds pressure, the average capacity is 6060 pounds per hour, the smallest 4020 pounds, the largest 11,050 pounds.

To make the use of the rule more direct where the evaporation of the boiler is only indirectly known it may be expressed in terms of the boiler-heating surface or grate area. This modification consists merely in substituting for the term E (pounds of total evaporation per hour) a term H (square feet of total heating surface) multiplied by pounds of water per square foot of heating surface per hour which the boiler will evaporate. Evidently the value of these modified forms of the formula depends upon the proper selection of average boiler evaporation figures for different types of boiler and also upon the possibility of so grouping these boiler types that average figures can be thus selected. This modified form of the formula is

$$D = C \times \frac{H}{L \times P},$$

in which H equals the total boiler heating surface in square feet and C is a constant.

Values of the constant for different types of boiler and service have been selected. These constants are susceptible, of course, to endless discussion among manufacturers and it is undoubtedly more satisfactory where any question arises to use the form containing the term E itself. Nevertheless the form containing the term H is more direct in its application and it is believed that the values given in the following for the constant will prove serviceable. In applying the formula in this form rather than the original one containing the evaporation term E, it should be remembered that these constants are based upon average proportions and, therefore, should not be used for boilers in which any abnormal proportions or relations between grate area, heating surface, etc., exist.

For cylindrical multitubular, vertical and water-tube stationary boilers a constant of 0.068 is suggested. This is based upon an average evaporation of 3½ pounds of water per square foot of heating surface per hour, with an overload capacity of 100 per cent., giving 7 pounds per square foot of heating surface, the figure used in obtaining the constant.

For water-tube marine and Scotch marine boilers, the suggested constant is 0.095. This is based upon an overload or maximum evaporation of 10 pounds of water per square foot of heating surface per hour.

For locomotive valves the constant is 0.055, determined experimentally as explained in what follows: In locomotive practice there are special conditions to be considered which separate it from regular stationary and marine work. In the first place the maximum evaporation of a locomotive is only possible with the maximum draft obtained when the cylinders are exhausting up the stack, at which time the throttle is necessarily open. The throttle being open is drawing some of the steam and, therefore, the safety valves on a locomotive can never receive the full maximum evaporation of the boiler. Just what per cent. of this maximum evaporation the valve must be able to relieve under the most severe conditions can only be determined experimentally. Evidently the severest conditions obtain when an engineman, after a long, hard, uphill haul, with a full glass of water and full pressure, reaches the top of the hill and suddenly shuts off his throttle and injectors. The work on the hill has got the engine steaming to its maximum and the sudden closing of throttle and injectors forces all the steam through the safety valves. Of course, the minute the throttle is closed the steaming quickly falls off and it is at just that moment that the severest test upon the valves comes.

A large number of service tests have been conducted to determine this constant. The size of the valves upon a locomotive has been increased or decreased until one valve would just handle the maximum steam generation and, the locomotive heating surface being known, the formula was figured back to obtain the constant. Other special conditions were considered, such as the liability in locomotive practice to a not infrequent occurrence of the most severe conditions; the exceptionally severe service which locomotive safety valves receive; and the advisability on locomotives to provide a substantial excess valve capacity.

As to the method of applying the proposed safety-valve capacity rule in practice, manufacturers could be asked to specify the capacities of their valves, stamping them upon them as the opening and closing pressures are now done. This would necessitate no extra work, only the time required in the stamping, because for valves of the same size and design giving practically the same lift this would have to be determined but once, which of itself is but a moment's work with the small portable lift gage now available. The specifying of safety valves by a designing engineer could then be as definite a problem as is that of other pieces of apparatus. Whatever views are held, as to the advantages of high or low lifts, there can be no question, it would seem, as to the advantage of knowing what this lift actually is, as would be shown in this specifying by manufacturers of the capacities of their valves. Further, as to the feasibility of adopting such a rule (which incorporates the valve lift) in statutes governing valve sizes, this would involve the granting and obtaining by manufacturers of a legal rating for valve designs based upon their demonstrated lifts.

Wrought Pipe

By H. E. Schuler

At one time I worked in the pipe shop of a large manufacturing concern and became more or less familiar with the mistakes made by engineers and others in ordering pipe.

Standard pipe is always measured on the inside (that is 2-inch pipe measures 2 inches inside diameter, etc.) up to and including 12-inch pipe. Above 12-inch, pipe is always measured on the outside and is called "O.D.," or outside-diameter pipe. Extra-strong and double-extra-strong pipe are very nearly of the same outside diameter as standard pipe, the extra thickness being on the inside, thereby decreasing the inside diameter or area of the pipe. For this reason no special die is required to thread them.

In ordering pipe always remember that standard pipe comes threaded, with a coupling on one end, up to and including 12-inch pipe, and above this size, or all "O.D." pipe, the pipe comes with plain ends and an extra charge is made for threads and couplings. The thickness of "O.D." pipe must be specified if you wish it threaded, as it is impractical to thread this pipe when less than 5/16 inch in thickness. Extra-strong and double-extra-strong pipe also come with plain ends and an extra charge is made for threads and couplings.

A great many engineers in ordering pipe simply specify a certain number of feet of wrought pipe of certain size and labor under the delusion that they are getting wrought-iron pipe when they are really getting wrought-steel pipe.

If you wish wrought-iron pipe you must specify: "This pipe must be strictly wrought-iron." Wrought-iron pipe costs a little more than wrought-steel pipe and the bursting pressure is considerably less.

A great many engineers claim that wrought-iron pipe is more durable than and not as susceptible to corrosion as wrought-steel pipe and are willing to pay a little more for it. Of course, the safe working pressure of any pipe varies with the inside diameter and the thickness; also the weld, which is always an uncertain factor. From 1/8- to 3-inch pipe can be secured in the butt weld and from 1½-inch up in the lap weld.

Pipe from 1/8- to 3-inch is tested at from 600 to 1000 pounds, and 3-inch to 15-inch at from 500 to 1000 pounds, before leaving the factory. Several lengths of 8- and 10-inch standard pipe were tested and burst at from 1800 to 3200 pounds pressure, but of course there are factors, such as expansion, joints, strains due to improperly hanging threads, etc., which should be taken into consideration when installing pipe. Pieces of pipe 12 inches or under in length are called nipples and are measured from end to end the same as pipe and not between the threads, as thought by some people.

Some of the defects to look for in wrought pipe are poor threads, brittleness, defective welds, flat places and hard spots. The most common complaint is of poor threads, and nine times in ten this complaint would not be registered if a little judgment were used by the engineer or steamfitter. Quite often the end of pipe is jammed against something which pushes the first thread back against the second, making it impossible to start the fitting on the pipe. A few minutes' work with the hammer and cold chisel repairs this and the fitting goes on all right. Sometimes a thread or two are slightly broken, but if one or two threads are completely stripped from the pipe it will not spoil a properly made joint.

When the pipe breaks off in layers just ahead of or between the cutting points of the dies it is defective and should be returned. There are several good dies in the market for threading pipe, also several poor ones, and some judgment should be used in purchasing a set. Personally I always buy an adjustable die so that in cutting pipe 1½-inch or over I can take two cuts, thereby decreasing the labor. Adjustable dies are also very handy in cutting special threads for any purpose.

Dr. Frederick W. Taylor, past president of the American Society of Mechanical Engineers, gave an address before the College of Engineering of the University of Illinois, on Thursday, February 18, along general engineering lines supplemented by anecdotes from the early part of the careers of successful engineers.

A movement has been set on foot by the English Ceramic Society for a conference of representatives of the various technical institutes and societies, to consider ways and means of arranging for the "grading" and standardizing, as far as possible, of the refractory materials, such as fireclay, magnesite, etc., used in the construction of furnaces, kilns and ovens.

Square Plaited Ropes

Square plaited ropes, which are, we believe, of German origin, are much more extensively used abroad than in this country. Quite recently, however, Venhardt & Co., Limited, of 26 and 27 Bush lane, Cannon street, E. C., has taken up the agency here and has already supplied several factories with this type of rope. From what we can gather it appears to

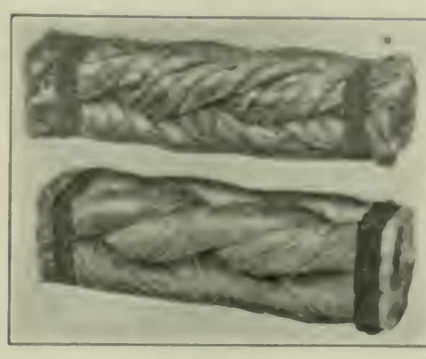


FIG. 1. SQUARE ROPE

give excellent results and to be very durable. The accompanying engraving shows two forms of this rope. They are designed specially for driving and not for cable work, as it is recognized that they will not turn and are, therefore, unsuitable for the latter use. The severest work to which any form of rope may be submitted is probably the driving of

FIG. 2. SQUARE ROPE IN GROOVE

rolling mills. Yet many such mills are now being satisfactorily driven with square plaited ropes. For this purpose a cabled construction is used, its form being shown in the top view of Fig. 1. Each strand is twisted before use into an independent rope, and each strand comprises several threads. The lower view of Fig. 1 shows the plaiting of an ordinary standard construction rope. The ropes are made of hemp or cotton, and the firm guarantees a hemp rope, although stronger, to outlast a cotton rope. No special pulleys are required, as the rope lies into an ordinary groove in the manner shown in Fig. 2. The ropes each comprise eight strands, two sets of four strands each are so to speak opposed to each other, by which means it is claimed that the rope follows an even and uniform course, while it is free from any tendency to twist or turn. High pliability is another advantage claimed for this form of rope, and pulleys of very moderate diameter may be used, which is small compared with what is required for round ropes. We were told that special attention is paid to the treatment of the rope while under construction to take as much of the stretch out of it as possible. Each strand is stretched before use, and the special manner of plaiting permits of stretching the ropes to the maximum limit. To render these waterproof they are impregnated with a special solution, no tar being used.

With regard to the properties of the square plaited rope, we were informed that the 1¾-inch size will replace and give the same power as a 2-inch round rope and that it is from 10 to 15 per cent. lighter than the round rope which it displaces. The square ropes which have been impregnated as a protection against the influence of the weather are naturally heavier than those which have not been so treated. The following table by the maker gives some interesting data relating to the square ropes which will enable a comparison to be made with the better known round rope drives.

Square Plaited Ropes			[illegible]	[illegible]
[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

The load is generally assumed to be from 85 to 115 pounds per square inch of section, the latter being the general practice with these ropes. The square plaited ropes appear to have a long life, and to be free from the normal amount of stretching. We were assured that there are cases where the ropes have been working for eight and nine years in running belts without re-splicing being necessary.—The Engineer, London.

POWER AND THE ENGINEER

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Contents PAGE

Progressiveness and Asininity

There is really a very narrow line of separation between real, commendable progressiveness and a stupid belief in one's ability to upset natural laws. The same underlying spirit produces both the brilliant investigator and discoverer and the pitiable dupe of his own ignorance who firmly believes in perpetual motion and the creation of energy—that is, unwillingness to accept as final the dicta of other seekers after knowledge. If we all were content with the fruits of investigations made by dead and gone physicists and engineers there would be no more progress in applied physics and engineering; neither would there be the perennial crop of perpetual-motion and similar misguided inventors.

There is one supreme test, however, which invariably differentiates an intelligent investigator from a self-centered fool: the application of established natural laws to his ideas. The work of the former type of man is always in conformity with the fundamental laws of nature which have been proved to be sound, while that of the false prophet is always based on a violent distortion or total disregard of all physical laws applying to his problem; the former never tries to upset the laws of gravity and of the conservation of energy, whereas the latter invariably manifests a lofty contempt for theory and a valiant determination to force tribute from Nature without giving up an equivalent.

Safety Valves

For years the rule of the Board of Supervising Inspectors of the Steamboat Inspection Service of the United States, which was our principal if not our only official expression upon the subject of safety-valve capacity, was one square inch of safety-valve area for each three square feet of grate surface. Gradually it became apparent that the grate surface, apart from the rate of combustion, was no measure of the steam-making capacity of a boiler, and that a given orifice would discharge more steam at a higher than at a lower pressure, in fact, that the weight discharged per unit of time was in direct proportion to the absolute pressure.

Five years ago the board adopted the following formula devised by L. D. Lovekin, chief engineer of the New York Shipbuilding Company:

$$Area = 0.2074 \frac{\text{Weight of steam per hour}}{\text{Absolute pressure}}.$$

The derivation of this formula is explained on page 473. It is based upon Napier's approximate formula for the flow of steam through an orifice:

$$W = \frac{A\ P}{70},$$

where the weight, W, is in pounds per second, the area A in square inches and pressure P in pounds absolute.

Mr. Lovekin's formula is based upon the assumption that the valve lifts one-thirty-second of its diameter, i.e., that a one-inch valve will lift one-thirty-second of an inch and a six-inch six-thirty-seconds, or three-sixteenths; and the coefficient 0.2074 comes by multiplying the 70 of Napier's formula by 32 and dividing by 3600, to reduce the area required to release the given weight in a second to that required to release it in an hour, by 0.75 chosen arbitrarily "for safety" and by 4, which is the 4 of the common expression for area:

$$Area = d^2 \frac{\pi}{4} = d^2\ 0.7854,$$

the π canceling out. If the weight W is taken as per square foot of grate surface the area must, of course, be multiplied by the number of square feet of grate surface involved, and this may be an excuse for striving for accuracy in the coefficient, for any inaccuracy would be multiplied in proportion; but it is difficult to see the necessity or sense, in a formula based upon Napier's confessed approximation, involving an assumed lift, which the valve will hit only by accident, including an arbitrarily chosen factor of safety, and used to indicate the next larger size of valve commercially available, of carrying the coefficient out to four places of decimals. If the formula had been written:

$$A = 0.2 \frac{W}{P},$$

it would have been more simple and sensible and would have indicated the same size of valve in any case except where the present rule falls just above an available size.

But the experiments made by Mr. Darling and reported on pages 473 +, as well as the discussion at the meeting at which the paper was presented, brought out the fact that safety valves do not lift in proportion to their diameters; that the lift is practically the same for a large, as for a small valve, smaller for the larger valve if anything, and is around three-thirty-seconds of an inch for all valves in normal condition. The recognition of this fact makes a beautifully simple formula possible.

The area available for the discharge of steam with a flat-seated valve is the product of the circumference and the lift, or with a beveled seat, the above product multiplied by the sine of the angle which the seat makes with the vertical axis. If the Napier formula,

$$W = \frac{A\ P}{70},$$

be multiplied by 3600 to express W in pounds of steam to be discharged per hour instead of per second, and transposed to indicate the area required, it will read:

$$A = \frac{70\ W}{3600\ P}.$$

If A be taken as the product of the circumference and the lift ($d \times 3.1416 \times l$), and the lift be assumed as one-sixteenth of an inch,

$$\frac{d \times 3.1416}{16} = \frac{70\ W}{3600\ P}$$

or

$$d = \frac{16 \times 70 \times W}{3.1416 \times 3600\ P},$$

and

$$d = 0.1\ \frac{W}{P},$$

almost exactly.

Dividing the weight of steam to be delivered per hour by the absolute pressure of that steam and moving the decimal point one place to the left would give the diameter of valve required directly, without any reference to tables of areas and, the available area varying directly as the diameter, the result can be proportioned among a number of valves, if too large for one, by simple division. If the rule indicated 12 inches of diameter two 6-inch, or three 4-inch valves could be used.

For the common 45-degree beveled seat the constant would become 1.4; but if the lift be assumed to be 0.0714 instead of one-sixteenth or 0.0625 the constant will return to 0.1. This is less than $\frac{5}{64}$. Mr. Lovekin's rule has been assuming that a three-inch valve lifts $\frac{3}{32}$ or $\frac{6}{64}$, and any maker will guarantee a valve of any size to lift three thirty-seconds, when the valve pops, and to stand at that hight so long as the pressure is maintained. Should the pressure increase the valve is free to open farther, and more of the higher pressure steam will escape through the same area due to its greater density so that there is an ample margin of safety. Mr. Lovekin's rule has proved ample and the proposed rule gives the same results for valves 2 5/4 inches in diameter, requires less diameter of valve below this and more than his formula does for diameters greater than 2 5/4 inches.

The purpose of a rule for safety valves is not to determine with mathematical precision the exact area required to discharge a given amount of steam per second, but to indicate a size of valve which will be ample for that service without being so large as to discharge the boiler too quickly or to be extravagant in cost. The proposed rule is simpler and safer than the present, is more consistent with the governing facts, if, as it appears, the lift is practically the same for all sizes of valves, and will, we believe, indicate valves ample to discharge the assumed amount of steam, but not needlessly large.

In estimating the quantity of steam which the valve may be called upon to discharge it should be borne in mind that the maximum rate of evaporation for a few minutes is apt to considerably exceed the average rate. The performance of a boiler for an hour is the aggregate result of varying conditions of fire, draft, rate of feed, etc. The momentary evaporation under favorable conditions may be considerably more than the average evaporation for the hour.

The establishment by Mr. Darling of the fact that Napier's formula applies so closely to the discharge from a safety valve is very gratifying. It remains to be determined if any allowance is required for superheated steam within the limits of ordinary practice.

Be Exact

In all professions it pays to be exact in thought and statement, oral or written, and more especially does this apply to engineering. Although a great many engineers are, perhaps, exact enough in thought, there is a general tendency to be careless in the expression of the thought. To a certain extent this is only natural, for back of the statement, in the mind of the writer, is the idea, and the meaning to him is perfectly plain, but to the reader, who sees only the expression, the statement not only may not be clear, but is often misleading. Long-continued carelessness in this regard will surely leave its mark, and in time the careless writer becomes the careless thinker; and the same characteristic will creep into the solution and computation of the problems which enter into the everyday life of the engineer.

Many errors have been caused by the careless use of the word "pressure," or failure to specify what pressure is meant. Customary use of the word in connection with steam practice refers to pressure per square inch above the pressure of the atmosphere, as indicated by an ordinary gage. But many calculations require the pressure to be taken in pounds absolute, i.e., as the quantity indicated by an ordinary pressure gage plus the pressure of the atmosphere. In other calculations the pressures must be taken per square foot; and other situations which should be taken in millimeters of mercury or kilograms per square centimeter are [illegible] taken in the customary pounds per square inch.

Other words, such as work, power, energy and force, are often confused. To know the proper definitions and how to use each word in its right place requires but a few moments and is plainly worth the effort.

Another error of common occurrence is found in the expression of the number of heat units in water at a certain temperature; that is, if the water is at a temperature of [illegible] degrees Fahrenheit, it is not uncommon to be informed that it contains [illegible] B.t.u., when as a matter of fact it contains only [illegible] B.t.u., the starting point of 32 degrees Fahrenheit, from which the amount of heat is reckoned, being entirely overlooked. A designation should always be made as to what thermometrical scale the temperature applies. There are a great many other things along this line requiring the same attention.

The Care of Commutators

Several times we have heard of operating engineers who [illegible] to use emery habitually for smoothing off commutators, and with no bad results. One well known contributor to our columns says he has used it for years without any trouble whatever, and we do not question his veracity in the slightest degree. The number of men who have reported favorable experience with emery, however, is small; the number who have brought trouble upon themselves is large. In a practical operating experience of [illegible] years the present writer has never but once seen emery used for the purpose mentioned without producing worse trouble than that which it was intended to cure; the exception was explained by the facts that no lubricant was used on the commutator and the mica between the bars was unusually thick and of just the quality to match the copper in its rate of wear. Whenever a commutator is lubricated, the use of emery is very likely to be followed by "leaks" across the mica strips which separate the commutator bars. Of course there may be cases where this does not happen. There have been many cases of recovery by persons who have [illegible] doses of deadly [illegible], but this does not prove that [illegible] is a safe habit to form.

The more progressive city libraries of the country are paying increased attention to engineering and technical subjects in their work with the public. Among those which are especially active in this field is the Public Library of Washington, D. C., as shown by the annual report for [illegible] just issued. This institution has organized a special department, the Useful Arts Department, to meet the demands of its readers for books on the engineering trades, and [illegible] [illegible]

Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

"Schutte" Electric Motor Operated Gate Valve

The "Schutte" precision electric motor-operated gate valve is illustrated in Figs. 1 and 2. The loose-fitting handwheel has a vertical movement on the upper end of the yokenut to which it is clutch-connected only when in its lowest or hand-operating position; this step-clutch is formed on the handwheel hub, around which there is a continuous rim, the latter engaging with the two extensions of a pivoted or hinged-gear clutch lever, the heavy end of which, when lowered, engages with a narrow lug on the inside of the rim of the large spur gear also loosely mounted on the yokenut below the clutch collar that carries the aforesaid hinged lever. As this hinged clutch lever and the lug on the inside rim of the gear are both narrow, the gear can make about ⅞ of a revolution for impact and for the purpose of allowing the motor to acquire speed.

When the valve is used for motor operation the handwheel is prevented from revolving and held in its highest or out-of-gear position by the two vertical lever-supported rods resting against the under side of the handwheel rim. From this it will be seen that the handwheel is entirely cut out when the valve is being operated by a motor and can therefore exert no jamming action at the end of travel due to the stored-up inertia, nor does power have to be exerted to set it in motion even frictionally.

The handwheel and gearing as described interlock so that both cannot be out of action at the same time, nor can both be in action at the same time. When the handwheel is in use the motor gearing is disengaged and *vice versa*.

As these valves are intended for operation from a distance, such as from a different floor where the operator at the reversing controller is unable to see in what position the gearing has been left, an instruction plate is provided on each arm of the yoke, so as to insure that the gearing is left ready for emergency use. It is placed on the side opposite to that shown in the illustration and reads: "Always leave valve ready for motor operation with handwheel in highest position;" the raising and lowering of the wheel being accomplished by means of a screw spindle attached to a central lever on the rock-shaft carrying the side levers that raise and lower the supporting rods.

To cut the motor out at the proper time, two travel-limit switches are provided, one for the upward and one for the downward stroke; these close the circuit on a shunt trip coil in the controller so that the latter will be thrown to its off position, thereby informing the operator that the valve has made its complete upward or downward travel, as the case may be. In addition to this a double-pole circuit-breaker is used to guard against burning out of the motor or controller from overload.

These valves find special application as an emergency shutoff on steam mains between boiler and engine, or in turbine rooms. They are fitted with motors for either direct or alternating current of any standard voltage.

To guard the threaded valve spindle from grit or dirt, and to insure a clean, oiled surface, a protecting sleeve is screwed to the upper end of the handwheel hub.

The motor is of special construction, fully incased, provided with self-oiling bearings, of large overload capacity and capable of standing the heat of high-temperature steam to which the valves are subjected.

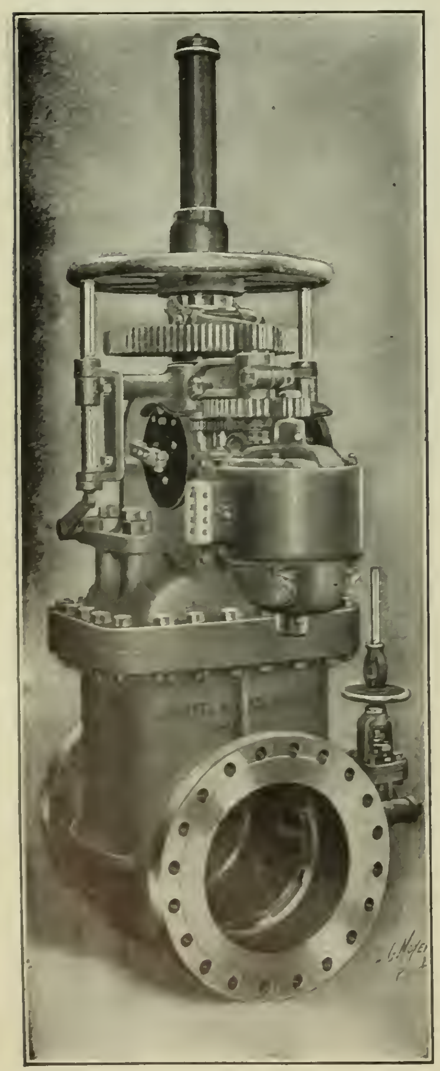


FIG. 1

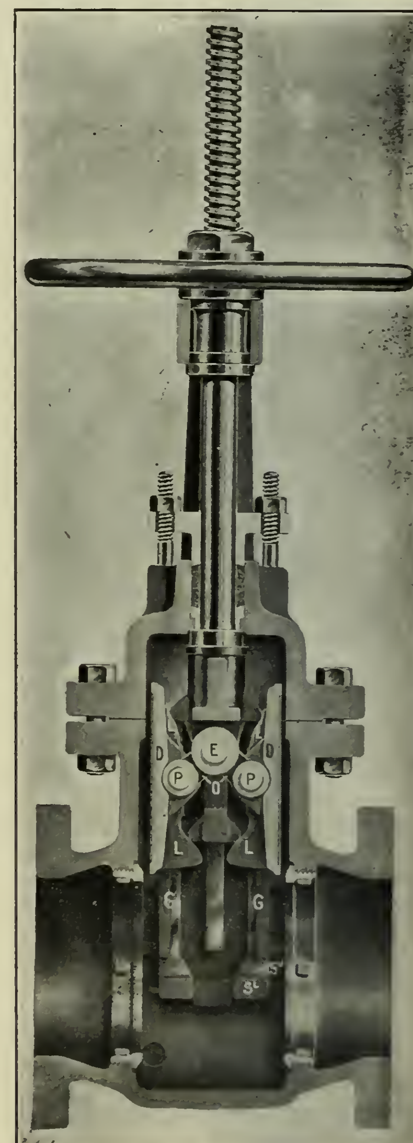


FIG. 2

As gravity is used to engage and disengage the motor gearing and keep the handwheel in its lowest position, these valves must be used with the spindle vertical and with mechanism on the top as shown. They can, however, be fitted with a spring so that the spindle may be used in a horizontal position and the valve may be used inverted.

Fig. 2 is a sectional view of the valve proper, *G G* being the guides which keep the valve disks *D D* in place, the whole being made tight by means of the leverage due to the arrangement shown at *P*, *E* and *L*.

This valve is manufactured by the Schutte & Koerting Company, Twelfth and Thompson streets, Philadelphia, Penn.

Westinghouse Large Direct Current Motors

The accompanying engravings illustrate a line of direct-current motors recently brought out by the Westinghouse Electric and Manufacturing Company in order to meet a growing demand for machines of larger size than the ordinary direct-current lines supply. These machines, known as Type E.M., are built in capacities ranging from 90 horsepower upward

FIG. 1. WESTINGHOUSE HEAVY-DUTY MOTOR

FIG. 2. MAGNET YOKE OF WESTINGHOUSE MOTOR

FIG. 3. WESTINGHOUSE ARMATURE AND COMMUTATOR

FIG. 4. BRUSH AND HOLDER OF WESTINGHOUSE MOTOR

and for all standard direct-current voltages. They are supplied with a standard bed frame and pedestals, as illustrated in Fig. 1, or without bed and pedestals, for direct mounting.

The field magnet consists of a cast-iron yoke ring with laminated magnet poles bolted to the ring. The magnet poles are built up of relatively thick sheets of steel; one pole-tip corner of each sheet is cut off and the sheets are assembled with the remaining tips staggered, as close inspection

of Fig. 2 will reveal. This gives [illegible] possible high magnetic density at the tips, tending to stability of field at the edges of the air gap, of course, and [illegible] improvement in commutation. The field winding is shunt, series or compound, according to the requirements. All three classes of winding are standardized, so that no special construction is necessary in order to [illegible]. The field-magnet coils are wound on heavy

paper tubes or bobbins and treated with a waterproof insulating compound, but they are not wrapped with tape; better radiation is obtained by leaving the surfaces unwrapped.

The armature is of the familiar slotted-core type, with a bar-connected winding of individually insulated coils. The core disks and commutator are mounted on a shell or drum with a smooth spider into which the shaft fits. This construction permits the shaft to be removed and replaced without disturbing the armature-core disks or the commutator connections. The armature winding is equipped with equalizing connections housed in the rear "overhang" of the winding, which is protected against centrifugal force by a band of binding wire, as shown in Fig. 3. This engraving illustrates the general construction of the armature and commutator; the end of the spider into which the shaft fits is just visible within the commutator core. The armature winding is held in the core slots by wooden wedges.

The brush holders are of the simple box type shown in Fig. 4. The brush is pressed on the commutator by a flat spring coiled about an adjustable spindle and a finger loop is riveted to the spring for convenience in lifting the spring away from the brush. The latter is a rectangular carbon block with a flat flexible "pigtail" attached to its upper end by means of a strap and a bolt; the nut on the end of this bolt is held in place by a lock washer. The commutator construction is along the well known standard lines of Westinghouse practice, as is also that of the self-oiling bearings and pedestals.

"Faultless" Metallic Packing

"Faultless" metallic packing is manufactured by the Hoyt Metal Company, [illegible] Locust street, St. Louis, Mo. The metal used in this packing is said to be of a special mixture, made in the form of rings turned [illegible] in the diameter of the rod and cut into [illegible] sections. The sections are held together by wire springs. The rings are in [illegible], with the flat sides together. [illegible] rings with [illegible] hold the packing rings to the rod with a [illegible] and makes [illegible]. The construction is shown in the illustration.

SECTION AND COMPLETE RING OF FAULTLESS METALLIC PACKING

The rubber section of the ring is of especially prepared stock, which is said to be unaffected by steam, oil or ammonia. The rubber does not come in contact with the rod, but acts as a cushion to take up vibration, there being a continuous metal surface beyond the rod.

Obituary

Francis H. Boyer, 64 years old, died at his home in Somerville, Mass., Sunday, February 21. Mr. Boyer was a widely known mechanical engineer and architect, at one time superintendent of the refrigeration department of the De La Vergne company and later master mechanic for the John P. Squire Company. He was a member of the A. S. M. E., and once served on its board of managers for three years. He also belonged to the N. A. S. E., and other engineering organizations. Latterly Mr. Boyer was in business with his son, Charles W. Boyer, manufacturing refrigerating and ice-making machinery, designing abattoirs, building water-cooling towers and coal-handling and conveying machinery.

Business Items

Richard Thompson has opened an office at 123 Liberty street, New York, for the sale of steam specialties.

The York Manufacturing Company, York, Penn., manufacturer of ice and refrigerating machinery, reports 28 recent orders aggregating 1350 tons of refrigeration.

E. J. DuBois, son of William J. DuBois, in charge of the engineering of the fleet of the United Fruit Company, and prominent in M. E. B. A. circles has accepted a position with the sales department of the William B. McVicker Company. His especial attention will be given to marine business.

The "Selden and Zena" packing has just been furnished for use on the plungers of the pumping engines at the waterworks in St. Petersburg, Russia. These packings are made by Randolph Brandt, 72 Cortlandt street, New York, who also advises us that a number of pump manufacturers use these packings for outside-packed plungers, this packing being specified by many chief engineers.

The Hughson Steam Specialty Company, 60 South Halstead street, Chicago, Ill., has succeeded the John Davis Company, of Chicago, in the manufacture of the "Eclipse" steam specialties. George F. Hughson, who is president of the new company, was the original owner and inventor of these specialties, which include regulating, back-pressure relief and blowoff valves, pump regulators, steam traps and separators. All of the former agents of the John Davis Company will continue to handle these goods.

G. J. Burrer, proprietor of the Sunbury Flour Mill and electric-light plant at Sunbury, Ohio, in a letter to the Buckeye Boiler Skimmer Company, South End, Toledo, Ohio, says: "I find the skimmer all right. My boiler has not foamed since I put the skimmer in. When I put the device in there was ⅛ inch of scale on the tubes, and in three weeks they were as clean as could be. I opened the boiler again on Monday and there was not a particle of dirt or mud in the back head, but I took out two gallons of scale from the front head.

"Aid to Shippers" is the title of a 72-page book containing a quantity of information of value to all engaged in the export or import trade. The book is issued by Oelriches & Company, of New York, for more than forty years the American representatives of the North German Lloyd Steamship Company, who, by reason of long experience, are qualified to advise. The table of foreign moneys with United States equivalents, together with weights, measurements, tariffs, customs requirements, etc., will be found of value. A copy of this book will be sent, postpaid, on request to Oelrichs & Company, Forwarding Department, 5 Greenwich street, New York.

Among the recent orders taken by the Crocker-Wheeler Company, of Ampere, N. J., is one for a 250-kilowatt, motor-generator set for the Tennessee Coal, Iron and Railroad Company, at Ensley, Ala. It will consist of a 250-kilowatt 275-volt direct-current generator driven by a 6600-volt 3-phase 25-cycle synchronous motor, and will be used as an exciter. Another order is one for about 50 horsepower of small elevator motors purchased by the Haughton Elevator and Machine Company, Toledo, Ohio. Yawman & Erbe, of Rochester, New York, have also placed orders for a number of 2/5-horsepower motors for use on some of their specialties.

The Missouri Valley Milling Company, Mandan, North Dakota, has given contract to the Minneapolis Steel and Machinery Company, for furnishing and installing the complete power plant for a new mill being built at Dickinson, North Dakota. The contract includes one 12 and 26x36 heavy-duty cross-compound Twin City Corliss engine, with evaporative surface condenser, a 300-horsepower feed-water heater and purifier, a boiler-feed pump, pumps for fire service, a 50-kilowatt direct-current generator, switchboard and motor, one 5000-gallon wooden water tank, oil and steam separators, miscellaneous transmission machinery and all piping, valves and fittings.

J. E. Lonergan Company has been incorporated in Pennsylvania, with a paid-in capital of $200,000, to succeed to the business of J. E. Lonergan & Company, 211 and 213 Race street, Philadelphia, Penn. The new company will have the following officers: John E. Lonergan, president; M. A. Hudson, vice-president; H. S. Whitney, secretary; W. E. Crofton, treasurer; directors, John E. Lonergan, M. A. Hudson, H. S. Whitney, W. E. Crofton, James F. Lonergan. H. S. Whitney and M. A. Hudson were connected for many years at New York and Chicago with Manning, Maxwell & Moore. W. E. Crofton, for the past 26 years, has been cashier and head bookkeeper for J. E. Lonergan & Company.

The International Acheson Graphite Company, of Niagara Falls, advises us that it is the only maker of graphite in the world. It operates the electric-furnace process, and thus the company is in full control of every ounce of raw material that enters its furnaces, while it also controls the application of the furnaces during the entire period of their operation. Because of these facts and the thorough scientific skill applied, this company makes what it calls, "grade 1340 Acheson-Graphite," guaranteed to be at least 99 per cent. pure, very fine, soft, lusterless and unctuous. The company's claim is that this is the best lubricating agent now known, as it is not tough, and has those spreading qualities so necessary to ideal lubrication.

The Keystone Lubricating Company, Philadelphia, manufacturer of Keystone grease, has recently been advised of the efficiency and economy of this product in the lubrication of governor pins of an installation of Westinghouse high-speed engines at the plant of the Electric Storage Battery Company, Philadelphia. In this type of flywheel governor the conditions of safe and effective lubrication are severe, as the governor pin carries a pair of heavy weights and oscillates through a short arc only for its maximum travel between light load and full load on the engine. The chief engineer, reporting on the performance of Keystone grease, states that it gives perfect satisfaction, with a consumption of four to six ounces of No. 2 density grease on each engine per week of thirteen consecutive shifts.

Typical Low-Pressure Steam Turbine Plant

Double-flow Turbine Utilizing the Exhaust of Two 750-Kilowatt Corliss Engines. No Governor, and Capacity Varies with Initial Pressure

BY J. R. BIBBINS

Probably the first application of the low-pressure type of steam turbine to commercial work in connection with American mining properties is to be found in the power plant of the U. S. Coal and Coke Company, Gary, W. Va. Considerable progress has been made in this country in the low-pressure turbines in connection with light and power plants, and this installation will serve as an illustration of the possibilities of this type, not only in mining properties, but also in other industrial work where similar conditions of power service are encountered.

Power Plant

The Gary plant was installed in [illegible] with an equipment of two [illegible]-kilowatt generators, each driven by two simple Harrisburg engines which were later changed to cross-compound engines. In 1904, a 750-kilowatt cross-compound Corliss engine driven unit was added, and in 1905 a duplicate unit, aggregating 2300 kilowatts in engine-type units. On account of installing some new machinery, a low pressure turbine was added in 1907 to utilize the exhaust from the Corliss engines—also a complete expansion turbine, both of standard Westinghouse construction. Each of these drives a 1000-kilowatt generator.

The property at Gary, W. Va., consists of eight coke plants and four coal mines, all electrically driven with the exception of the hoisting engines and fan at one of the mines, which is a shaft; hence the plant is subject to a combination load from a large number of rotary converters which furnish direct current for mine locomotives, pumps, coal-cutting machinery, larries and coke-drawing machines, and for a large number of induction motors which drive fans, [illegible], crushers, picking tables, compressors, conveyors, etc.

The present equipment consists of two 400-kilowatt generators driven by [illegible]-inch Harrisburg engines; two 750-kilowatt generators, each driven by [illegible]-inch Corliss steam engines; one 1000-kilowatt Westinghouse single-flow steam turbine, and one 1000-kilowatt Westinghouse double-flow low-pressure turbine.

This equipment occupies a building [illegible] feet, with an additional 18-foot longitudinal bay for auxiliaries, etc. The 2000-kilowatt capacity in turbines occupies about one-third of the building, and the [illegible]-kilowatt engine-driven units occupy about two-thirds of the building.

It would be noted that the low-pressure turbine receives steam only from the two Corliss engines. The Harrisburg engines, although exhausting into the common header, are [illegible]

FIG. 1. TURBINE INSTALLATION AT GARY, W. VA.

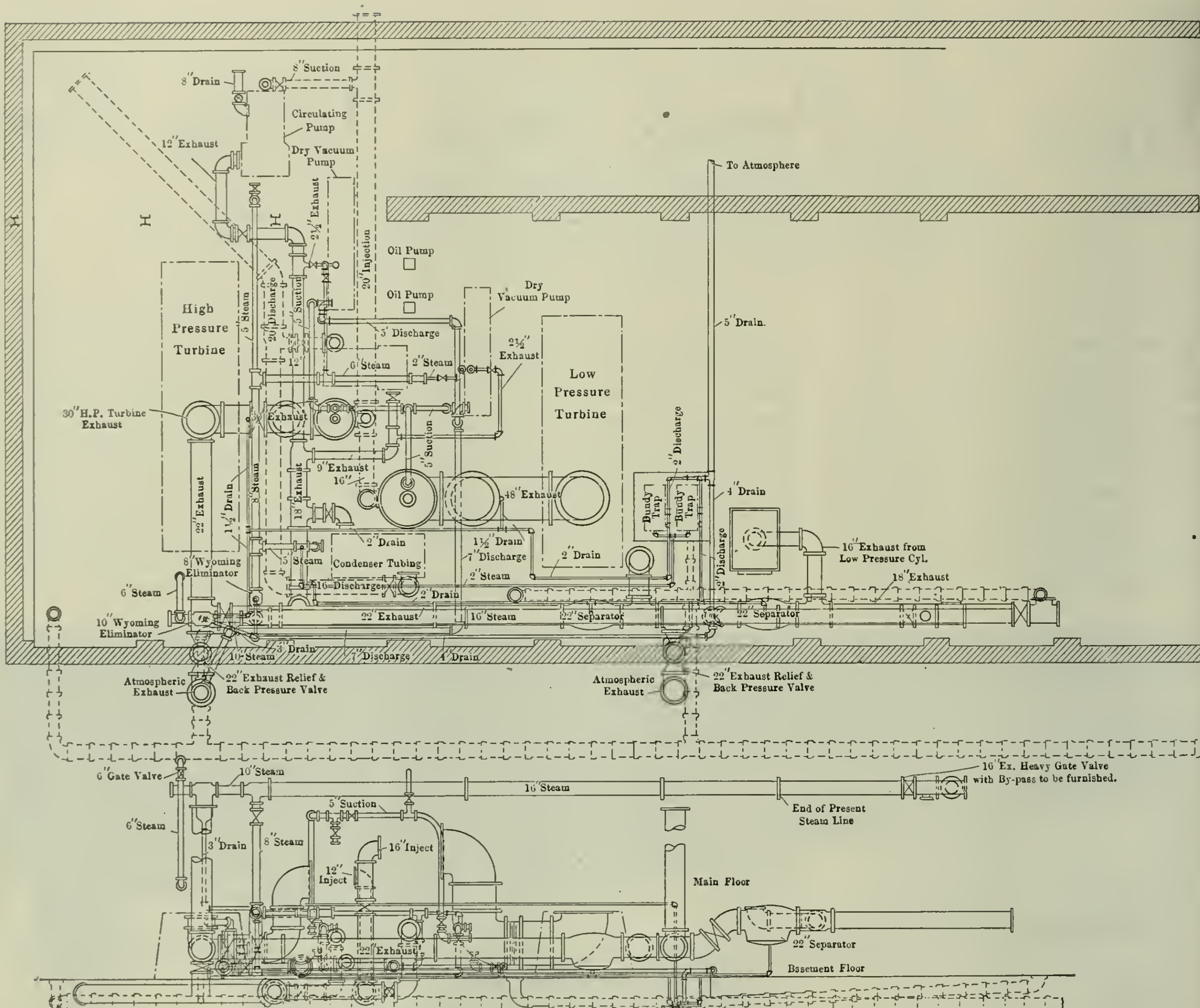


FIG. 2. PIPING PLAN AND ELEVATION OF TURBINE EXTENSION TO POWER PLANT

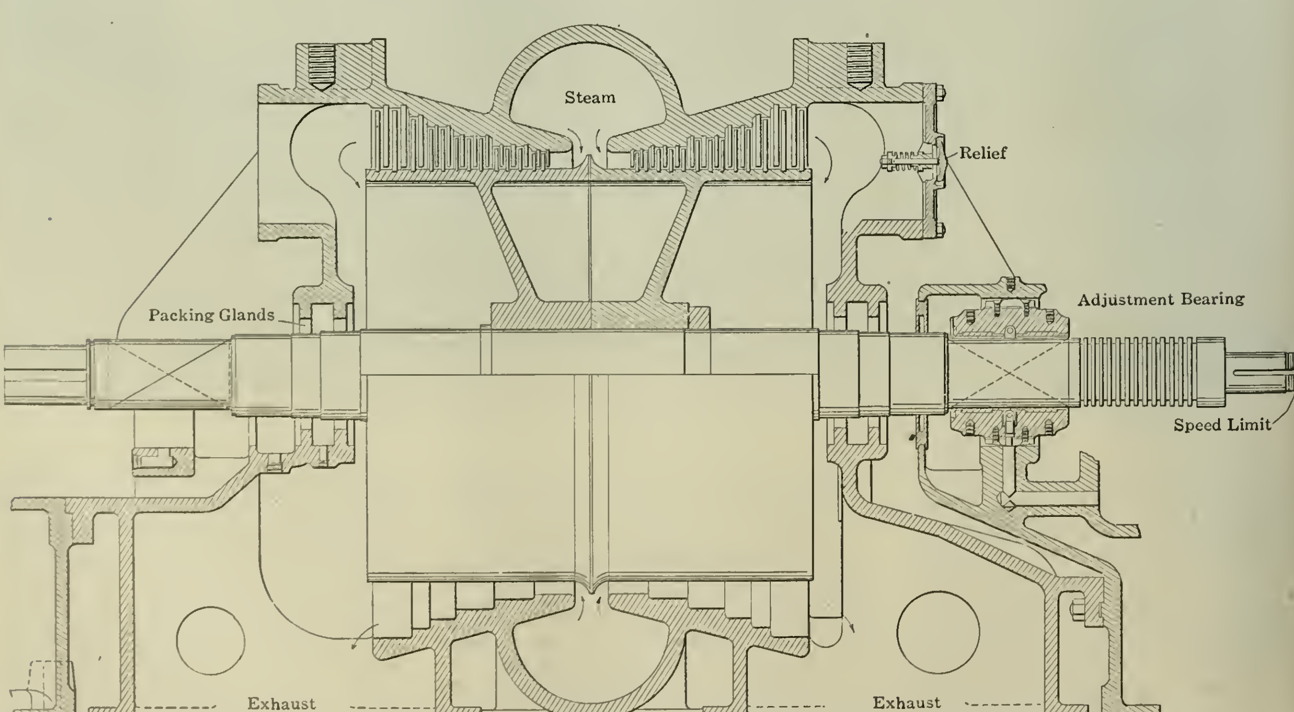


FIG. 3. SECTION THROUGH LOW-PRESSURE TURBINE

FIG. 4. LOW-PRESSURE TURBINE WITH THROTTLE VALVE IN FOREGROUND

ing the day. This exhaust steam is all sent to heaters in the boiler room and a valve in the exhaust header is provided to separate these engines from the remainder of the system, so that the low-pressure plant at Gary is only concerned with the 1500-kilowatt capacity in Corliss engines.

Turbine Types

An interesting comparison of the two types of turbine unit is afforded by these two machines which are of equal capacity. It will be noted from the accompanying table that the low-pressure turbine is one-third shorter than the high-pressure machine, but the hight and width are about the same, the exhaust area of the high being 2.5 times greater. The generators both deliver three-phase power at 6600 volts and each revolves 1500 revolutions per minute. The fields are strap-wound and the armatures form-wound with coils

COMPARATIVE DATA

	Low Pressure	High Pressure
Length of turbine	[illegible]	[illegible]
Length of generator	[illegible]	[illegible]
Length of unit	[illegible]	[illegible]
Width of bed	[illegible]	[illegible]
Hight, floor to center line	[illegible]	[illegible]
Hight over all	[illegible]	[illegible]
Diameter steam pipe	[illegible]	[illegible]
Diameter exhaust pipe	[illegible]	[illegible]
Inlet pressure, lb.	[illegible]	[illegible]
Quality of steam	[illegible]	[illegible]
Vacuum (in.)	[illegible]	[illegible]
Speed, r.p.m.	[illegible]	[illegible]
Rated capacity, kw.	[illegible]	[illegible]
Overload*		[illegible]

*Overload based on initial pressure.

held in place by overhanging lips of the laminated mold. A puncture test of 15,000 volts was made on the armature winding and 1000 volts on the field. The generators will not exceed 40 degrees rise at continuous full load with a power factor ranging from 90 to 100 per cent., and at full load will give an efficiency of 94 per cent., including iron and copper losses.

The complete-expansion turbine unit has an overload capacity of 50 per cent., but the low-pressure turbine unit, being dependent upon a fixed initial pressure of 15 pounds absolute, can have no overload unless the initial pressure is raised. But with 18 pounds initial pressure, an overload of 25 per cent. would be realized; with longer cutoff on the engines, an initial pressure of perhaps 25 pounds would be obtained with correspondingly greater overload.

Governing

Owing to the service conditions arising in this plant, the simplest system of gov-

FIG. 5. [illegible]

erning has been adopted for the low-pressure unit. In fact, the turbine has no governor at all, but delivers its current to the same busbars as do the two engine units supplying it with exhaust steam. Under this condition, then, the low-pressure turbine is equivalent to the third cylinder of a triple-expansion steam-engine system, and instead of the turbine generator being directly driven by mechanical means from the engine shaft, it is held in perfect step by electrical means; i.e., by connecting with the same bus. It therefore occurs that with the turbine throttle valve open, the load on the turbine and engines will rise and fall together, depending upon the variations in external load, which accordingly varies the amount of exhaust steam supplied to the turbine. By reason of this arrangement, the pressure in the exhaust main varies according to the load on the entire plant, just as the receiver pressure of a compound engine varies.

The low-pressure turbine may be considered as an engine with a fixed cutoff. As the blade proportions are constant, the ability of the turbine to carry load depends entirely upon the initial pressure available; and consequently, as the load on the engine increases, the volume of steam passed per minute increases, the exhaust pressure rises and the low-pressure turbine is enabled to pass the extra quantity of steam required to generate the additional power. Thus it will be seen that this combination of prime movers presents simplicity and flexibility of operation. Under other conditions of service, where the turbine would be able to utilize but a small proportion of the exhaust steam available, it would be necessary to install a governor of the standard type which would convert the turbine into a constant-pressure instead of a variable-pressure machine, as here installed.

Turbine Construction

The construction of the turbine is clearly shown in the accompanying photographs and section. A low-pressure machine is characterized by the large steam passages necessary. Referring again to the accompanying table, the steam-supply mains to the high-pressure and low-pressure machines were 6 and 22 inches respectively; exhausts, 30 and 48 inches. It would be expected that this large difference would increase the bulk of the low-pressure machine beyond reasonable proportions, but through the adaptation of the Westinghouse double-flow design, the machine itself does not occupy even as much space as the single-flow complete-expansion turbine installed in the same power house.

On the other hand, the condenser serving the low-pressure turbine is twice as large as that serving the high-pressure machine; for the reason that in expanding the steam from boiler pressure, 150 pounds gage, down to atmosphere in the Corliss engine, nearly half of its internal work has already been expended, and twice as much steam must, therefore, pass through the low-pressure machine to do the same work as through the high-pressure turbine. The low-pressure turbine condenser at Gary, to be sure, serves 2500 kilowatts combined generating capacity, but owing to the superior economy of the combined plant, the work actually done by the condenser is much less than if serving a straight engine or turbine.

Referring to the sectional view of the turbine, it will be noted that the rotor is of simple construction and reasonable blade lengths, no balancing pistons, and a stator symmetrical in proportions. The disadvantage of excessively large exhaust areas is overcome by dividing the flow in its passage through the machine, combining the two halves in the bedplate into a single discharge to the condenser. In the foreground, Fig. 4, will be observed the automatic, quick-closing throttle which is operated by a centrifugal safety stop at the end of the turbine spindle. This is an important guarantee of the safety of the plant, for should the machine isolate itself electrically from the busbar either by short-circuiting or by an open circuit in the cable leads, the machine would be taking full steam without load. This safety stop operates at a predetermined overspeed, under 10 per cent., and closes the automatic throttle to shut down the machine. As a further precaution, a vacuum breaker may easily be operated instantly to lower the vacuum by the admission of air when the safety stop operates. Owing to the higher density, the turbine would then come to rest much more quickly than if it still were revolving in a high vacuum.

The remaining parts of the turbine conform to Westinghouse high-pressure turbine construction. One distinctive detail, however, is the rotary oil pump driven by worm gear from the turbine shaft. The wing pump is exceptionally simple and durable in construction, and requires little attention. It is located below the floor level at the base of the vertical housing surrounding the gear drive. This pump simply suffices to keep the journals flushed with oil. A complete system of strainer and intercooler provides for continuous return of the oil to the bearings. This apparatus, together with the steam strainer, is located beneath the steel floor plates at the side of the machine.

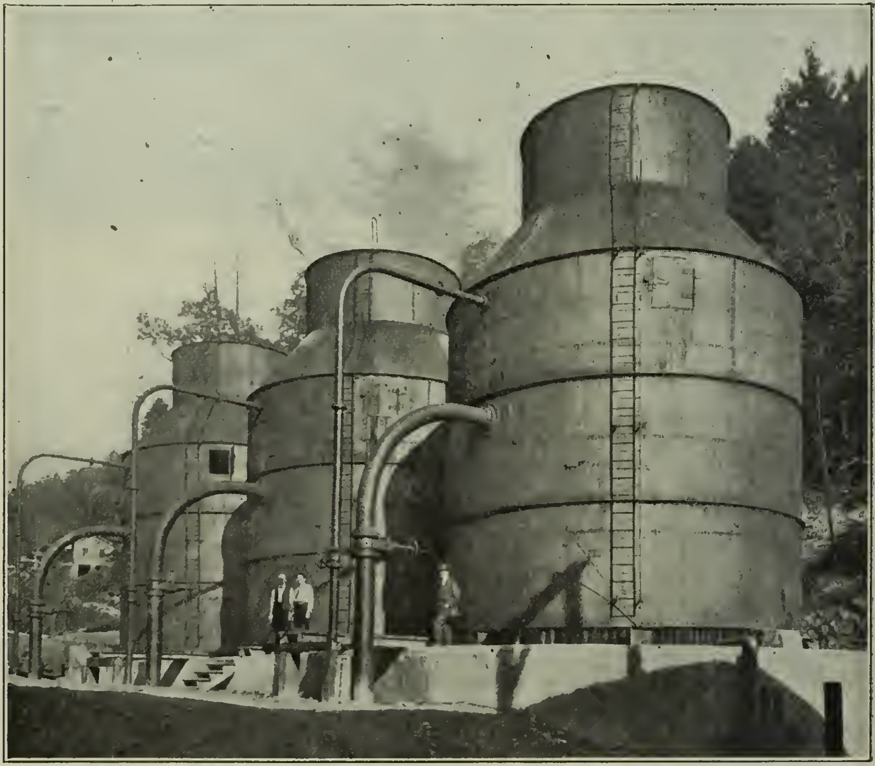


FIG. 6. BATTERY OF THREE ALBERGER COOLING TOWERS

Piping

Reverting to the plant arrangement, Fig. 2 shows in plan and elevation the general piping layout. It will be noted that all turbine-plant auxiliaries exhaust into the main low-pressure line in common with the steam engines. They do not appear to be affected by the variable back pressure of the exhaust system. A 22-inch separator on the side of the low-pressure turbine intake serves to abstract most of the suspended water of condensation, which, if passed through the turbine, would simply be detrimental in increasing the fluid friction. The piping is arranged so that feed water may be drawn either from the condenser hotwell, or the water-service main. In any event the feed would all pass through a Cochrane heater, where the oil coming over from the engines and pumps would be largely removed. Since the low-pressure plant went into com mission, a 3-inch live-steam connection has been made to the exhaust main through a reducing valve set at seven pounds. This is intended for emergencies only, to provide for either one or both Corliss engines being inoperative. It has been of service on several occasions to provide considerable overload capacity on the turbine during a deficiency of engine steam.

Condenser Plant

Both condensers are of the Alberger centrifugal jet type provided with individual turbine driven circulating pumps and engine-driven dry-vacuum pumps. All of the circulating water is cooled by a battery of Alberger cooling towers located a short distance away, each measuring 24 feet in diameter by 34 feet high. These are of a recent type, but standard in regard to the cooling surface employed. A distributor of the "Barker's Mill" type delivers the hot water at the top of the tower. But the draft fan, instead of being located as is ordinarily the case, at the base of the tower, is here installed horizontally in the contracted stack, the fan blades covering the entire area of the stack, which is 11 feet in diameter. This fan is driven at a speed of 175 revolutions per minute by a small Pelton waterwheel which, in turn, is supplied by a small turbo-pump located in the power house. With this arrangement the tower operates upon the induced-draft principle, and it is permissible to lower the shell some 5 or 6 feet below the standard type of tower with base fans, thus effecting a considerable saving in the hight to which the water must be elevated. Of the three towers installed, two were normally employed to serve the combined engine and low-pressure turbine plant, and the third, the high-pressure turbine. Thus far, good service has been obtained from this plant. Considering the combined plant only, with the two engines running and an engine load of 1400 kilowatts, the low-pressure turbine carried 1200 kilowatts with an inlet pressure of 16 pounds absolute and a vacuum of 25.8 inches, due to the high temperature of the injection water, 88 degrees, at the time. These observations were taken during hot weather, and with an increased vacuum, 28 inches, as in colder weather, the turbine would carry loads up to 1500 kilowatts.

E. O'Toole is general superintendent of the plant, and Howard N. Eavenson, chief engineer. The latter reports that with the relief valve set at 16 pounds absolute and the two Corliss engines running, a great deal more steam is obtained than is needed by the low-pressure turbine, even when running at its full load of 1500 kilowatts. This, then, makes the interesting combination of a low-pressure turbine without a governor running on a system of fixed back pressure and excess steam, which virtually amounts to no control on the turbine other than the throttle; i.e., the turbine carries a steady load as long as there is an excess supply of steam.

Gas Engines and Engineers

By F. L. Johnson

One day not long ago a friend, who had spent a great deal of time during the past few years attempting to design a noiseless gas engine, called to explain why more or less noise was necessary in the operation of a gas engine. Just as he had made it plain (to himself, if not to me) that the valve cams, gears and the mushroom-headed valves were of necessity more noisy in their action when used on a gas engine than when employed in the same way on a steam engine, my young friend Sawyer was shown into the room. Introductions followed, and the conversation was resumed.

"It has been found," said the designer, "that machinists and handy men make much better gas-engine operators than regular steam engineers."

Sawyer, who has a settled conviction that it is a steam engineer's business to know more about the theory and practice of operating moving machinery than anyone else, at once became interested and asked for an explanation.

To make his point clear, the designer said:

"The machinist's one real advantage over the steam engineer is that he does not know how to run a steam engine, and because of his ignorance of the steam engine or of any type of engine he will naturally be more inclined to accept advice and instruction.

"Steam engineers expect engines to run quietly. Machinists do not know whether they should be noisy or not, and the usual noises which accompany gas-engine operation do not annoy him. Not expecting any particular sounds, he accepts the noises as he finds them as a matter of course and attempts no adjustments until he knows what to adjust and why it needs adjustment."

"In other words," broke in Sawyer, "the machinist-operator handles a gas engine just as he does a lathe, a planer or a countershaft. He oils the [illegible] parts in the morning and [illegible]. The countershaft gets attention when it squeaks and he runs the machine until something fails. Then he reports to the foreman and a mechanic is called in to fix things.

"I have never known an engineer who would not give an engine a chance to prove what it could do before starting in to make changes, and I do not believe one would treat a gas engine differently from what he would a steam engine. Of course, he does not like the everlasting clatter of cams and gears, because he has known these things to operate noiselessly in other places and does not understand why they need to be noisy here."

As the designer saw that my young friend was getting in earnest, he said, in a conciliatory manner:

"If the steam engineer will not demand of the gas engine that which it cannot give, and will leave all adjustments alone until he understands what the effects of making them will be, he will be able to hold his own against all comers."

Soft words and superior smiles in this case did not produce the desired effect, and my friend Sawyer, trying to conceal as much as possible his earnestness, said:

"I was present at a meeting of mechanical engineers where the alleged unfitness of the steam engineer successfully to operate suction producers and gas engines was dwelt upon and the present and prospective owner gravely cautioned against employing an attendant whose previous condition of servitude had been in the boiler room or otherwise connected with the operation of a steam engine. And I wish to say that I know that the steam engineer will have little or no difficulty in demonstrating his fitness for the work of operating gas engines and producers should any of your superior class of thinkers ever succeed in designing a machine of nearly enough correct thermal and mechanical principles to be operated by anybody, not to mention the intelligent teamster taken from his seat on the wagon box, or the laborer drafted from the dirt pile and its attendant pick and [illegible].

"Your remarks remind me of the time when a whole lot of college electrical engineers condemned the Corliss engine as unfit for driving electrical generators because of the impossibility of satisfactory speed regulation. Most of these men have lived to see most of the electric current used for power and light come from generators driven by Corliss engines. It is the same class of professionals who to-day demand that a gas-engine operator shall be different from the steam engineer. Just how you want him different you do not say, but you leave it to be inferred that those characteristics which are the making of the successful steam engineer are handicaps on the other.

"It is perhaps possible that in the course of evolution from some of the masses of cast iron, steel and brass assembled by the cut-and-try process, with inaccessible moving parts mounted by [illegible] and [illegible] engines, a machine will be produced that, like the brush, will go on forever, requiring little or no skilled attention and no mental effort on the part of the operator. The steam engineer whose trade it is to operate and care for moving machinery will be found the most successful in overcoming the difficulties of gas-engine operation and maintenance."

Inaccuracies of Indicator Diagrams

Distortion of Pencil Motion Due to Inertia, Pressure Lag or Inaccuracies in Mechanism and Spring. Calibration of Indicator Diagrams

BY JULIAN C. SMALLWOOD*

Drum-motion distortion has been discussed in a previous article, and it has been observed that the errors inherent to the indicator emanate from the untruth of its drum motion and from the faultiness of its straight-line mechanism and spring. The former causes inaccuracy in the abscissas and the latter in the ordinates of the diagram. There is still another source of error in the abscissas, namely, the imperfection of the mechanism reducing the motion of the engine crosshead, but this is external to the indicator.

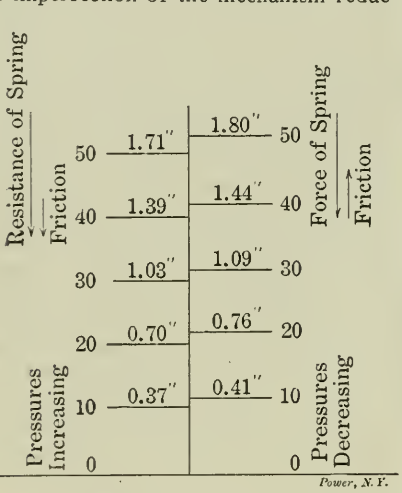


FIG. 1. CALIBRATION OF A 30-POUND SPRING

Distortion of Pencil Motion

Analysis of the pencil motion indicates that its distortion may be due to any or all of four causes: First, when applied to high-speed engines, the inertia of the indicator piston and attached linkage causes it to travel beyond its normal position. This results in a peaked admission line and a wavy expansion curve. Second, under the same conditions, the pressure in the indicator cylinder lags behind that operating on the piston of the engine because of the inability of the steam immediately to traverse the passages to the indicator. The error resulting is most considerable at about mid-stroke where the velocity of the reciprocating parts of the engine is greatest. The general effect is to increase the area of the diagram, cutoff and compression being represented later than they actually occur. Third, the mechanism actuating the pencil may incorrectly magnify the piston motion, and, fourth, the indicator spring almost invariably fails to exemplify the principle upon which its truth depends, that the contraction or extension of the spring is proportional to the force causing it.

Inertia—Of these four possibilities of error the first is troublesome only at high piston speeds. It may be obviated by the use of special indicators or by using stiff springs. Concerning the ordinary types, Professor Reynolds** has pointed out that the effect of inertia of the indicator piston and the attached moving parts can be expressed by two equations, one of which gives the probable distortion in per cent. during one cycle of the mechanism, and the other gives the number of oscillations of the pencil arm during that cycle. The same authority states that the former should be kept within 1 per cent. and the latter within the number 30. Using these figures the following values may be obtained from his equations:

$$s = \frac{0.00563\ W R^2}{a\ r}$$

and

$$s = \frac{0.0252\ W}{a\ r\ R^4},$$

where

s = Spring scale,
R = Revolutions per minute,
a = Area of indicator piston in square inches,
r = Ratio of piston to pencil motion,
W = Sum of the products of the weights in pounds of the separate moving parts and the squares of the ratios of such parts' motions to that of the indicator piston, respectively.

These equations may be reduced for any particular indicator to the form,

$$s = K R^2 \quad \text{and} \quad s = \frac{K'}{R^4},$$

in which K and K' are the constants combined. The greatest value of s resulting from their solution will give the lowest spring scale to be used for a given number of revolutions per minute.

Pressure Lag—The second cause of distortion of the pressure line, named above, cannot well be avoided at high speeds, nor can the resulting error be easily corrected. The disturbance is aggravated by long or tortuous pipe connections and may be considerable on this account even at low piston speeds. A comparison of diagrams taken with long and short connections shows that such piping should always be as short and direct as possible. The consequent error in mean effective pressure may be as high as 25 per cent.

Mechanism and Spring—Of the remaining sources of inaccuracy in the diagram's ordinates, that due to faulty pencil motion is in good indicators so small as to be unmeasurable. But the untruth of the spring not only may be very marked in a particular specimen, but may change with its use and age. Professor Carpenter, in a paper† discussing a lengthy series of calibration tests upon indicator springs, states that their "errors are of such magnitude that they cannot in general be neglected." Because of this fact it is the chief purpose of this article to tell how indicator springs may be tested and calibrated. It will be noted in the following that the corrections provide for error of the pencil linkage as well as of the spring.

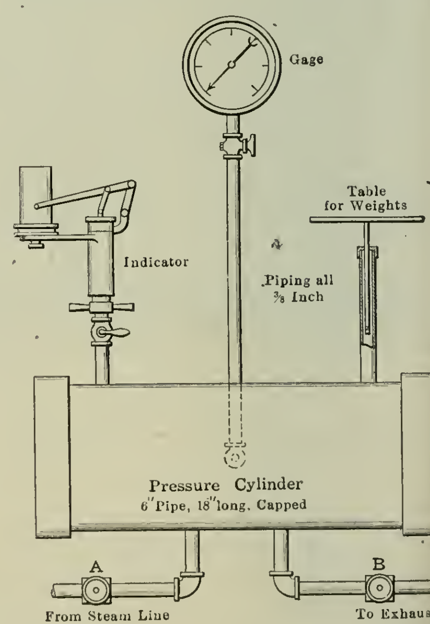


FIG. 2. TESTING BY STEAM PRESSURE

Calibration of Indicator Springs

It is first necessary to apply known pressures to an indicator which is fitted with the spring to be tested. Horizontal

*Instructor in mechanical engineering at the University of Pennsylvania.

***Proceedings*, Institution of C. E., Volume LXXXIII.

†*Transactions*, A. S. M. E., Volume 15, page 454.

lines should then be drawn on a card to correspond to these pressures. The vertical distances between the separate lines and the bottom one may now be used to obtain a value of the actual spring scale. Referring to Fig. 1, five horizontals corresponding to pressures of equal increments are shown on the left, the pressure increasing. On the right the same is shown with the pressure decreasing. It will be noted that these lines do not coincide. The reason for this is that the friction between the piston and the cylinder walls and in the moving parts aids the resistance of the spring when the pressure is rising, but acts against it when falling, as is represented by the arrows. The conclusion will therefore be reached that to calibrate accurately an indicator spring, steam pressure should be used so as to reproduce exactly the conditions of friction, temperature, etc., met with in practice. This, however, is not always convenient and, when it is not, pressure may be applied mechanically to obtain a reasonably accurate calibration.

Steam Pressure—Fig. 2 shows an apparatus for obtaining steam pressure of any desired amount up to that of the line. The drawing will be readily understood when it is explained that by adjusting the valves *A* and *B* the pressure is varied, and that the "table" is for the purpose of measuring it. An accurate gage would serve the purpose as well but because of the unreliability of gages, this device is preferable. The table is of known weight and is integral with a rod which terminates in a plunger of small cross-section. The steam pressure within the cylinder may be measured by balancing it with standard weights placed on the table.

Mechanical Pressure—For the purpose of applying mechanical pressure to the indicator piston, the author suggests the simple lever shown in Fig. 3. This is of oak, with metal strips *S* screwed to the short arm of such weight as to maintain equilibrium in the position shown. A weight equal to that of *A* and *B* may be hung at *E* when balancing. The detail of the piece *A* will be noted. It is a piece of rubber which fits into the lower side of the piston, and is backed by a special washer fastened to it. The rod *B* is made of ¼-inch round iron rounded at one end and filed to a knife edge at the other. The purpose of the combination is to transmit the load from a precise lever arm uniformly to the piston. In the position shown in Fig. 3, a one-pound weight on the weight pan *P* will effect a load of five pounds on the piston, which is equivalent to a steam pressure of ten pounds to the square inch, as the area of the ordinary indicator piston is one-half of one square inch. Thus, with 10 one-pound weights a 50-pound spring may be tested to 100 pounds. To test a lighter spring the weight pan may be placed nearer the fulcrum with a consequent reduction of force at the piston, the jockey weight *J* being employed to compensate for this change of position of the pan.

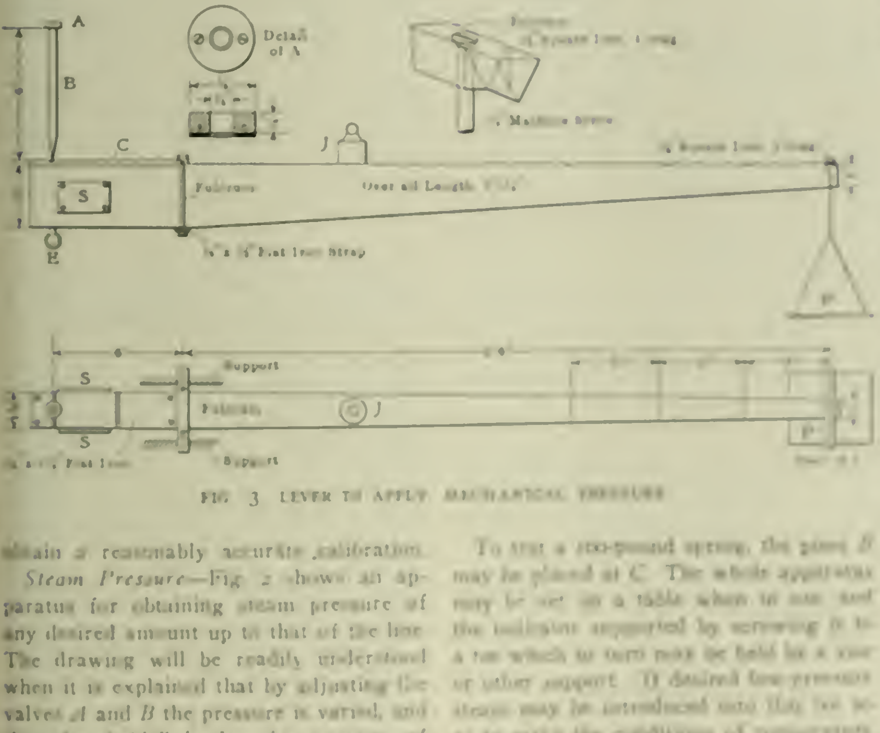


FIG. 3. LEVER TO APPLY MECHANICAL PRESSURE

To test a 100-pound spring, the piece *B* may be placed at *C*. The whole apparatus may be set on a table when in use and the indicator supported by screwing it to a tee which in turn may be held in a vise or other support. If desired low-pressure steam may be introduced into this tee so as to make the conditions of temperature, friction, etc., more nearly those obtained in practice.

In the series of tests performed under the direction of Professor Carpenter, it appeared that a calibration of indicator springs tested cold resulted in an average spring scale 1.8 per cent. less than that obtained when heated first. Professor Carpenter further states that by reducing the spring scale determined with the spring cold by this per cent. an error of not more than 1 per cent. may be expected.

Whichever apparatus for testing is used the results are to be applied correctly to calibrate the spring. For this purpose any of the following three methods may be selected, depending upon the degree of accuracy desired.

METHODS OF CALIBRATION

Referring first to Fig. 1, the figures placed on the horizontal lines give the distances of each line from the bottom one or zero. Obviously, the distance between two lines corresponding to the same pressure represents double the value of the friction of the moving parts in the position corresponding to that pressure. It will be seen that to apply these results correctly it would be necessary to alter the ordinate of each point on the diagram and to construct an entirely new one. This, however, is so cumbersome a process as to be out of the question, especially as a single calibrated value of the spring scale combining those of the ascending and descending scales usually gives very acceptable results.

Extreme Values—To obtain a rough approximation of this combined scale, the highest ordinate of each set of lines, Fig. 1, may be divided into its corresponding pressure and the two averaged. Thus in the example cited,

$$\left(\frac{50}{1.71} + \frac{50}{1.81}\right) \div 2 = 28.4.$$

This is a crude result and has the disadvantage that it is impossible to tell its limiting degree of accuracy or whether the error is positive or negative. The method has this merit, however, that if one of the scale divisions of a gage is known to be correct, then by its aid the above determination may be quickly and conveniently made. For example, suppose a gage has been compared with a known boiler pressure of 90 pounds and its error determined at this pressure. If now a simple slide-valve engine with indicator connections is accessible, it may be used instead of the apparatus in Fig. 2. To do this the indicator cock should have [illegible] so it is [illegible] of which [illegible] to the indicator fitted with the spring to be tested and the other on the gage. If now the throttle of the engine is put on dead center so that it will not start, the steam valve and one of the cylinder drain valves may take the place of valves *A* and *B* in Fig. 2. The steam is first allowed to flow through the drain from the main and then the lower valve slowly closed until the gage registers 90 pounds. A line may then be drawn to give the ascending scale. The drain should now be closed to raise the pressure above 90 pounds and then [illegible] opened until it has dropped to that amount to obtain the descending scale.

Graphic—A close approximation of the actual spring scale may be obtained by plotting the results in the form of two curves, as shown in Fig. 4, pressures as abscissas and heights of lines as ordinates.

A straight line is passed through each curve, so inclined as to deviate from it as little as possible. If, now, the tangents of the angles made by these straight lines with the vertical axis are separately multiplied by the ratio of the scales of abscissas to ordinates of the curves, the values resulting will be the new ascending and descending spring scales. From Fig. 4 these values are,

$$\frac{10}{0.2} \times 0.589 = 29.45$$

and

$$\frac{10}{0.2} \times 0.577 = 28.85,$$

the mean of which is 29.15.

Inspection of these straight lines shows that neither of them passes through the origin of coördinates, and it may be said generally that this is a characteristic of such calibration curves. The cause of it is lost motion in the pencil linkage, and friction. If these did not exist, a straight line passing through the origin and parallel to the one found would result.

Least Squares—The graphic method depends upon estimating the "most probable" straight line represented by the points plotted and is necessarily a guess. But it may be expressed algebraically, and from the equation a value of the spring scale may be found by the method of least squares. By this process the best obtainable result will ensue. No attempt will be made here to explain the theory of the method; only its particular application to the subject under consideration is given. The equation of the calibration line is,

$$p = h\,s + c,$$

from which

$$ph = h^2\,s + ch,$$

where

p = Pressure corresponding to the hight of the ordinate h,
s = Spring scale and
c = Unknown constant.

The observations shown in Fig. 1 are substituted in these equations thus, to obtain the descending scale:

$$\begin{aligned} p &= hs + c \\ 10 &= 0.41s + c \\ 20 &= 0.76s + c \\ 30 &= 1.09s + c \\ 40 &= 1.44s + c \\ 50 &= 1.80s + c \\ \hline 150 &= 5.50s + 5c \end{aligned}$$

$$\begin{aligned} ph &= h^2s + hc \\ 4.1 &= 0.1681s + 0.41c \\ 15.2 &= 0.5776s + 0.76c \\ 32.7 &= 1.1881s + 1.09c \\ 57.6 &= 2.0736s + 1.44c \\ 90.0 &= 3.2400s + 1.80c \\ \hline 199.6 &= 7.2474s + 5.50c \end{aligned}$$

The last equation of each series is the sum of the equations preceding it, and dividing these resulting equations respectively by the coefficients of c contained in them, the following results are obtained:

$$30 = 1.1s + c$$

$$36.29 = 1.3177s + c.$$

From the solution of the two equations:

$$s = \frac{6.29}{0\ 2177} = 28.89$$

pounds for the descending scale, and similarly for the ascending scale, $s = 29.33$ pounds per inch. The mean of these values is 29.11.

To compare the results obtained by the three different methods, the following is instructive:

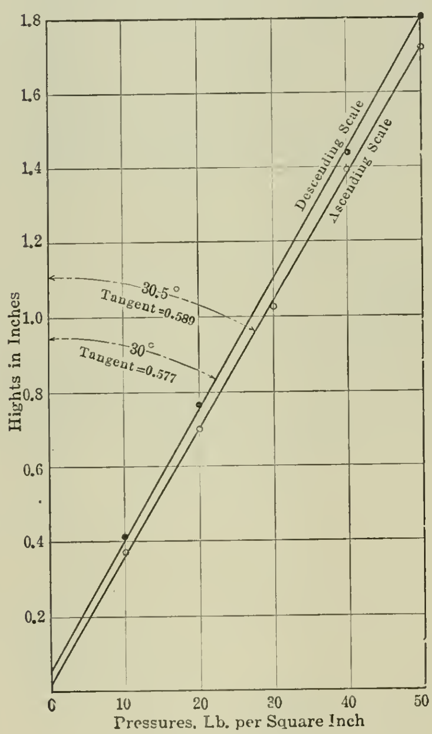


FIG. 4. CALIBRATION CURVES FOR A 30-POUND SPRING

Method.	Ascending Scale.	Descend'g Scale.	Mean.
Extreme values..	29.25	27.8	28.5
Graphic..........	29.45	28.85	29.15
Least squares....	29.33	28.89	29.11

An examination of these results shows that there is 0.13 per cent. of error involved in the graphic method, assuming the value obtained by least squares as correct. The accuracy of this method is dependent upon that of the estimation of the straight lines and the limitations common to graphic measurements. Referring to the first set of values tabulated, that for the ascending scale is fairly close; but, because that for the descending scale is low, the mean is 2 per cent. in error. The explanation for these disparities is found on the calibration curves. If the points whose coördinates have been used in the calculation lay on the lines, and if the ordinates of these points were corrected by subtracting from them the intercepts of the lines with the vertical axis, respectively, the results would be correct. It is impracticable to determine these intercepts, however, without actually drawing the lines. The error caused by neglecting them obviously is less appreciable when the values of the ordinates are high, and this is the reason why the hights at the greatest pressures are used in the calculation.

In conclusion, it may be well to lay stress upon the fact that the accuracy of calibration is primarily dependent upon the truth of the pressure-measuring device. If weights are used, as suggested, their values must be definitely known, as any error will be magnified. The conditions of practice, as to lubrication, etc., must be as far as possible duplicated. If the method of least squares is used the calculations must be performed with precision to the last decimal, as will be apparent from the sample calculations in this article. In any case, the more determinations made the closer will be the result. With reasonable care in making observations, distortion of the pressure line may be compensated for within 1 per cent. of error.

Motive Power Equipment for Textile Establishments

In an informal talk before the Southwick Textile Club at Lowell, Mass., recently, Charles G. Burleigh referred to some of the blunders made in the motive equipment of textile mills and pointed out the advantages of alternating-current motors and steam turbines for that class of work. To begin with, he strongly urged leaving the engineering details of the power equipment to the manufacturer of the apparatus, selecting a manufacturer who has had creditable experience in this particular class of work. This advice was based on the hypothesis that no reputable manufacturer can afford to recommend anything else than the most satisfactory types and sizes of machine.

Direct-current generators and motors are less desirable than alternating-current machines, he said, because of the limited voltage, which militates against a central power plant for a large group of factory buildings, and the commutators and brushes of the motors, which are undesirable from the insurance point of view and are much more expensive and troublesome to maintain than the simpler induction motor. The gradual increase in the speed of a direct-current motor, due to the heating of the field-magnet winding and consequent decrease in field excitation during each day's run, was also cited as a serious disadvantage. In order to avoid overspeeding a textile machine after the field winding of the motor becomes warm, he explained, it must be operated at less than its rate of maximum production while the motor is warming up.

Mr. Burleigh then reviewed briefly the advantages of electric drive over distributed shafting and belting, flexibility of control being the chief benefit.

He advocated the use of the steam turbine for the prime mover in the power house on the score of reliability, economy in first cost, operating expense and floor space, absence of oil in the exhaust steam and the feasibility of taking steam out from the intermediate stages for dyeing, bleaching, etc. He favored the Curtis type of turbine because it is obtainable in either the vertical or the horizontal form, the speed rate, in revolutions, is lower than that of other types, the distance between bearings is shorter, there is no appreciable end thrust in the horizontal form and the clearances are relatively large for a given economy.

The Conservation of Our Water Powers *

By John F. Vaughan

There are two subjects we have heard a great deal about lately: (1) The combining of corporate interests, and (2) The conservation of our natural resources.

Probably the most important example of corporate combination has been in the merging of steam railroads into a few comprehensive systems. This has been followed by a more or less successful movement to consolidate lighter electric railroads, with a tendency further to combine these with the older steam roads. And now in the development of high-tension electrical transmission we have the physical means of combining widely scattered water powers, and in the adoption of electricity as a distributing medium a strong incentive for the combination of interests of all three of these classes: Heavy and light railroads and water powers.

As a matter of fact the combining of steam and electric railroads has already begun, and now there is scarcely a steam road in the country which is not seriously considering electrification of at least a part of its system, and there are many which are either acquiring or are actually developing water power privileges to furnish them with motive power. Here, then, among the railroads we find a common interest in the economic development of our water powers.

The second subject—that of the conservation of our natural resources—in its bearing on the welfare of the country is of general interest to railroad men, and so far as it affects the regulation of stream flow is of especial importance to them, wherever water power is available. As traffic grows, as train weights and speeds increase, and fuel becomes more scarce and more costly, water must be more and more depended upon for power.

The present rate of deforestation, increased as it is by fires set by passing locomotives, in its effect on the reliability of water powers, and on the increase of damage by flood, demands serious consideration.

Water-power Resources and Development

Now what are our water-power resources and to what extent have they been developed? The fullest source of information on the extent of the country's water-power resources is in the admirable hydrographic work of the United States Government, but unfortunately this is still insufficient for making more than approximate figures, and while the records of stream flow are fairly comprehensive, comparatively little is known of the possibilities of storage.

The following conservative estimate of the water-power resources of the country has been published recently by Mr. Van Schon. He gives the amount of water power already developed as 2,250,000 horsepower, and the available undeveloped power, without the help of storage, as [illegible] horsepower.

H. St. Clair Putnam, in his address before the recent conference called by the President at the White House, estimated the total unconserved power available in the streams of the United States considerably higher, i.e., 30,000,000 horsepower, which is equivalent to the total power of all kinds now installed in our land industries. He assumed that with storage and supplemental plants this may be increased to 150,000,000 horsepower, or five times the present total power of all kinds in use. Now, when we find the demand for power increasing at the same rate as our manufactures, mining output, product and railroad earnings—that is, doubling every ten years since 1870—we have evidence enough of the increasing value of water powers. Right in New England, yes, even in Massachusetts, where Dr. Stillman has made the surprising statement that there is more water power going to waste than is consumed in the whole of Niagara, we have plenty of opportunity for improvement.

Requirements for Successful Development

Now what are the requirements for this successful development, and why has it not been more rapid? The reasons have been partly lack of available market for the energy, partly the excessive cost of development and partly the difficulty of stream regulation. With the old type of water wheel and costly mechanical transmission, it was necessary to use the power at the wheel, and then with perhaps only a part of the fall available without elaborate and costly canal systems. The more recent turbine and pelton impulse wheel, although utilizing the full head of the fall, have been still hampered by the necessity for using the power near the fall. But now, with the growth of electrical transmission not only can remote markets be reached, but powers formerly inaccessible may be developed and operated singly or in groups, for better economy and efficiency. Thus the differing characteristics of power markets may be largely equalized and better service and larger returns obtained from the investment.

The best examples of the consolidation of water powers are in the California system, where plants scattered through the mountain valleys feed into common networks of transmission lines, serving large territories with power for railway and industrial plants, pumping, etc., and in some cases delivering the discharged water for irrigation; and the best example of combination of markets is in the great systems of Niagara, delivering power over hundreds of miles of lines for an infinite variety of uses.

We have good examples of the use of water power by railroads in the plans of the Chicago, Milwaukee & St. Paul, which is already making the initial development of some [illegible] horsepower available in 35 miles of the St. Joe river, for operating its trains electrically over the Great Divide, in the electrification of the Cascade tunnel of the Great Northern railroad, in the conversion of the Harriman lines around San Francisco, in the equipping of the New York Central for operation by Niagara power, and in many light electric railroads all over the country.

Requirements for Economical Use

Let us see what the principal requirements for the economical use of our water powers are:

Stream flow should be considered so as to get the maximum energy out of the stream as a whole, and not merely for the benefit of certain isolated plants. For instance, no one plant with storage should be allowed to hold back the natural flow when required by down-stream users who have no storage to draw on, or to flood them with excess water when detrimental to their interests.

The storage facilities of the drainage basin should be developed as far as practicable for equalizing the natural flow of the river, increasing the capacities of the various developments and reducing possible damage from floods. For instance, where any development uses more than the capacity of the ordinary natural flow of the stream, [illegible]

*A paper read before the New England Street Railway Club.

by other power, or the excess sold as cheaper secondary power subject to interruption, even an average stream will waste more power than it can use, and a torrential stream, which may flow in flood over one hundred times its low flow, will give up only a few per cent. of its total energy. It is evident that expensive storage cannot be accomplished without the coöperation of the power users and an equitable sharing of the expense.

A Good Example of Stream Control

Perhaps the best example we have of stream control is in the Merrimac river, where through the coöperation of milling interests at Lowell, later joined by Lawrence mills which shared the expense, the storage facilities at Winnepesaukee, Squam and other lakes were developed and a comprehensive plan of stream measurement and control established, and today the use of water at Lowell, Lawrence and Manchester is so closely watched and regulated that during dry months practically no water is wasted, and during last summer's drought, although the various small tributary streams furnished practically no supply, the flow of the river held up remarkably well.

As far as possible various plants should be tied together to feed into a common network of distributing lines so as to utilize the stream flow to its best advantage, to equalize local peaks and irregularities of load, to reduce surplus investment in spare and breakdown capacity, to cut down distribution costs, and to improve the regulation of the system. By such combination the number of units in each plant may be reduced, hydraulic and electric designs simplified, complication of switching and control cut down, and a corresponding saving made in fixed charges and operating costs. In this way many communities may be served which otherwise could not support the burden of individual development.

Arrangement with other power producers should be considered for the interchange of surplus power, especially where the peak demands are not simultaneous. For instance, an agreement between a lighting company and a coal mine in Pennsylvania for the interchange of power up to 2500 kilowatts, where the mine shuts down before the peak of the lighting load, now enables each to reduce its fixed charges on spare equipment and to improve its load factor.

Utilizing Surplus Power

Surplus power during light demand, or surplus water, should be utilized for industrial purposes, such as pumping, electrochemical or metallurgical processes. For example, the electrical recovery of peat from wet bogs and the manufacturing of fertilizers and certain other products of modern chemistry from nitrogen recovered from the atmosphere are not wholly visionary, nor is it necessarily crazy to use surplus flow to pump water into reservoirs above the natural water levels for use during dry periods or excessive loads. In certain localities surplus or discharged water should be utilized for water supplies or irrigation. Groups of plants now on the old series canal systems, or plants otherwise inefficient in the use of water, should be redeveloped.

Robert E. Horton recently pointed out, in an address before the Schenectady branch of the American Institute of Electrical Engineers, a number of opportunities of this kind among our eastern streams; as, for instance, at Holyoke, where there are about fifty mills taking water from a series of canals at three different elevations; at Cohoes, at the junction of the Mohawk and the Hudson, where about thirty mills draw on five canal levels. There are also many cases where for the same reasons the available fall is divided up by series of low dams, each with its own wheels dependent on the dams above for water and liable to backwater during flood.

Obstacles to be Overcome

There are, of course, many obstacles to overcome before our streams can be properly controlled and their power utilized to best advantage; legal tangles to straighten out, franchise restrictions to modify, dams to build and to rebuild, and innumerable physical and operating details to work out. But water is a permanent asset which is neither burned up like fuel nor carted off like our mineral resources, but returns with every fog and rain storm to be used again.

In the interdependence of the territories embraced by the various watersheds our interests in this asset become national, warranting federal control, or at least State action under federal supervision, and already we have in the hydraulic work of the New York State Water Supply Commission, established under the Fuller bill, a substantial advance made in the study of the storage possibilities and in its effect on present and future water powers of the State, and in the National Conservation Commission, appointed by the President, a definite establishment of Government policy. Both of these commissions recognize that the conservation of our water supply is of sufficient importance to call for comprehensive plans of water storage and stream control, and that the Government should eventually distribute the cost of such improvements among all interests in proportion to the benefits received.

On this basis, then, the water-power interests will be required to carry only a burden in proportion to the benefits they receive; and such a policy will not only enable individual enterprises to develop their resources to best advantage, but will give their properties a more definite and permanent value.

In this general movement toward stream betterment there is a definite beginning of a more economic use of our water-power resources, and in the growth of electrical transmission a means of reducing both first cost and operating expense. And from whatever point we view the matter we have plenty of reasons for encouraging the conservation work already begun by the Government and, in addition, plenty of opportunity for studying the improvement of our existing powers and the development of new.

Comparative Tests of Coal

By Peter H. Bullock

At present there is a good deal of uncertainty about the quality of coal delivered to customers in the East, and this applies to all coals regardless of the names they may be sold under. Coal has been sold and delivered under a hyphenated name that carried only a suggestion as to quality, and that suggestion would only be founded on the fact that either before or after the hyphen there would be a familiar name. John Smith-Pocahontas, or Georges-Paul Creek might be very good or very poor coal. Some buyers have adopted the B.t.u. system, the price to be a sliding scale determined by the analyses of samples of the coal. This seems to be fair, but it is one thing to know how many B.t.u. there are in any coal, and quite another to catch all the B.t.u. in the furnace.

It would appear that the only information needed by the purchaser is, how much water can be evaporated under regular conditions with a dollar's worth of coal? The exactness of chemical analysis is not to be doubted, but it is also certain that a fireman will sometimes do better with coal that does not show up the best when so tested.

It will undoubtedly be admitted that better tests can be made in small plants where all the coal and water used can be weighed and the steam generated applied to the usual and regular service. In large plants where there are many boilers and frequent changes of men, it is practically out of the question to deal with the whole plant and get satisfactory results. Of course it is possible to cut out the feed pipe of one boiler and weigh the coal and water fed to it in any given time, but the expense and the uncertainties that attend such a test make it advisable to provide a simple apparatus for this especial purpose Accordingly, the writer has designed and put into operation a small plant for comparative tests of all coal purchased. It will be noted that the word comparative is used, for the simple apparatus installed leaves out many things that are taken in standard tests. Not but what these data are valuable, but because they are not necessary in a case where the efficiency of apparatus is not a question, and it is only necessary to determine how much water one dollar's worth of A, B or C's coal will evaporate in a furnace and under precisely the same conditions.

Testing Apparatus

The testing apparatus is simply a plain return-tubular boiler 16 inches in diameter and 4 feet long, with thirty $1\frac{1}{4}$-inch tubes 3 feet long. It is set in firebrick and has a dumping grate of $1\frac{1}{2}$ square feet area. It has no fittings except a gage glass, and is fed through a funnel from a tank setting high enough for the purpose. The outlet pipe is short, open to the air and large enough to carry off all the steam the boiler can make. The stack is 8 inches in diameter and is used only to carry away the smoke, the necessary draft being furnished by a fan and engine run by steam from another source, so that the intensity of the draft can be maintained at any desirable point, and is measured by a U-tube at the ashpit.

When a test of fuel is to be made, light wood is burned until steam is flowing freely from the pipe. The hight of water in the gage glass is then noted and 4 pounds of fine wood is put into the furnace to start the coal fire. Then 100 pounds of coal is burned, and all the water that possibly can be is evaporated. When the coal is all burned the hight of water in the gage is left exactly the same as at the beginning of the test. It is then known how much coal has been burned and how much water evaporated.

The tubes, furnace and ashpit are now cleaned and all the refuse weighed, giving the percentage of combustible. To get the moisture in the coal $6\frac{1}{4}$ pounds, or 100 ounces, is put into a shallow baking pan which is placed in a flue where there is a current of air at 120 degrees and is left there for five hours, when it is again weighed and the loss noted. There may be some objection to this method, for it may be claimed that in order to get all the moisture out of the coal, the temperature should be 212 degrees. This treatment, however, leaves the coal practically dry, is as fair for one man's coal as another's, and the higher temperatures would in some cases carry off volatile gases that might better be left, as they have a fuel value which the seller is entitled to have the benefit of. The temperature of the water used is taken. The price of the coal is known, the equivalent between any temperature and 212 degrees is known, and it is then a simple matter to obtain the comparative amounts of water that the coal from A, B or C has evaporated in the same apparatus and under exactly the same conditions. The data can be reduced to either of two units: cost of evaporating 1000 pounds of water, or how much water will one dollar's worth of coal evaporate? The comparative economy is the same whichever unit is used.

A Question of Moisture

There is a question in regard to the moisture in the coal at the time of the test and the moisture in the coal at the time it was weighed for shipment. The bills are made out at the time of shipment, and if the coal is wet when weighed the water in the coal is paid for. The sample tested may have become partly dry so that the actual amount of coal burned would be that much more than would be represented in the bill. On the other hand if the coal was dry when weighed and it had been exposed to wet weather, the amount of fuel in the test would be less by an amount equal to the weight of water added. Recently a car was received that had been three weeks in transit and showed 9 per cent. of moisture in the 120-degree five-hour test. If the facts as to moisture could be settled when the coal was weighed and billed, it would be easy enough to make the proper allowance for any wetting or drying it got between the weighing and the testing points. This seems to be practically out of the question, and, of course, every dealer would claim that the coal was dry when weighed and that he ought to have the benefit of the doubt in the test.

In a trial test under standard conditions the quality of the steam as to dryness has to be taken into consideration, but in this apparatus the coal is burned to the best of our ability, clean water is fed into the boiler and to all appearances nothing but good, honest steam goes out of the pipe. At any rate it is the same as to conditions at all times, as an even draft is maintained and about as much coal burned per square foot of grate per hour as in regular work in the fire room.

The writer has uniformly found a greater per cent. of ash than the sellers want to admit. This may be due to the fact that the tubes, setting and furnace are brushed clean after each test and everything is weighed as ash, for it all comes from the coal and certainly is not combustible. In tests under commercial conditions, no doubt considerable ash and dust escape that properly belong in the ash column.

Tests of Sample Lots

In samples Nos. 1 and 2 in the tests following the coal was the same, only in No. 2 sample it had been exposed out of doors to the sun and rain for six months in an open box. For samples Nos. 3 and 4 coal was taken from the same car, only No. 4 had been kept in a closed box indoors for six months. The last two samples tested substantially the same, while sample No. 2 showed a loss from exposure. It is improbable, however, that coal in large, deep piles will lose its heat value to any great extent, although the exposed surface of a large pile for a few inches in depth might readily do so.

Recently the writer made a test of some coal and put another similar quantity under water for a future test, the first sample being left under water until [illegible] it would be perfectly saturated, or, of course, the other would be when taken out for trial. For an exact comparison this method would appear to be better than to make figured corrections for moisture contained; besides, it keeps the local conditions of firing the same in both cases.

In the test records the unit of comparison is the cost of evaporating 1000 pounds of water into steam at zero pressure, and the formula is:

$$\frac{1000 \times \text{Pounds of coal burned} \times \text{Price per ton}}{\text{Pounds of water used} \times \text{Factor of evaporation} \times \text{Pounds per ton}}$$

Samples Nos. 1 and 2 were taken from the same car and each weighed 100 pounds with 7 per cent. moisture. Sample No. 1 was tested at once and No. 2 six months later after being exposed to the weather in an open box, so that at the time of the test it carried 12 per cent. of moisture. As the lots of coal when bought and weighed were the same, and the moisture at the time of testing different, the computations were made on dry coal in each case, so that instead of using 100 pounds as weighed, 93 pounds of dry coal was substituted, and the amount of water considered to be in the coal was added to the amount evaporated. No. 1 sample contained 11.5 per cent. of ash, and the cost to evaporate 1000 pounds of water was found to be:

$$\frac{1000 \times 93 \times \$4.40}{(796 + 7) \times 1.157 \times 2240} = \$[illegible]$$

Sample No. 2 contained 12 per cent. of ash and the cost was:

$$\frac{1000 \times 93 \times \$4.40}{(587 + 12) \times 1.17 \times 2240} = \$[illegible]$$

Samples Nos. 3 and 4 each weighed 100 pounds and were taken from the same car. No. 3 was tested at once and No. 4 was put into a closed box and kept six months. Moisture was not found in either case, and ash in both lots was 14½ per cent. To evaporate 1000 pounds of No. 3 cost:

$$\frac{1000 \times 100 \times \$4.05}{811 \times 1.142 \times 2240} = \$0.195$$

and of No. 4:

$$\frac{1000 \times 100 \times \$4.05}{807 \times 1.179 \times 2240} = \$0.197$$

At the time the tests of samples Nos. 1 and 2 were made, the 12 per cent. of moisture seemed excessive, as 8 or 9 per cent. is usually considered about the limit. The writer has since made several tests for moisture and found that dry coal soon absorbs and carries up to 12½ per cent., but samples from lumps often left under the cover for several months seldom show over 4 or 5 per cent., [illegible] when unloaded. Can the [illegible] know the coal makes its [illegible] to the company without including [illegible] qualities with it? is a question that [illegible] would like answered.

The Plunger Hydraulic Elevator

Practical Instructions in the Care and Management of the "Standard" Plunger Elevator, Illustrating the Essential Features to Look Out For

BY WILLIAM BAXTER, JR.

Whenever it is desired to take out the main valve of the Standard plunger elevator, it can be removed through the back end of the valve cylinder. Before it can be drawn out, however, the rack at the end that rotates the pinion of the pilot valve must be thrown out of gear. To do this all that is necessary is to remove the hood in front of the pilot valve, into which the rack runs, and then the shoe that holds the rack and pinion in mesh can also be removed and the rack can be pushed to one side so as to clear the teeth of the pinion. When this is done the valve can be drawn out of the back end of the valve cylinder without difficulty.

To remove the automatic stop valves the cylinder head must be removed, and also the bonnet under the center. The cranks that operate the automatic stop valves are fastened to the shafts on which the operating levers are mounted by means of caps, and the screws that hold these caps can be reached when the bonnet is removed. If the cap is taken off the crank can be pushed upward and can be drawn out, together with the valve, through the end of the valve cylinder; all of which can be readily understood upon examining the valve drawing, Fig. 283, shown in a previous article. The cranks are keyed to the shafts, to prevent them from turning, and in putting the valve back care must be taken that the key is returned to position and the screws tightened up as much as they were before, so that there may be no danger of working the parts loose thereafter.

Pilot Valve Removal and Adjustment

The pilot valve, body and all, can be removed by taking off the end hood the same as for throwing the rack out of gear, as explained above. When this hood is removed, the bolts that hold the pilot-valve body can be reached and taken out and then the valve can be removed, together with the shaft that carries the pinion and the cams that prevent too rapid reversal of the elevator motion. A side view of all these parts is given in Fig. 307, which is a vertical section. This drawing does not show the means by which the valve body is fastened to the end casting of the main valve body; these consist of lugs that spread out on each side of the shaft L'' at the top and bottom, opposite the bearings through which the shaft slides. A view of the valve body at right angles to Fig. 307 would show these lugs, on opposite sides of the parts *E* and *F*. To remove the valve alone, all that is necessary is to take off the connecting arm *D* and the lower cap *C*; then the valve can be drawn out through the lower end.

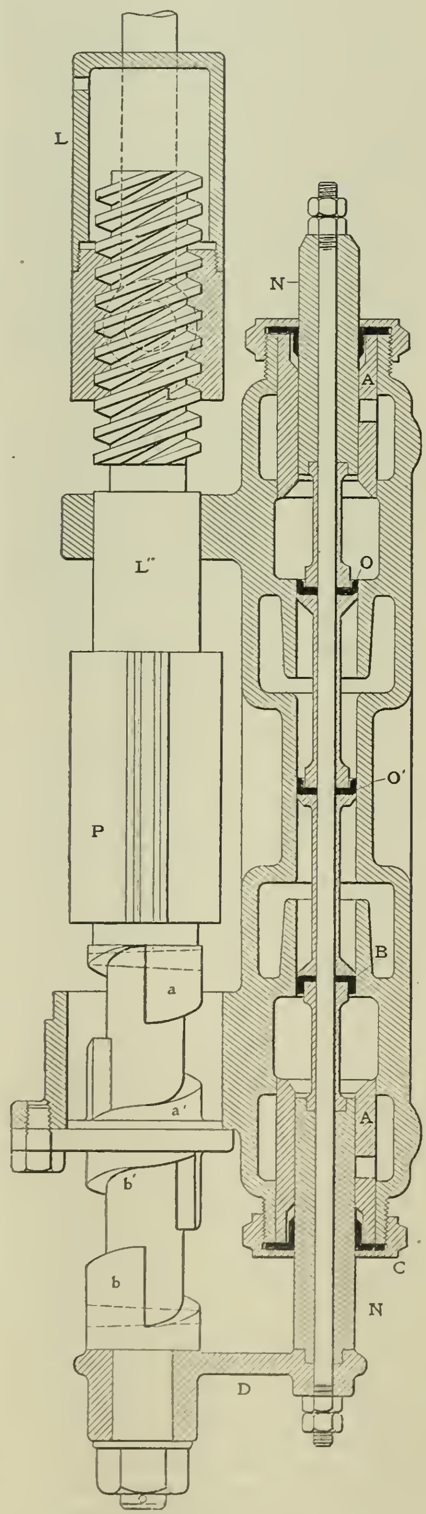


FIG. 307

Referring to Fig. 307 it can be seen that no provision is made for adjusting the position of the pilot-valve cup packings, nor for adjusting the cams *a*, *b*, *a'* and *b'*. Adjustment of the position of the cup packings would only serve to vary the lap of the valve, and such adjustment is not only not necessary but not advisable, because the manufacturers know better than anyone else what the adjustment should be and they make the valve of proper proportions. Increasing the depth of the cups will not have any effect on the lap of the valve, because they enter their seats back end first and make a joint after entering a certain distance, independent of the depth of the cup. Under certain conditions, if the edge of the cup projects beyond the end of the cylinder, water may force its way between it and the cylinder and thus leak through. This is not likely to occur, but as it may, it is wise to use cups of the proper depth, and no deeper. The cams require no adjustment, because all they are intended for is to prevent moving the lever any farther, in stopping, than it was moved in starting; and if once made of the proper dimensions to accomplish this result, they will always do so.

The only adjustment provided in the pilot valve is in the ports through the sleeves *A*, *A'* at the ends of the valve, and the similar adjustment on the side ports, which was fully explained in the article describing this apparatus. If in the course of time the water flowing through these port holes enlarges them so as to cause the main valve to close too rapidly in stopping, the proper adjustment can be obtained by running in the adjusting plugs a trifle. It may be found in making such changes that the car speeds up too fast in starting when the valve is partly opened in order to run at a slow speed. If this should be the case, the acceleration can be reduced by screwing in farther the plug opposite the port hole in the inner end of the sleeve *A*, and if after doing this the car does not get under headway fast enough when the valve is fully opened, the acceleration can be increased by drawing out one of the other adjusting plugs. In making these adjustments it should be remembered that a very small difference in the opening of the ports will make a decided difference in the rapidity with which the elevator will get under way; hence, the position of the plugs should be changed only a little at a time. In the type of valve shown in Fig. 283 the main valve is moved to the right to cause the elevator to start upward; it is also moved to the right to stop the elevator on downward trips. Therefore, if the flow of water through the ports of the top sleeve *A* is decreased, the effect will be to reduce the acceleration in starting on up trips, and to prolong the stopping on down trips. To stop going up and to start going down the main valve must be moved to the left, hence, if the adjusting plugs opposite the ports in the lower sleeve *A* are run in, the up stops and the downward starts will be made slower, and *vice versa*.

If the elevator is arranged so that the cylinder discharges into an open tank located on a level with the main valve, there will be no back pressure to force the water into the cylinder through the bypass connection, and the adjustment of the velocity of motion of the main valve must therefore be made so as to reduce the velocity enough to prevent jumping the plunger off the water in the cylinder when the car is brought from its maximum speed to a stop. If, however, the water in the cylinder is discharged into an elevated tank, or into a pressure tank, the valve is adjusted with reference to starting on the downward trips, so that the car may not move so rapidly as to produce an unpleasant sensation. Therefore, it will be seen that the adjustment of the plugs at the lower end of the pilot valve, opposite sleeve *A*, must be made with reference to the rapidity of stopping on the upward trips, with one method of piping, and with reference to starting on the downward trips with the other method.

The adjustment of the plugs opposite the sleeve *A* at the top of the pilot valve is made with reference to the rapidity of starting on the upward trips, and stopping on downward trips. There is little danger of starting too rapidly, because the water flowing into the cylinder has to lift the load, and it cannot very well get it under headway so rapidly as to produce an unpleasant sensation, unless the lifting capacity of the plunger is excessive, and the load in the car is light. In stopping on the downward trips, however, the reduction of speed can be so rapid as to greatly increase the tendency to buckle the plunger, hence the adjustment of the plugs at the top of the pilot valve should be made with reference to the rate of retardation of speed in stopping on the down trips, and this adjustment will be found satisfactory for the starting on upward trips.

In the valve shown in Fig. [illegible] the movement of the main valve is the reverse of that above explained, that is, the valve moves to the left to start on the upward trip, instead of to the right; hence the top adjusting plugs are used to do just what the bottom ones do in Fig. 283.

The Packings

All the packings used in the valves of the Standard plunger elevators are leather cups, as can be seen by looking at the various drawings we have presented. These packings are replaced in the same manner as in the elevators of other makes previously explained, and require no further explanation here. The stuffing box at the top of the plunger cylinder is packed either with hemp or any good soft packing, or with a specially constructed double cup leather packing. The cross-section of this packing is shown in Fig. 308. The packing is made in two parts, *A* and *B*, both of leather. These two parts are cut on one side so that they may be slipped over the plunger from the side, and they are placed in the stuffing box so

FIG. 308

that the joints are on opposite sides of the diameter.

To keep any hydraulic elevator in perfect running order it is necessary that all the packings be kept tight; if they are not, the car will not remain stationary when stopped at a floor, but will move gradually either up or down, according to where the leak is located. In plunger elevators, if the stuffing box at the top of the cylinder leaks the car will settle when standing at a floor. It is an easy matter to determine whether the cylinder stuffing box leaks or not, for if it does the water can be seen trickling over the top of the stuffing-box gland. If there is no leak at this point, then the trouble will be found in the main valve, which will permit water to flow through to the discharge pipe; hence, the packing in the piston that closes off the discharge must be renewed. If the car creeps upward after being brought to a stop it indicates that the cup packings in the valve pistons that close the supply ports are leaky. Sometimes the plunger after being brought to a standstill, creeps up a short distance and then creeps back, and continues this alternating motion indefinitely. This indicates that the pilot valve is defective, but as it is an occurrence that can take place with any type of hydraulic elevator it will not be explained here. In a future article this subject will be discussed in detail, by the aid of diagrams that will make the action perfectly clear.

In addition to keeping all the packings in good condition it is necessary that the running gear of the valves be not allowed to get out of adjustment. The rope that moves the pilot valve and those that operate the automatic stop valves must be examined frequently to see that they are in good condition and their fastenings tight, particularly so in the stop-valve ropes, because these valves are safety devices.

With the Standard plunger elevator system in which the discharge tank is closed and a pressure is maintained therein, it is necessary that the pressure be kept up to the proper point to obtain the best results. The pressure is required to cause the water to follow up the plunger when the valve is closed suddenly in making a stop on the up trips. If the pressure is permitted to drop the plunger may be drawn away from the water in the cylinder, with the results already explained. There is no danger of getting the pressure too high, as this is limited by the height of the reversed goose neck provided for that purpose. It is not desirable, however, to permit the pressure to rise above the proper point because too much water will be forced out through the goose neck, and this will have to be replaced by water drawn from an outside source, which generally will be at a lower pressure; hence it will represent just so much power thrown away. It is also necessary that the supply of air in the discharge tank be well maintained; otherwise, the pressure will vary too much when water is drawn from the tank or discharged into it. Whenever the construction of the building permits, the pressure in the discharge tank is obtained by locating it at the proper elevation, as this is decidedly the best arrangement, as the pressure then cannot vary. With an elevated tank all that is necessary is to keep the water at the proper level, so that the pipe running down to the cylinder may always be far enough below the surface not to draw in air.

At the University of Wisconsin, February [illegible], one hundred and fifty [illegible] engineers, [illegible] and [illegible] organized the Engineering Society of Wisconsin. The officers elected were: [illegible].

Municipal Producer Gas Plant at Peru, Ind.

A Lighting and Power Installation Which Supplanted a Steam-Engine Plant and Has Shown an Appreciably Reduced Consumption

BY OSBORN MONNETT

Producer-gas power is being successfully used in the municipal plant at Peru, Ind., generating electricity for city pumping, street lighting, commercial lighting and power service. It is supplanting a steam plant which has been variously estimated as producing a brake horsepower-hour on from 5 to 15 pounds of coal and, to date, with light loads and uneconomical conditions, has succeeded in reducing the of one pound of coal per horsepower-hour. At present the one unit installed, a view of which is given in Fig. 3, carries all of the street lighting, consisting of 160 series arcs, all of the pumping load and day power load, and half of the incandescent lighting. This necessitates running twenty-four hours per day.

The city pumping is done with two 2-stage Worthington centrifugal pumps, series, maintaining the maximum volume capacity of one pump and doubling the pressure.

The layout of the plant is shown in Fig. 2, and it can be seen that provision has been made for doubling its capacity. At present there are two 150-horsepower Smith suction producers installed, using semi-anthracite pea coal costing $4.50 per ton. The coal is delivered from the rail-

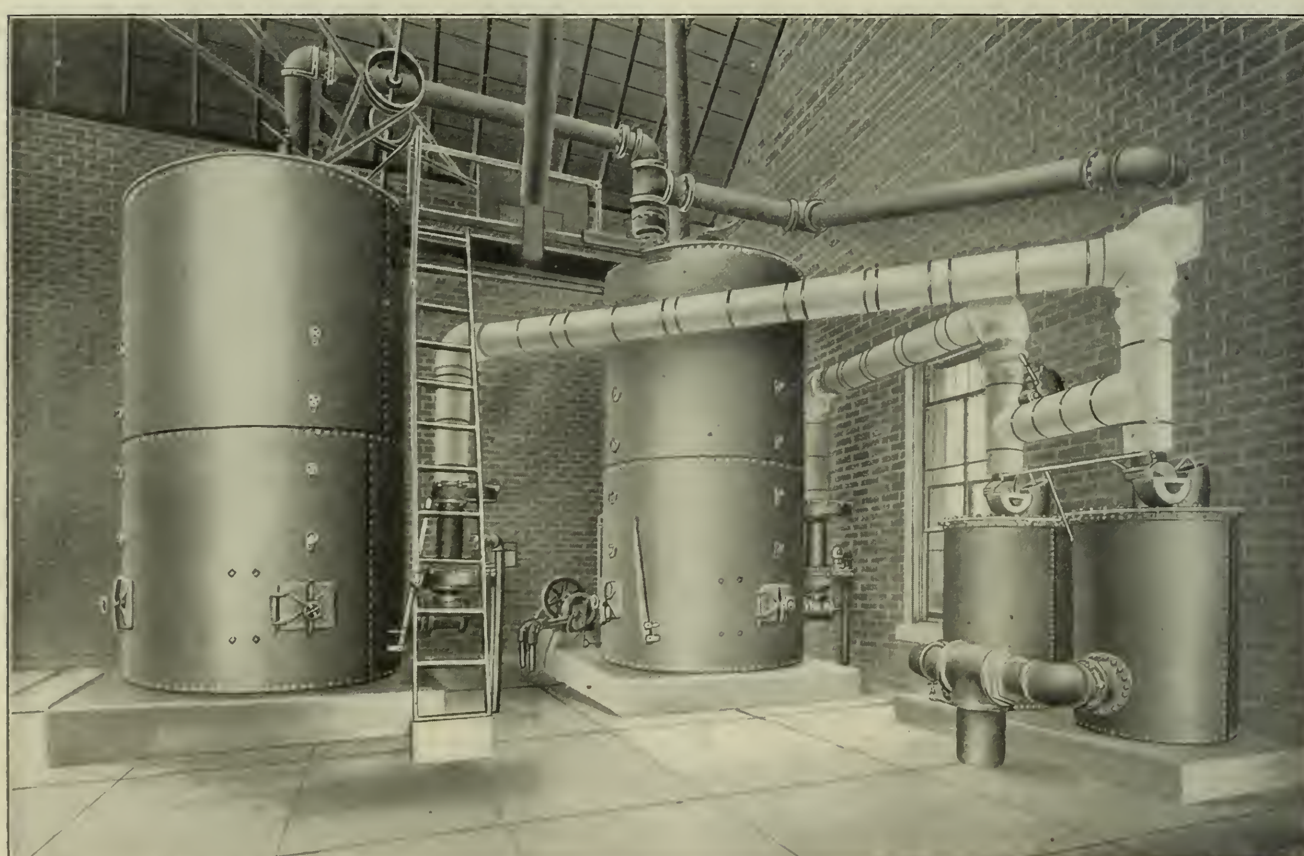


FIG. 1. PRODUCERS IN MUNICIPAL GAS-POWER PLANT AT PERU, IND.

consumption to 1.6 pounds. The steam plant consists of high-speed engines driving 133-cycle belted alternators through a jack shaft. During the period of transition from steam to gas power it has been thought advisable to change to the more modern 60-cycle system; consequently, both plants must be kept in operation temporarily and for this reason it has not been possible to load the gas-power plant sufficiently to come within its guarantee each driven by a 60-horsepower Western Electric induction motor. The pumps are located in a cement-lined water-tight pit, adjacent to the power plant, and are below the level of water in the wells from which the supply is obtained. Each pump has a capacity of 1,500,000 gallons in twenty-four hours, against the city pressure of 55 pounds. Valve connections are provided so that in the event of an alarm of fire the pumps may be connected in road cars into a storage bin and brought by an underground screw conveyer to a bucket elevator which discharges into a hopper. From here the coal is spouted to the charging platform of the producers. Centrifugal scrubbers are used, belt-driven by an 8-horsepower induction motor. A 6-horsepower "Model" gasolene engine is installed to operate a blower for starting the fires and a small air compressor for use in starting the engine; it also serves to furnish power for the centrifugal scrubbers before current is available for the motor.

The heat of the exhaust is utilized to generate the steam necessary for the producer generator and also to preheat the air used. In Fig. 1, at the right, can be seen the economizers in which this exchange of heat takes place; the exhaust gases from the engine pass in at the side and out at the bottom. The economizers also muffle the exhaust effectively, so that no other arrangement is necessary for this purpose, the exhaust pipe merely passing under the floor to a trench outside of the producer house.

Main Generating Unit

The main generating unit consists of a 300-horsepower vertical four-cylinder "Model" gas engine, direct-connected to a 200-kilowatt Western Electric revolving-field three-phase 60-cycle generator, with exciter belted from the main shaft. The engine, which was built by the Model Gas Engine Works, Peru, Ind., operates on the four-stroke cycle, with power strokes in the cylinders in the order of 1-3-4-2. An unusual feature is the construction of the cylinders, which are cast integral with the cylinder heads. This is well shown in Fig. 3, where the cylinder is seen to consist of one unbroken casting from the crank case up to the top of the head. This construction has been followed with satisfaction for years in all the smaller engines built by the company and is therefore continued in the larger sizes. It eliminates the gas joint and the water joint, and correspondingly reduces the liability to trouble. A partly sectional view of the cylinder is shown in Fig. 4. One important advantage of this construction is that by the elimination of the cylinder-head studs, an exceptionally large space is obtained for cooling water around the exhaust valve cage, which is obviously advantageous in cooling this important member. The cage and valve complete may be easily removed from the cylinder for inspection and repairs. On the valve stem is located a dashpot to cushion the valve when closing; this is shown in Fig. 5, which illustrates the valve and cage complete with the rocker arm, spring and dashpot. From Fig. 6 the method of cooling the valve itself will be apparent. The stem is hollow and the incoming water passes through an inner tube down to the valve head and up through the annular channel between the wall of the valve stem and the outside of the tube, passing out through a hose connection.

At the side of the cylinder is the inlet-valve chamber, over which a removable cover is bolted, making it easy to remove the valve for regrinding and repairs. Both valves receive their motion from cams on a shaft located outside of the crank case, the movement being transmitted through rollers to the push rods.

On the push rod leading to each exhaust is a small hand lever which when turned has the effect of lengthening the rod and holding the exhaust valve [illegible] open throughout all strokes. This isolates the cylinder so that examination can be made and minor troubles corrected without shutting down the engine.

Ignition and Starting

Ignition is effected by a make-and-break system. The igniter shaft runs along the side of the cylinders, driven by bevel gears from the cam shaft. A belt-driven magneto is provided for regular operation and a battery is held in reserve.

For starting there is a [illegible] carrying two auxiliary cams on the end of the cam shaft. When this is shifted over by a

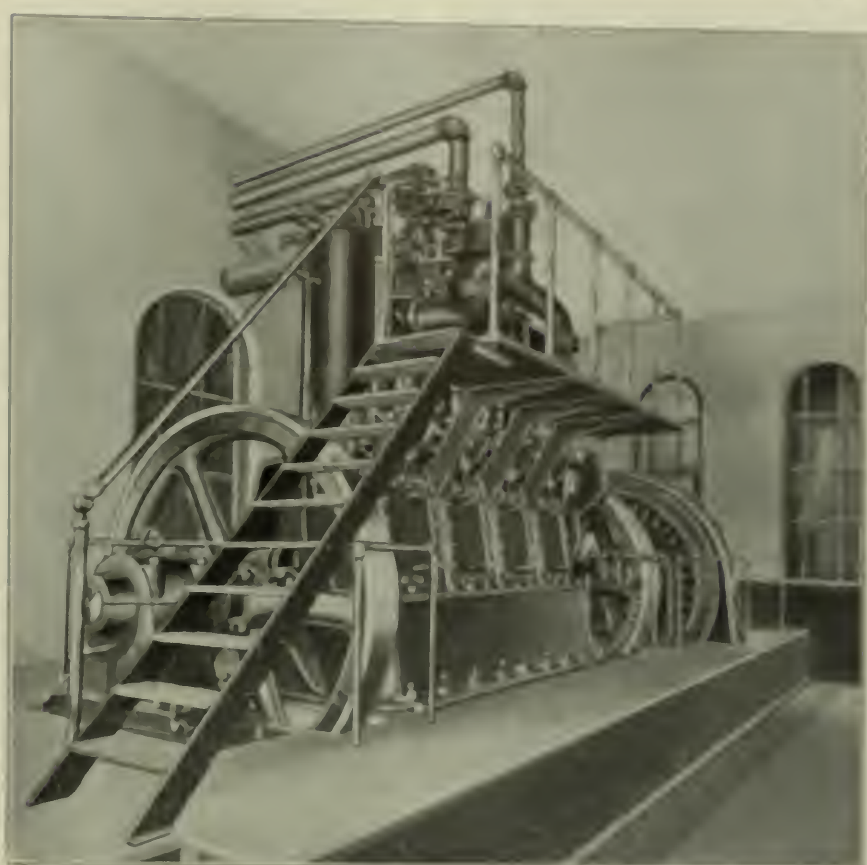


FIG. 3. ENGINE ROOM OF MUNICIPAL PRODUCER GAS-POWER PLANT AT PERU, IND.

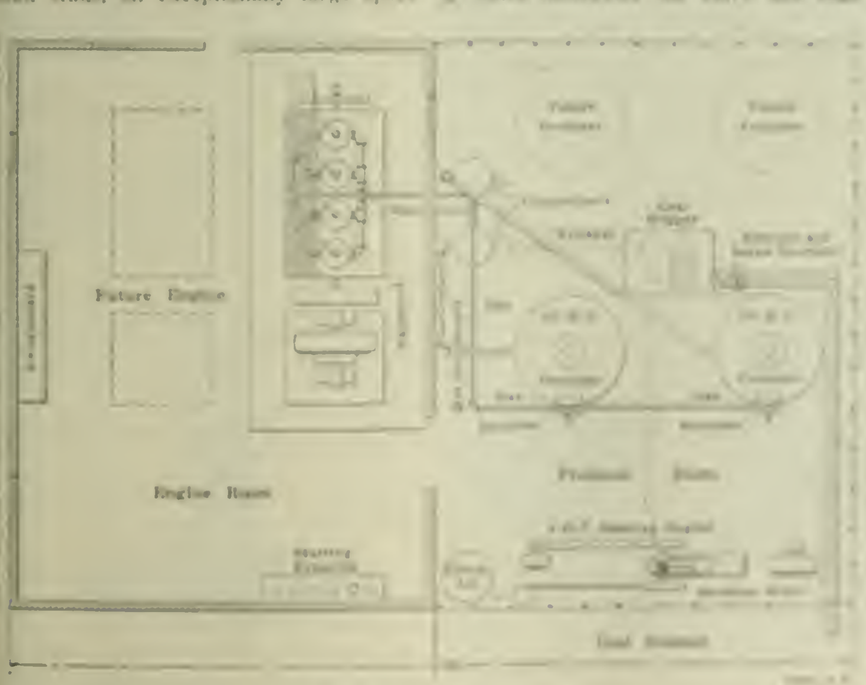


FIG. 2. LAYOUT OF PLANT

lever it throws out of commission the inlet cam on the first cylinder and one of the auxiliary cams opens the exhaust valve at each revolution; the other auxiliary cam engages a poppet valve in an air-supply line and is properly timed to run the first cylinder on compressed air until the others pick up the charges of mixture.

With the solid construction of the cylinders adopted on this engine, one of the first questions occurring to an operating engineer would be as to the method of removing a piston. This is accomplished by taking out the exhaust-valve cage, screwing an eye-bolt into the piston and, after disconnecting the crank-pin brasses, lowering the piston and connecting rod down into the crank case; they are then taken out through the crank-case doors. The piston, as shown in Fig. 7, has three packing rings above the wristpin and one below; it is also provided with three oil rings.

The lower end of the connecting rod is of the marine type and a plain cast-steel box, working on a wristpin sleeved with bronze is used at the upper end. One of the special features of the engine is the provision for varying the compression pressure by shortening or lengthening the connecting rods. The rods are hammered-steel forgings, finished all over, and screw into the top casting where they are locked in position with ⅞-inch studs and nuts, as indicated in Fig. 7. With this arrangement the compression can easily be changed to suit any kind of fuel or any altitude. Fig. 8 shows the complete details of construction.

The Main Bearings

Five main bearings are provided, with an outboard bearing outside of each flywheel. The bearings are set solidly into the frame, each one being braced with a heavy reinforcing rib which extends downward to the bottom of the frame and is firmly grouted to the foundation. As the thrust on the bearings is all downward, no adjustment is provided other than that necessary to follow up on the bearing caps. In order to prevent unequal wear of the bearings by reason of differences in lubrication, splash lubrication is not relied upon entirely; oil is forced to each bearing by a pump driven from the cam shaft. Oil from this pump is also forced to each piston in two places,

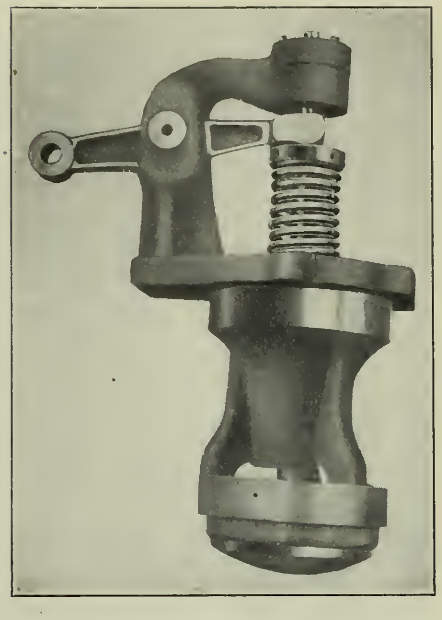


FIG. 5. EXHAUST VALVE AND CAGE

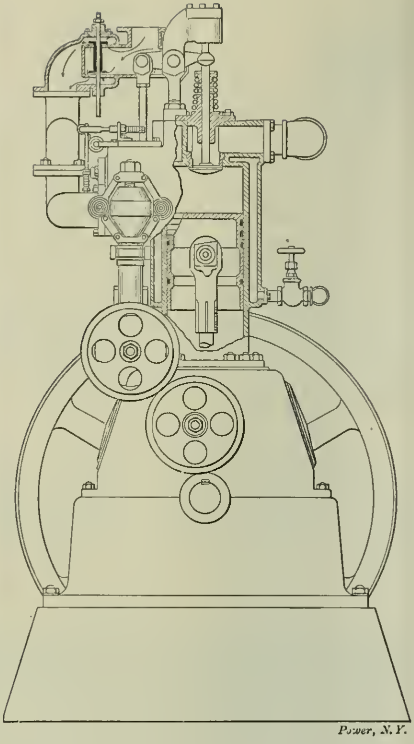


FIG. 4. PART SECTIONAL ELEVATION OF ENGINE

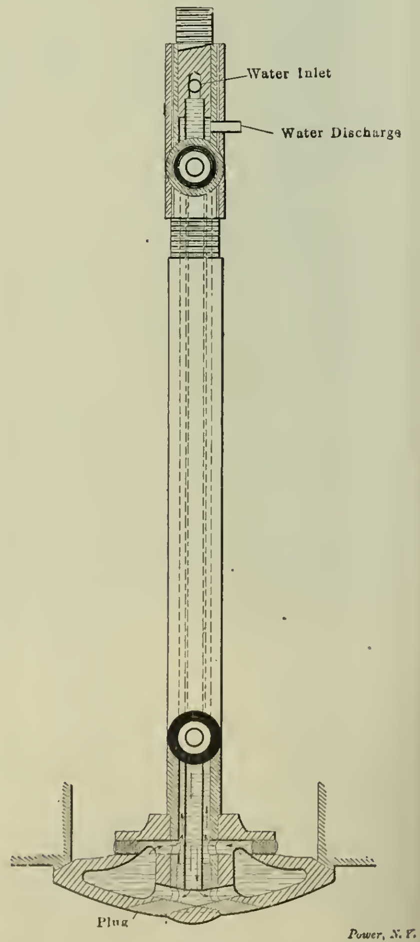


FIG. 6. SECTION OF WATER-COOLED EXHAUST VALVE

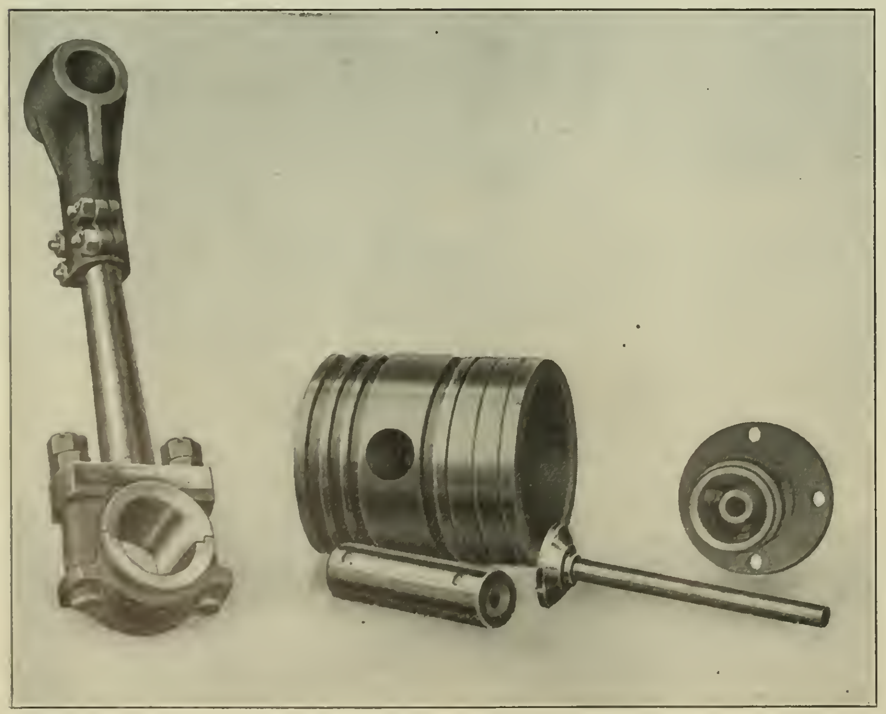


FIG. 7. PISTON, AND CONNECTING ROD

one on the thrust side and one on the opposite side.

Gas and air come to the engine through 5-inch supply pipes, each of which is provided with a lever-actuated gate valve by the manipulation of which the proper mixture may be obtained. The mixture then passes through a balanced throttling valve, shown in section in Fig. 4, which is controlled by the governor. The cylinders are connected in pairs by two inlet manifolds, and they are in turn united directly under the throttle valve.

The flyball governor is gear-driven and

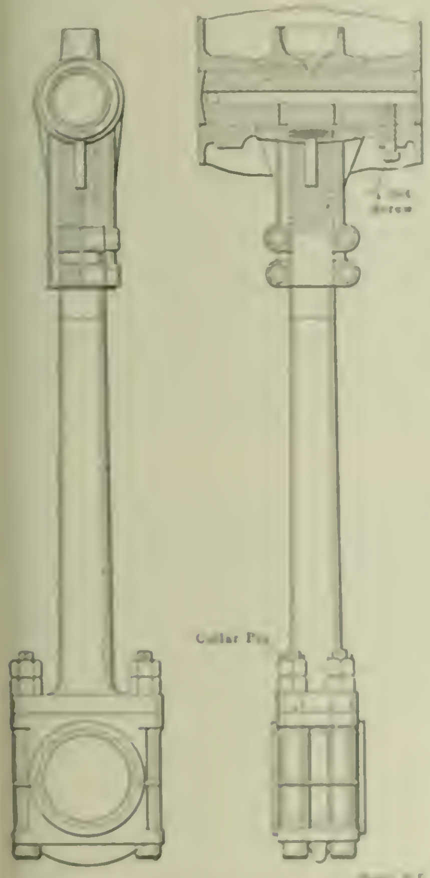


FIG. 8. DETAILS OF CONNECTING ROD

equipped with a dashpot to facilitate steadiness of operation. Ball-and-roller bearings are used in the governor mechanism and linkage.

According to a press despatch a company has been formed at Vineland, N. J., with a capital of $100,000, to develop the water power of the Maurice river. It will be known as the Maurice River Light, Heat and Power Company. A dam one-half mile long will be constructed, affording a head of 16 feet. Marcus Fry, of Vineland, is secretary.

The Combined Associations of Engineers of Brooklyn, N. Y., are up to the minute, especially in matters social, and they have already secured the date of July 18 at Bellwood park, N. J., for their annual outing.

Energy Charts for Steam

By R. M. Neilson

In steam-engine investigations involving the question of work obtainable from a given weight of steam, or the steam consumption to produce a given amount of work, it is, of course, necessary or desirable to know the maximum amount of energy obtainable from the steam. Mechanical-engineering pocket books and treatises on the steam engine commonly give tables of the properties of saturated steam, which include a column setting forth what is termed the *total heat* of steam. These "total-heat" values are often of great use; they represent the heat required to be put into 1 pound of water to raise it from 32 degrees Fahrenheit to the boiling point and convert it into steam at the boiling-point temperature. This temperature varies with the pressure, as is well known, and consequently the "total heat" depends on the pressure; at atmospheric pressure it is 1147 B.t.u., at a pressure of, say, 200 above atmosphere, it is about 1200 B.t.u. A "total-heat" table is, as aforesaid, of much use. For example, with steam-generator problems it gives—after deducting the difference between the feed temperature and 32 degrees Fahrenheit—the heat required to be supplied to the water in the boiler per pound of feed.

These total-heat values do not, however, represent in any way the work which can be got out of the steam. If we are told that a steam engine consumes 12 pounds of steam per hour per indicated horsepower, with a steam pressure of 150 pounds and a vacuum of 26 inches (with the barometer at 30 inches), we may want to know what would be the steam consumption of an ideal engine working under the same conditions, or—what comes to the same thing—how many foot-pounds of work is obtainable from a pound of steam expanding from 150 pounds to a pressure of 4 inches of mercury. No tables, as far as the author is aware, have been published which give this information. The information can certainly be obtained with a little trouble from entropy-temperature or other heat-energy charts which are in fairly common use, but not, the writer considers, in a sufficiently convenient manner. The average engineer wants a direct reading.

The charts shown on the accompanying supplement were prepared by the writer to give this direct reading. It is unnecessary to say here how the charts were prepared,* but it is desirable to explain how they should be used and, in order to do this, it is necessary to say something about the conversion of the energy of steam into mechanical work.

Steam does mechanical work when it expands against a resistance. Such expansion may take place in a steam-engine cylinder, the resistance being the load on the piston; or it may take place in a nozzle—say of a turbine—the resistance being the weight of the steam, the velocity of which is increased. Work in the one case is done in moving the load on the piston and in the other case in giving kinetic energy to the steam.

The steam may receive heat during the expansion, as in the case of a steam-jacketed engine cylinder, or it may have heat abstracted from it (beyond that converted into work) and transferred as heat to other bodies, as in the case of an unjacketed steam-engine cylinder. When the steam neither receives nor loses heat, as heat, the expansion is commonly termed adiabatic; but, as there is some difference of opinion as to the meaning of this term,** the word isentropic, about which there is no difference in opinion, will be used. The word isentropic signifies that no heat is added to or withdrawn from the fluid during expansion and, therefore, from the law of the conservation of energy, it follows that if the expansion is isentropic the work done, whether in driving the piston or in giving kinetic energy to the steam, must be an exact equivalent of the heat energy given up by the steam. In the case of saturated steam, the heat energy given up corresponds to a definite drop in pressure, so that a fall from one pressure to any other pressure by isentropic expansion corresponds to the performance of a definite amount of mechanical work. This work, whether performed in moving a piston or otherwise, is expressed on the charts in foot-pounds per pound of steam; in the case of steam expanding in the nozzle of a steam turbine it represents the kinetic energy acquired by the steam.

The smaller chart gives the work of expansion from initial pressures of from 25 to 250 pounds to final pressures of from 15 to 200 pounds, the initial pressures being written [illegible], while the abscissas or horizontal distances represent the final pressures and the ordinates or vertical distances the mechanical work done.

The large chart is a continuation of the other but deals with final pressures below atmosphere, the scale for final pressures being made much greater [illegible] than in the other chart.

How to Use the Charts

As an example of the use of the charts take the case of a noncondensing steam engine which consumes 25 pounds of steam per indicated horsepower per hour. This steam is supposed to be saturated [illegible] and at 175 pounds [illegible] gage pressure—that is [illegible] pounds absolute. It is required to compare the

*This is explained in the author's book "The Steam Turbine," [illegible]

**[illegible]

steam consumption of this engine with that of an ideal one; with an engine in which all the available energy in the steam would be shown on an indicator diagram.

Referring to the smaller chart, it will be seen that the energy obtainable from the expansion of 1 pound of steam from 170 pounds to 15 pounds (approximately atmospheric pressure) is 136,000 foot-pounds. Therefore to work at the rate of 1 horsepower for one hour, which means doing

$$60 \times 33{,}000 = 1{,}980{,}000$$

foot-pounds of work, would require

$$\frac{1{,}980{,}000}{136{,}000} = 14.6$$

pounds of steam, as against the 24 pounds actually used.

To show another and more important use of the charts, suppose that an exhaust steam turbine takes 33 pounds of steam per kilowatt-hour when the steam is supplied at atmospheric pressure (say 15 pounds per square inch absolute) and the vacuum is 27 inches, with the barometer at 30 inches (say 1½ pounds absolute pressure). It is required to find what less vacuum we can afford to have to obtain the same steam consumption, if we supply the steam to the turbine at 5 pounds above atmosphere, say at 20 pounds absolute. The kinetic energy obtained from 1 pound of steam expanding from 15 pounds absolute to 1½ pounds absolute is seen, on the large chart, to be 113,600 foot-pounds. Drawing a horizontal line through this point to cut the curve denoting 20 pounds absolute pressure, we find the final pressure to be about 2.1 pounds absolute; say 25.7 inches of vacuum with the barometer at 30 inches, the 5 pounds additional steam pressure therefore only allowing of a reduction of 1.3 inches of vacuum.

This assumes that the effective efficiency* of the turbine was equal in the two cases, which is generally approximately true under the conditions considered, but is not true with high steam pressures or very high vacua.

As a third example, suppose that it is desired to expand steam from, say, 200 pounds per square inch pressure, absolute, to 1 pound absolute, in four steps or stages so that the steam gives up the same amount of energy in each.

The energy obtainable from the complete expansion is, it will be seen from the large chart, 260,000 foot-pounds. Therefore, the total energy given up at the end of the first, second and third stages is 65,000 foot-pounds, 130,000 foot-pounds and 195,000 foot-pounds, respectively; and, by noting where the 200-pound curve cuts the horizontal lines representing these amounts of energy, we find the final pressure at each of these stages. These final pressures will be seen to be 70 pounds, 21 pounds and 5.05 pounds per square inch, respectively.

It may be well to point out that it must not be thought that there is an error because the chart gives the energy of 1 pound of steam in expanding from 70 pounds to 21 pounds, or from 21 pounds to 5.05 pounds, or from 5.05 pounds to 1 pound, as other than 65,000 foot-pounds. This is because, in the four-stage expansion considered, for every pound of steam at the start, we have not a pound of steam at the beginning of the second, third and fourth stages, but a pound of fluid which is partly steam and partly water, some of the steam condensing (according to well known laws) during the expansion.

Other uses of the charts will suggest themselves. In fact the writer has found that many problems that would have been ignored, or the results simply guessed, on account of the trouble of obtaining the available energy in the steam will, by the use of the charts, be scientifically solved.

*The effective efficiency is the ratio of brake work to available heat energy.

Value of High Pressure

The advantages of high-pressure steam, even when used in the single-expansion cylinder of a locomotive, are brought out in the "Report on High-Pressure Steam in Locomotive Service," issued by the Carnegie Institution, of Washington, of which a resumé has been issued by the University of Illinois.

Tests were made under the direction of W. F. M. Goss, dean of the College of Engineering at Illinois, in the laboratory of Purdue University, while he was connected with that college, to determine the performance of a typical locomotive when operating under a variety of conditions with reference to speed, power and steam pressure. The results of one hundred such tests have been recorded and show that the steam and coal consumption vary with the pressure as follows:

Pressure Lb. Per Sq.In.	Steam Per Ind. H.P.-H., Lb.	Coal Per I.H.P.-H., Lb.
120	29.1	4.00
140	27.7	3.77
160	26.6	3.59
180	26.0	3.50
200	25.5	3.43
220	25.1	3.37
240	24.7	3.31

The same results are shown graphically on the accompanying diagram. They show that the higher the pressure the smaller the possible gain resulting from a given increment of pressure. An increase of pressure from 160 to 200 pounds results in a saving of 1.1 pounds of steam per horsepower-hour, while a similar change from 200 to 240 pounds improves the performance only to the extent of 0.8 of a pound per horsepower-hour.

An increase of pressure from 160 to 200 pounds results in a saving of 0.16 of a pound of coal per horsepower-hour, while a similar change from 200 to 240 pounds results in a saving of but 0.12 of a pound.

CURVES SHOWING RESULTS OF TESTS TO DETERMINE TYPICAL LOCOMOTIVE PERFORMANCE

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

How to Make a Tool Board

In order to make a tool board large enough to hold all the wrenches, hammers, screwdrivers, etc., one may have use for, and wishes to keep in a handy place, first gather all the tools together and arrange them on a table in the position desired, so as to take up the least space and yet not be crowded when placing the heavy part of all tools upward. Then by measuring the length and width the amount of lumber required is determined. Note the thickness of the thickest tool and make that the thickness of the boards.

Call it, for example, 2 inches. Then get enough clear pine stock 1 inch thick and the same amount of second quality, also 1 inch thick, to make the size of board desired. Butt joint the best lumber and glue the joint and clamp well. When dry, place all the tools on this board, arranged as when on the table, and make an outline drawing around each with a pencil. Then nail on the second quality of 1 inch stock to the back, with the strips running at right angles. Then bore and jigsaw through both boards spaces to conform to the shapes and sizes of the tools, making the fit snug. Mark each piece 1, 2, 3, etc., as you saw them out; also number the places from which they were taken.

Next find the center of gravity of each tool by placing each across a knife edge until it just balances; mark the spot on the tool with chalk and place the tool back in the [illegible] space. Then in order to allow a good grip to be taken [illegible] tool, gouge out an opening [illegible] in proportion to the size and weight of the tool. Next nail [illegible] on the back, and [illegible] all the openings at the back [illegible] "[illegible]" [illegible] difference of thickness between the tools will thus be compensated for by [illegible] the backing [illegible] openings. Glue or nail them [illegible] when the tools [illegible] be flush with the outside of the board.

Next nail ogee molding round the edges and finish with sandpaper. Paint first with drop black, then a good coat of wood filler on front, back and sides, then two coats of shellac and two of furniture varnish. Rub down with [illegible] before applying the last coat of varnish. Next paint the bottom only of each tool receptacle white. The board when finished will have an appearance something as shown in the illustration.

A HOMEMADE TOOL BOARD

With this tool board all the tools are in sight, and if one is missing the white back will act as a telltale. They are so arranged that no amount of knocking [illegible] will knock them out.

If the back and front of such a board be varnished alike it will prevent warping. In hanging such a board I would advise the placing of two or more screws at the back close to the bottom, allowing them to stick out ½ inch, so as to make the board stand slightly back at [illegible] and so obviate the possibility of any tool falling out by jar or vibration.

Henry [illegible]

[illegible], N. Y.

Sparkless Commutators

Here are a few hints which, if followed by Mr. Baker, will help him to run his [illegible] without sparking. Keep the machines clean and dry and the commutator smooth, true and free from [illegible] [illegible] the copper coating of the brushes to come into contact with the commutator [illegible] [illegible] inch above the [illegible] and [illegible] sandpaper the heel and toe of the brushes round, after sandpapering each to a fit with no sandpaper [illegible] and use no lubricant of any kind on the commutator [illegible] [illegible] the brushes [illegible] when making contact on the commutator [illegible] When the load is light [illegible] brushes back and forth [illegible] until the proper [illegible] is found and then leave it [illegible].

If Mr. Baker follows these simple rules and still has sparks at the brushes he had better [illegible].

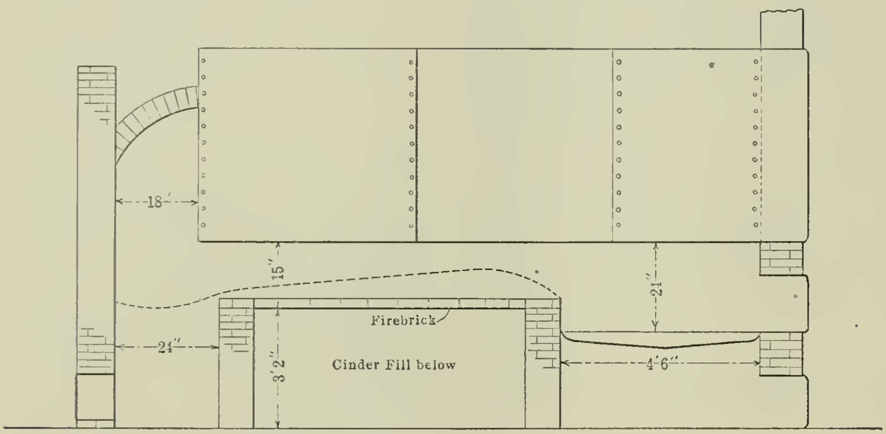
Frank [illegible]

[illegible], Mass.

Burns Too Much Coal

In our electric-light plant we have two 66-inch by 16-foot return-tubular boilers, set as shown in the accompanying sketch. We burn slack soft coal and occasionally run-of-mine, our regular working steam pressure being 100 pounds.

One boiler only is operated at a time, and usually at a comparatively light load, our runs being from sunset to midnight, with a short morning run during the winter. Our peak load amounts to about 75 horsepower for two hours, gradually running down to about 15 horsepower at midnight.



ONE OF THE BOILERS IN MR. SPRAGUE'S PLANT

I have never operated a boiler set in this manner for burning the fuel we do. I refer more especially to the combustion chamber, its construction making a contracted passage for the gases. The dotted line shows how I found the combustion-chamber ashes heaped up on my first cleanout, the rear end being entirely full. I have formerly been accustomed to combustion chambers that were much larger, either being entirely open behind the bridgewall, or sloped off to the rear from the top.

Our furnace is 6 feet wide by 4½ feet long. I am of the opinion that we would have better results from our fuel if the grates were set farther from the boiler shell, and in view of the light load it may be advisable to brick off part of the grate bars in the rear. The boilers have flush fronts and the lower part is separate, which would facilitate the construction of a dutch oven, should such construction seem advisable. The stacks are 32 inches in diameter and 60 feet high, and we have an excellent draft, but no damper regulator.

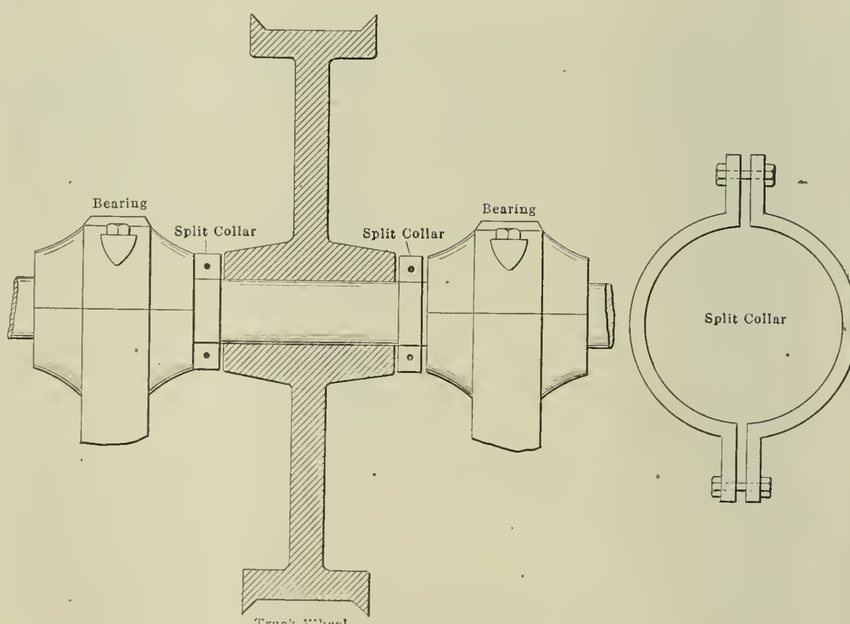
In checking over our output I find we are using about 18 pounds of coal per kilowatt, which I consider nearly double the amount we should require. Our engines are all in good condition and first-class adjustment. We run noncondensing.

G. S. Sprague.

Geneva, Neb.

Remedying a Traveling Crane Trouble

A traveling crane was driven by a double vertical steam engine and boiler located on the crane. The engine and boiler were replaced by a motor last summer, and after a few days it was noticed that the trucks on each end of the crane were not running in line.



HOW A TRAVELING-CRANE TROUBLE WAS REMEDIED

Upon examining the wheels on both trucks I found considerable play between the two bearings and the hub of the wheels, as shown in the illustration.

I filled this space with split collars, but in order to give the wheels a little play, a ¼-inch space was left between the hub and the two bearings. After the collars were put in place and the crane started, no further trouble developed.

H. Jahnke.

Milwaukee, Wis.

A Lighting Problem

In reply to Mr. Rolph's letter, as the transformer voltages or the lamp voltage were not given, I assume that the voltages are 110 volts between the middle lead and the outside ones and 220 volts between the outside leads of the transformer, and that the lamps are for 110 volts. If the lamps are of the assumed voltage, then series connections would not do; but if the lamps he has in mind are designed for series grouping, and if desired to run that way, it would be advisable to have a choke coil across the lamp terminals, so that in case the lamp failed, the coil would take its place and keep the remaining lamps burning.

As the town is small, it would be better to run the lamps in multiple and use 110-volt lamps. This would only require another length of wire in addition to that required on the series circuit, and the extra insulators and pins. This would do away with the necessity of the choke coil, and each lamp would be independent.

To balance the transformer it would require seven of the lamps per circuit, one circuit taking the middle and outside lead and feeding in one direction and the other circuit taking the middle and opposite outside lead and feeding in the other direction.

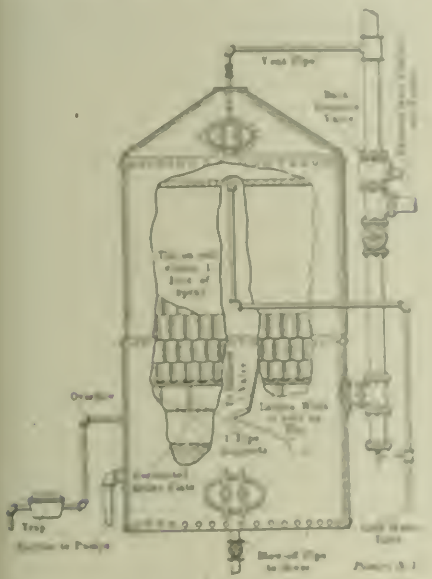
Another scheme would be to feed the circuits with 220 volts and connect the lamps in multiple series. This can be best determined by local conditions. The arc circuits are connected all right, but it is best to run the three wires both ways from the transformer for the commercial circuits, and care should be taken to keep the load evenly divided between them.

JAMES E. KILROY.

Lincoln Place, Penn.

A Homemade Heater

The accompanying sketch is of a homemade heater made out of an old tank. It is 6 feet in diameter and 10 feet high, and takes care of 1000 horsepower of



A HOMEMADE HEATER

boilers. The draintile must be renewed about once a year, according to the condition of the feed water. It has been in use about one and one-half years and at the present time there is no sign of any oil in the boilers.

JOHN S. JUNG.

Milwaukee, Wis.

Difficulty in Starting a Motor

One of our customers using a 5-horsepower 220-volt two-phase motor experienced considerable difficulty in starting, due to the belt slipping off. The motor was not furnished with a starting compensator and the owner did not care to go to the expense of procuring one, so we rigged up a four-pole double-throw switch, as shown by dotted lines in Fig. 1, and at the same time connected the neutrals of the two-pole transformers together.

The switch was thrown to the right, the motor starting off without a jerk, and when up to speed the switch was thrown to the left. On starting the situation was as shown in Fig. 2, the motor leads 2 and 3 being connected to line 2, motor lead 4 to line 3, and motor lead 1 to line 1, making one half of each phase acting together on a full coil of the motor; this gave 155 volts instead of 220, as the voltages of the two phases are 90 degrees apart in

FIG. 1

FIG. 2

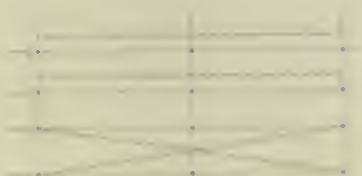


FIG. 3

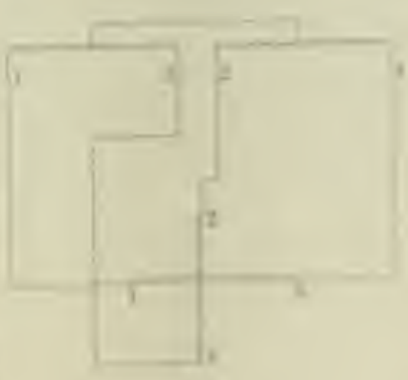


FIG. 4

phase and the resultant voltage is the square root of the sum of the squares, or

$$\sqrt{110^2 + 110^2} = 155.$$

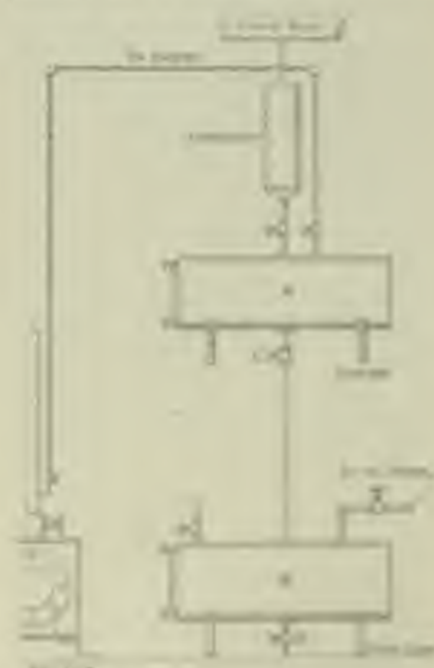
The same effect would be obtained by connecting the switch as shown in Fig. 3, giving result as shown in Fig. 4, and would give the same current in all coils of the transformers, but the starting current is [illegible] a short time that this is [illegible] necessary.

LORENZ B. CLARK.

Brookfield, N. Y.

Cylinder Oil Distributer

The oiling system herewith described is in operation in a large steel mill. In the engine room are twelve engines in a row, all the same size and speed. There is but a lubricator in the plant. The cylinder-oil tank, which is located in a convenient place, has one pipe connection to the steam main and another to the sight-feed glasses. The supply for each engine is regulated by a feed valve at the bottom of the glass. The line from the steam main to the supply tank is provided with a condenser.



CYLINDER-OIL DISTRIBUTER

The novelty of this system is the [illegible] tank arrangement. The supply tank A [illegible] is placed on the wall and supported by brackets. Tank B is placed on the floor and is connected with tank A which is provided with a gage glass. When tank A is nearly empty, B is shut off from it by closing the valve C, and it is drained from the bottom drain pipe. The valve D is then closed and the tank filled with oil. Then opening the valve [illegible] the oil [illegible]

The advantage of this arrangement is that there is no need for an expensive outlay for lubricators and the oil supply is not cut off from any engine or pump while filling.

EDWARD T. BINNS.

Philadelphia, Penn.

The Actual Cost of Power

In one of the recent issues, in the editorial on "The Actual Cost of Power," I read the following statement: "It is important for the engineer to be able to figure power cost, including the fixed charges, however, when occasion arises, and to appreciate the influence of the annual interest, depreciation, insurance and taxes on the unit cost of power produced." True, this is important, but to what end? To find out if the production is economical, or if the plant is efficient?

The most accurate computation of the cost of power can only show that its unit cost has increased or decreased; and in the editorial mentioned we find the statement that the unit cost decreases when the output increases, and *vice versa.* Therefore, it follows that by knowing his actual cost of power the engineer will only learn that the good or poor work of the sales department has made him produce cheaper or more expensive power. What will he gain through such knowledge?

He will have sufficient data to "kick" against the management of the concern; he will learn—perhaps—what the profits of his employers are; he will learn how difficult it is to do another man's work, and he will be kept in training in the high art of arithmetic. All this is a considerable gain to him personally, but is it all so very useful and necessary?

He will not have learned what his task really is. All these computations will not show him what his part is in the process of decreasing the cost of production; they will not teach him how to increase the immediate efficiency of his power plant. He will have to ask his employers to engage standard-practice specialists, who will determine standard-unit costs and work out a system of record keeping which will enable the engineer to find out at each given moment what the total efficiency of power generation is, where the leaks in the numerous steps of the transformation of energy, from the coal pile to the switchboard are located, how large the losses are in each step of this process, and which of these losses depend upon inefficient operation and which upon outside causes.

By the actual unit cost of power generated it is impossible to know whether the plant is doing well and the engineer is up to his task. The data of previous months are of little use, as it is valueless to compare casual and inaccurate figures with others which are also indefinite. That would only be an attempt to bluff oneself and others by irrelevant and absolutely misleading data. To make any comparisons one must have scientifically determined standards, just as one must have a zero point and a boiling point on a thermometer scale.

It often happens that with a high actual unit cost the efficiency is much higher than with a lower one, and then the activity of the engineer must be in quite another direction than the one which might be prompted by the casual figures of actual cost. The type of calculations recommended in the article quoted will be also useless for a comparison with unit costs of neighboring power plants. These plants have other prices and specifications of fuel, other fixed charges, etc., and, therefore, there is very little sense in trying to compare unit costs before they can be measured by a common scale and from a common zero point; in other words, before the plants are standardized and before special efficient engineers have given into the hands of the permanent staff the scientific methods of determining the plant's efficiency.

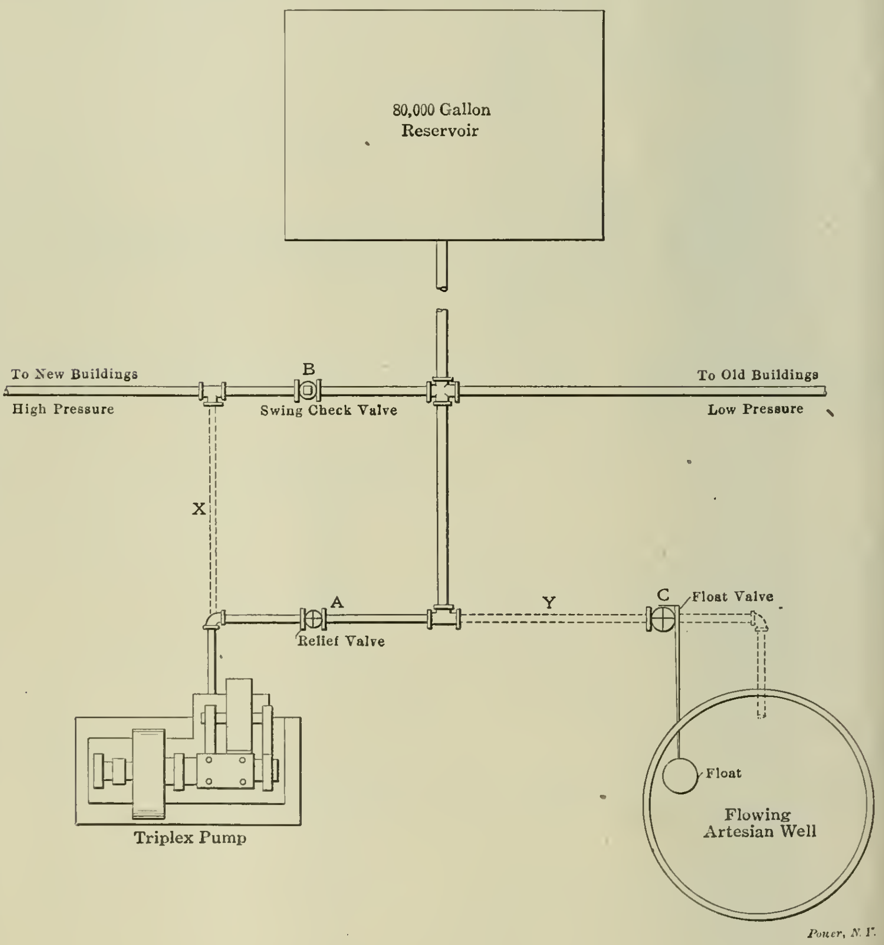
W. N. POLAKOV.

New York City.

Increasing Water Pressure

Several years ago about half of a large factory was rebuilt, the old buildings being replaced by new and modern structures two stories higher. Difficulty was at once experienced in getting water to the top floors of the new buildings.

A water pressure of 27 pounds was maintained by an 80,000-gallon reservoir and a triplex power pump. The new buildings required between 35 and 40 pounds pressure, so it was necessary to raise this pressure about 13 pounds, while keeping the pressure on the rest of the system at its normal value.



GENERAL LAYOUT OF WATER SYSTEM

The sketch shows the general layout of the system. The full lines, with the exception of the valves, indicate the system as it was before alteration. The dotted lines and valves show the additions that were made.

On the top of a hill, half a mile away, is the 80,000-gallon reservoir. At the factory is a flowing artesian well. The reservoir is connected through the pump to the cistern of the well, and the factory mains are tapped from a point between the pump and reservoir, so that the factory may draw its water from either source. The reservoir is kept full by the extra water pumped when the pump is running.

The required extra pressure was obtained by putting a relief valve set at 45 pounds between the pump and the reservoir at *A*, a swing check valve on the high-pressure supply pipe at *B*, and connecting the high-pressure main beyond the check valve to the pump through the pipe *X*. This arrangement permitted the pump to feed the new buildings at 35 pounds pressure, or more, while the old buildings remained on the lower-pressure system. In case the pump was shut down, the reservoir would supply both old and new buildings, the former as formerly, and the latter through the swing check valve, but at a low pressure.

During certain seasons of the year the flow of the well declines and becomes insufficient to supply all the water needed. In order to keep enough water in the well cistern to supply the pump for the higher buildings, at such times, a supply pipe *Y* was tapped from the main to the cistern through the float valve *C*, which was set so as to keep the water at the required level.

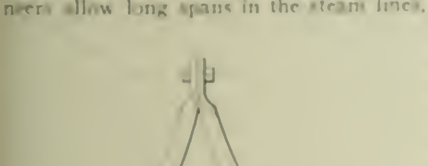
The desired results were thus accomplished at the expense of three valves, about 10 feet of piping at *Y*, and some 3 feet of piping at *X*. The plan has proved entirely satisfactory, and has been working for several years.

W. W. Parker.

Chicago, Ill.

Support for Flanged Piping

In putting up large steam pipes I have noticed that some steamfitters and engineers allow long spans in the steam lines,



FLANGED PIPE SUPPORT

and although hangers are used, a great strain still remains on the flanges.

The way I have done is to use two clamps on steam pipes, one on each side of the flange, and bolted tight to the pipe (see illustration). I then take two pieces of iron and make a V-shaped piece to act as a keystone and prevent the pipe from sagging, thus removing the strain from the flanges.

E. H. Marsh.

Wheeling, W. Va.

The Centrifugal Pump

The discussion on centrifugal pumps has been very interesting to me and I think some good practical points have been brought out. George H. Gibson very clearly explains his idea of the action of the water in his article in the January 12 issue, page 122, but I think his argument applies more to pumps with the circular casing than those of the volute form and as it was a common volute pump that started the discussion, I confined myself, in a previous letter, to that type of pump, so I was not as surprised as Mr. Gibson imagined when I heard of "other types." I will give my reason for wishing to know if the statements relative to closing the discharge valves of centrifugal pumps while running at full speed applied with equal accuracy to the common low-lift volute pump.

Some time ago I was visiting a large manufacturing establishment and the engineer was showing me a centrifugal pump there used for filling a large reservoir, when all at once the pump started to run hard, the belt slipped and snapped and finally came off the pulley. The engineer excused himself with the remark that some fool had shut down the discharge valve by mistake and that he was going to have a lock put on it. With that he left me and I went over the rest of the plant and eventually went home without seeing the engineer again.

This pump was a common volute pump and I should guess that the discharge pipe was about 10 inches in diameter. I never thought any more about it until I saw the statement about the decrease in power needed when the discharge was closed, and as this was so directly contrary to this incident I naturally was doubtful if this applied to this type of pump and so asked for more data. I note that G. H. [illegible], in his article on page 247, states that in his experience with about 20 centrifugal pumps he found that the power required to work against a column of water without discharge is about equal to the power needed when discharging fully under seven-eighths of the head. I mention this in comparison with Mr. Gibson's article merely to show that different results appear to be obtained under various conditions. I also note that Mr. [illegible]'s experience is that centrifugal pumps when operating with discharge closed require less power, but I am of the opinion that his pumps were not of the common volute type, as he speaks of an 80-foot lift.

I am sorry I cannot make any definite statement myself, but I have since tested one of these pumps to see what effect closing the discharge valve has, and I am not positive that the pump I saw threw off the belt because the discharge valve was closed, but the engineer certainly seemed to know what the trouble was just from the way he spoke of it as though this had happened before.

Has anyone had a similar experience with a common low-lift volute form of centrifugal pump?

[illegible]

Exeter, N. H.

A Homemade Filter

The sketch shows a filter I have just completed. It is made out of two 50-

A HOMEMADE FILTER

gallon cans. I cut the top out of one can and the bottom out of the other and used them for the strainers at the top [illegible]. It is painted so I have no occasion to feel ashamed of it.

Although it works well, I had much rather have a proper filter made by any good firm.

E. A. Young.

[illegible], Tenn.

How to Take Indicator Diagrams

[illegible]

[illegible]

[illegible]

Scaled Boiler Surfaces

Referring to the discussion of Hilton Williams' article by H. E. Gansworth in the January 5 number, and by Eriths' Engineering Company, Ltd., in the February 9 issue, the tests quoted by Mr. Gansworth included an item of considerable interest, but not mentioned in his quotation. Two boiler tests were made on a locomotive-type boiler working at a high rate of evaporation. One test was with the tubes and fire sheets covered with an average of ⅛ inch of carbonate scale. The other test was made under exactly similar conditions, but after the boiler had been cleaned of all scale. The result was an average of 10.5 per cent. loss due to this thickness of carbonate scale.

At another time, performance sheets expressed in terms of power generated, all under similar conditions, were kept for three months previous to and for three months after scale removal. The scale was mainly carbonate, and the result at the coal pile was 10 per cent. in favor of clean surfaces. On the other hand, many tests which are on record, and whose reliability is beyond dispute, tend to indicate that the effect of scale is much less than as herewith indicated, and others show that it is higher. I believe that these disagreements may sometimes, though not always, be reconciled when the real governing conditions are taken into account.

Rankine, I think, found that the heat resistance of dry carbonate-of-lime scale is about seventeen times that of iron, and that of sulphate of lime forty-eight times. Carbonate scales are soft and porous and sulphates hard and dense. The carbonate coating may be considered as a pipe covering, only the particles are somewhat cemented together instead of being loose. No engineer would expect much of a pipe covering that was saturated with water. The heat resistance of a porous scale in a boiler should be looked at in the same light.

If the rate of evaporation is low, and especially if the scale in question is in a part of the boiler, or its auxiliaries, where the flue gases have lost some of their heat, and the feed water has not reached its maximum temperature, the scale will be damp to some extent. If, however, the rate of evaporation is high, the body of the scale will be dry, or contain nothing but highly superheated steam, and in this condition it approaches the condition of a dry pipe covering, and we have an excellent heat insulator which, considering its thickness, compares favorably with what we know of the value of magnesia pipe coverings in general. This may account for the fact that tests made at high rates of evaporation generally show decided loss on account of scale. In any case, especially at low rates of evaporation, the composition of the scale should be taken into account and this may account for the vastly different results that have been obtained.

Even if in some cases porous scale causes only slight loss at low rates of evaporation, the fact that at high rates the loss is great makes the subject of considerable importance in view of the results of certain tests at the St. Louis Exposition, and the resulting tendency greatly to increase the volume and, therefore, the velocity of gases passing over any given heating surface, all with a view to greatly increasing capacity at very slight cost in economy.

E. W. Fiske.

Urbana, Ill.

Repairing Commutators

In the plant where I am employed there are three 250-kilowatt 600-volt three-phase rotary converters, all of which are subject to flashing, one being extremely so. This trouble probably occurs more frequently in rotary converters than in direct-current generators, due to the "bucking" or flashing-over characteristic of some of these machines. If this burning occurs out on the brush-bearing portion, or outer end of the commutator, it is not so difficult to handle, but when it is on the inner end, where the armature leads connect to the commutator, it is much more serious, as it is hard to get at it.

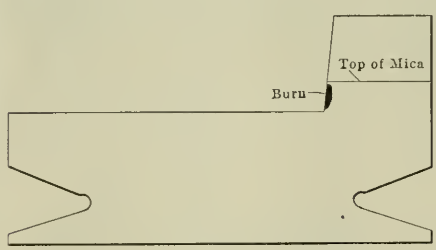


FIG. 1

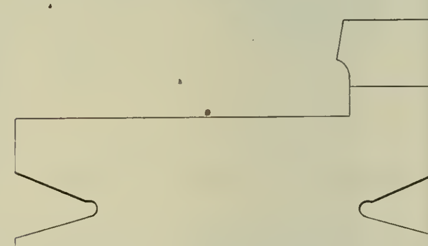


FIG. 2

In the three converters mentioned, burning at this point became so serious that it was necessary to cut off the copper with the lathe, increasing the length of the brush-bearing portion of the commutator until the tool went in behind the burned places, leaving the hard, firm mica between the bars. Figs. 1 and 2 will illustrate the idea, Fig. 1 showing the original shape of the commutator bar and Fig. 2 how it was cut away.

While the remedy suggested by Mr. Work, a solution of silicate soda and a filler, in the January 5 number, is probably the best we have, it is by no means a panacea. An experience extending over three years convinces me that one should not be too hasty in congratulating himself on the permanency of the repair, especially if the commutator is run where oil is likely to get on the surface, or if it is on a high-voltage machine. In some instances this filler seems to deteriorate under the action of oil.

As Mr. Work says, every particle of charred mica must be removed, and if the job is undertaken by anyone who does not fully realize the importance of having the cavity thoroughly cleaned, failure is most sure to result. The writer has used both powdered glass and plaster of paris as a filler for the silicate soda (water glass) solution, and prefers the former where any length of time may be had for the repair to dry before starting up the machine. With powdered glass, the mixture forms a doughy mass which is easy to handle and force into the cavity. If plaster of paris is used the mixture hardens almost before it can be applied, making it necessary to work very rapidly in applying, or else break it up again after it has set, which is bad practice.

With either filler, if the cavity is small, as between two commutator bars, the mixture will harden in a few minutes sufficiently to allow the machine to be started, but if the cavity is large some time will be required for it to dry, the longer the better. Where the mixture before drying forms a ground, the drying has been in some instances hastened by allowing a light current to flow through the filling to the ground, but care must be exercised that it does not become too warm.

One of the converters previously mentioned has been running for several months with a two- or three-ounce plug of the mixture (with plaster of paris as a filler) packed into a hole between the commutator bars and the clamping ring, the hole having been burned out from a ground against the clamping ring. In another is a plug of powdered glass as a filler between the bars of the commutator and the clamping ring of the thickness of the original insulation. When this repair was made the machine tested partially grounded, but the slight leak through the mixture soon dried it out until the machine tested clear. If a good fit can be secured it is probably better to use mica than the mixture spoken of, but the fit must be good or the trouble will surely appear again. If the trouble is on the outer corner of the commutator a crevice may be sawed out between the bars across the corner, care being taken to see that the bottom of the crevice is perfectly straight. A tight-fitting piece of mica with a perfectly straight edge should then be forced to the bottom of the crevice, after which the bars should be lightly calked on each side of the mica to hold it in place. The mica can then be trimmed off and smoothed up to conform with the surface of the commutator.

In a job of this kind it is important that more than an approximate fit be obtained and the angle at the surface of the commutator formed by the new piece of mica should not be less than 45 degrees. If so, the point of the new piece at the surface of the commutator will be so thin it will not stay in place, furnishing an inviting place for a new beginning of the trouble. In one or two instances the writer has sawed out the mica across the end of the commutator down to the clamping ring, securing a square corner for the new piece at the surface.

Whether mica or the filling mixture is used the work must be most carefully done or permanency will be lacking, and even with the utmost care permanency will be in doubt.

Where circumstances justify, if the trouble has become very serious, it is probably better to strip off the clamping ring, loosen up the bars and put in new insulation and also commutator bars, if the old ones are badly damaged.

C. L. Greer.

Handley, Texas.

The Modern Surface Condenser

In Mr. Orrok's letter in the December 22, 1908, number, he says that where good surface efficiency is possible and there are no serious air leaks, the air pump of ordinary size is usually more than sufficient. This is a rather vague statement, and not at all on the scientific lines he is anxious to pursue. When are air leaks beginning to become serious, and what does he consider the ordinary size of an air pump?

Mr. Orrok will, I believe, have noticed the great difference in opinions, and in actually operating plants, as to the size of air pumps. If he invites five tenders for certain conditions he will find the air pumps varying in sizes by at least 100 per cent. What the capacity of the air pump means and how it affects the surface efficiency of a condenser I will show by an example.

We will assume a condenser of a certain cooling surface, condensing a certain weight of dry-saturated steam per hour, accompanied by a certain weight of air from leaks and other sources, the cooling water of a fixed quantity per hour entering at 25 and being discharged at 40 degrees Centigrade. We further assume that this condenser maintains an absolute pressure of 0.12 atmosphere, and consequently the steam temperature at the condenser inlet will be 50 degrees Centigrade. The condenser is further assumed to be built strictly on the countercurrent lines, so that the mixture of air and vapors removed by the air pump may have a temperature of 30 degrees Centigrade. The mean difference of temperatures between the steam and water spaces will then be

$$\frac{50-40}{2}+\frac{30-25}{2}=7\tfrac{1}{2}$$

degrees Centigrade. The tension of the vapors at the air-pump suction is then 0.04 atmosphere absolute, corresponding to the temperature of 30 degrees Centigrade, consequently, the tension of the air at the place of removal will be

$$0.12-0.04=0.08$$

atmosphere absolute (Dalton's law).

We now increase the effective displacement of the air pump by 100 per cent., but otherwise leave everything unchanged. The next consequence will be that the pressure of the air at the air-pump suction drops to one-half of the original pressure, or 0.04 atmosphere absolute. Some trial calculations will then show that in order to preserve the original mean difference of temperatures between the steam and water spaces, that is $7\frac{1}{2}$ degrees Centigrade, which is necessary to keep the condenser doing its work, the initial temperature of the exhaust steam must drop to 45 degrees Centigrade, and the temperature of the mixture of air and vapors at the other end of the condenser must rise to 35 degrees Centigrade, when the total pressure will be 0.095 atmosphere absolute, leaving 0.055 atmosphere absolute for the vapors withdrawn with the air, this corresponding to 35 degrees Centigrade, and the total pressure to 45 degrees Centigrade. By doubling the air-pump capacity we have thus improved the vacuum by 0.025 atmosphere, or nearly ¾ inch. But the velocity of the exhaust steam at the inlet end of the condenser will now be 31 per cent. higher, and that of the air and vapors leaving 100 per cent. higher, and besides the percentage of steam in the mixture will be higher, and this is where the surface efficiency comes in, which will be increased, resulting in a still better vacuum and further increase of velocity, until a limit is reached by the increased resistance of flow. These facts have been taught by experience to all builders who endeavored to reduce the cooling surface of otherwise efficient types of condenser.

I now turn to the rate of condensation per square foot. Mr. Orrok again refers to record rates obtained by experiments under certain conditions. I think I have dealt with these and had better speak to figures, asking Mr. Orrok to point out to me any condensing plant in practical operation, "for turbine and cooling-tower conditions," i.e., 80 degrees Fahrenheit cooling water and an average vacuum of 28 inches on a 30-inch barometer, between the cleaning times, showing a rate of condensation of more than 12 pounds of steam per square foot and per hour. I will even go farther and allow 75 degrees Fahrenheit cooling water, although this is not good practice and calls for quite enormous towers.

Referring to Hausbrand's book on "Evaporating, Condensing and Cooling Apparatus," I, of course, know this. The author has had great experience in apparatus for distilleries, sugar factories and others, but has probably never built a steam-condensing plant or a cooling tower. I should like Mr. Orrok to try to design such plants from this book, and I am sure he will have some fun doing it. I can also assure Mr. Orrok that I know the other great book, that of Weiss, which is nearly always quoted when condensing matters are discussed. This book has its great merits, but strangely enough hardly touches on the question of heat transference and, instead, dwells on the countercurrent principle to unbearable length, the result of this one-sidedness being some fallacious deductions relating to the capacity of air pumps. Professor Josse's paper has up to the meantime been published.

In conclusion, I would say that from a scientific standpoint there is now sufficient information at hand to enable manufacturers to build efficient condensing plants. The surface condenser itself will hardly be subjected to radical changes as long as we have to adhere to straight cylindrical tubes. This is not so with the air pump, which for high vacua is open to many improvements. The greatest trouble, however, is the uncertainty about the amount of air to be handled. It is the air which makes condensing so complex a problem, as it not only affects the air pump, but the condenser also. The builders of condensers have to guarantee their plants for high vacua under unfavorable temperatures of the circulating water, without in the slightest way being protected against excessive air in the system.

A correct and reasonable guarantee for a certain vacuum should be based on the quantity of steam to be handled, the temperature of the circulating water and the amount of air carried into the condenser by the steam (or in the case of a jet condenser, by the water also). But as matters are standing, the estimate of the amount of air to be handled is an exceedingly rough one, and we lack the methods to measure the air actually discharged from a condensing plant. A clause like "Provided that the system is reasonably (or perfectly) free from air leaks," means, of course, nothing. Here is the point where scientific experiments on actually operating plants have to set in. If Mr. Orrok can help in this and his efforts will be greatly welcomed by the profession.

[illegible]

London, Eng.

How Improve the Diagrams?

Last fall I took a week off, and not knowing just what to do, I thought of taking indicator diagrams. Among others I obtained those shown in Figs. 1 and 2. These diagrams were taken from a Rey-

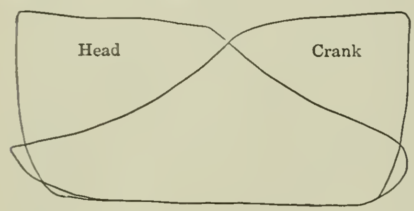


FIG. 1

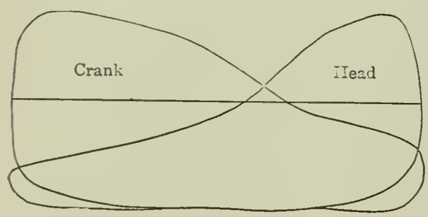


FIG. 2

nolds Corliss cross-compound engine. The high-pressure cylinder was 20 inches in diameter, the low-pressure 42 inches in diameter; stroke, 48 inches. The boiler pressure was 150 pounds per square inch; receiver pressure, 15 pounds; the revolutions per minute, 107; scale of spring for high-pressure, 80, and of the low-pressure cylinder, 15.

I should like to have the readers give their opinion of these diagrams, as to what changes would be necessary to make the engine give a better looking diagram.

LINDON A. COLE.

Blacklick, Ohio.

Boiler Efficiency

In the issue of February 2, page 239, there appears an article giving certain results relative to tests of run-of-mine coal as compared to briquets made therefrom, which is an abstract from a recent bulletin of the United States Geological Survey, in which it is stated: "In all classes of service involved by the experiments, the use of briquets in the place of natural coal appears to have increased the evaporative efficiency of the boiler tested."

The publication concerns itself more particularly, of course, with the matter of briquets, but the statement in the paragraph quoted is so far in error that it seems desirable that attention be called to it. The question is, how can the change of fuel affect the efficiency of a boiler? A boiler is efficient due to its design, the material entering into its construction, etc., and the purpose of the boiler is to abstract the heat from the gases flowing over it. Its ability to do this is dependent upon certain features of shape and arrangement of parts, and the efficiency of a boiler as a heat abstractor cannot be altered without changing the shape of the apparatus. If we have a plain cylindrical boiler without tubes in it, and we alter it by placing tubes therein so that the gases also pass through them, we have increased the efficiency of the boiler materially, but if in one case it should have coal burned under it and in the other briquets, the efficiency of the boiler would in nowise be affected, because in each instance it would be the same plain cylindrical boiler.

In my opinion it is well to call attention to these features, as it tends to a better understanding of the matter of boiler performance.

A. BEMENT.

Chicago, Ill.

Power Plant Records

In the February 2 number was an article on "Power Plant Records," by Mr. Bogart, which interested me greatly. I get all my meter readings at 7 a.m. The coal is conveyed to the boiler house on a small car, weighed on track scales and totaled once a day. All records are kept on a properly designed report sheet. By using a recording wattmeter and a water meter it is possible to come very close to what the boilers are doing. As to the live steam we are using we can only guess at that. We use recording pressure gages, a recording voltmeter and a recording meter on the heating main. Meters on the air compressors would help some. With the appliances I have, it is interesting to see the changes in the average evaporation, due to one cause or another.

A. G. MACFARLAND.

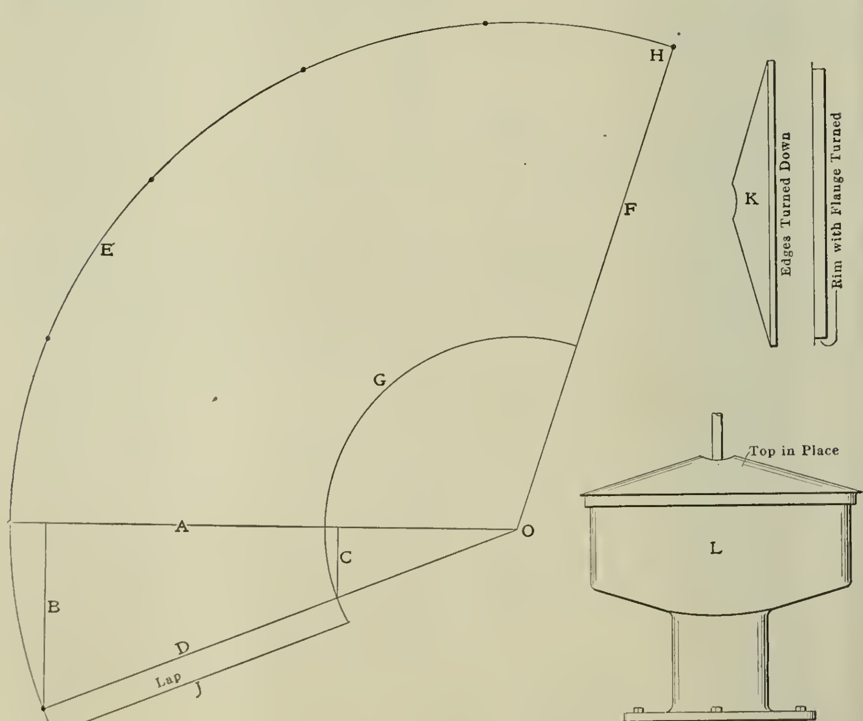
Ilion, N. Y.

Making Dashpot Covers

The accompanying illustration shows how I made covers out of heavy tin for my dashpots, to keep out dust and dirt. The cover was made large enough to fit nicely over the top of the dashpot. The hole in the cover was made large enough to leave room around the rod so the air can pass out when the dashpot is on the upward stroke, without lifting the cover. An explanation of the method used in making the dashpot cover is as follows:

First draw the line *A*. Then draw the line *B*, equal to one-half of the diameter of the cover, and at right angles to *A*. Lay off the length or hight desired from *B* on *A*, and draw the line *C*, at right angles to *A*, equal to one-half the diameter of the top. Then draw the line *D*, from *B* to *C*, up to *A*, cutting it at *O*. Set the dividers equal to the line *D* from *O* to *B*, and placing the stationary leg at *O*, draw as much of the circle *E* as necessary. Then set the dividers equal to the distance between the lines *D* and *A* in the circle *E*, and space off six times this distance on the circle *E*, as shown. From the point *H* draw the line *F* to the point *O*.

Next set the dividers equal to the distance between the line *C* and the point *O* on *D*, and draw the circle *G* to the line *F*.



METHOD OF LAYING OUT AND CUTTING DASHPOT COVERS

If lap is desired to fasten the ends together, add this on by drawing the line *J*, parallel to line *D*, at a distance equal to the required lap. Then by cutting along the lines *F*, *E*, *H*, *D* and *G* the cover is ready to be put together. A rim is then soldered on as shown at *K*. At *L* is shown the cover as applied to the dashpot.

CHARLES H. SPARBER.

Fertile, Minn.

A Harmless Scare

That a good engineer may make mistakes is not to be disputed, and often these mistakes are amusing, rather than serious. A case in point occurred recently where a gas engine and producer had been installed in the basement of a department store in the heart of the business district of a Western city. One of the requisites of this installation was that there should be no noise from the exhaust of the engine, and to accomplish this end, a large tank, buried in the floor of the engine room, had been used for a muffler, and from this tank a 6-inch exhaust pipe extended up seven or eight stories to the roof of the building. The plan worked nicely, the exhaust was quiet, and for months the plant ran beautifully.

The engine was rated at 75 horsepower and was started with compressed air. One morning the engineer turned on the air as usual, the engine began turning over and drew a charge of mixture into the cylinder. The charge did not ignite, however, and the mixture was expelled nonignited into the exhaust muffler. This was repeated several times. The engineer was at a loss to understand why the engine did not start, and kept turning it by compressed air until it had made 20 or 30 revolutions, and the unexploded charges drawn through the engine and pumped into the exhaust system had become sufficient in volume to fill the exhaust tank and the entire pipe line to the roof. In the course of his hunt for the trouble, the engineer discovered that he had neglected to turn on the switch connecting the magneto with the igniter. This he promptly did, and the engine "picked up" all right on the next revolution.

The engineer, being in the engine room, felt no disturbance beyond a slight thud when the first charge of burnt gas was exhausted into the muffler. On the other hand, those on the outside of the building were treated to an explosion that sounded like the bombardment at Manila and which shook the entire section of the wholesale district, calling out both the police and fire departments. Patrol wagons rushed hither and thither, the police dreaming of anarchistic bombs and the fire department hunting for a bursted boiler with its attendant horrors. The location of the noise was traced to the block in which the engine was, and the police and firemen, searching the buildings, finally arrived in the engine room, where they found the engineer placidly going about his business. He insisted that there had been no explosion from his engine; he had heard nothing at all and there was nothing to credit up to him. Since then, however, he has been very careful to throw the switch before starting his engine, on the basis, to paraphrase the old saw, that an ounce of prevention is better than a visit from the police and fire departments.

G. P. Kaler.

Chicago, Ill.

Safety Valve Formulas

In the paper upon safety-valve capacity, contained in the March 9 number, I gave briefly the results of two extended series of tests, one upon safety valve lifts and the other upon the coefficient of steam discharge in safety valves. The omission of a complete table of the former results has led to a serious misconstruction of them in the editorial in the same issue, in which they are quoted. In an endeavor to correct this, the results are here given with a little more detail.

The lifts at popping point of the seven 4-inch stationary-type valves of different design set at 200 pounds were 0.064 inch, 0.031 inch, 0.056 inch, 0.04 inch, 0.024 inch, 0.082 inch and 0.137 inch. Of the six 3½-inch muffler locomotive valves, set also at 200 pounds, the lifts at the popping point were 0.072 inch, 0.040 inch, 0.076 inch, 0.065 inch, 0.051 inch and 0.140 inch.

Inspection of these figures indicates, as by far the most important conclusion, the fundamental necessity that an adequate formula for rating safety-valve capacities must include a specific term for the valve lift. A necessity which arises from the fact that the great variation of over 300 per cent. in the lifts of the same-sized valves for the same pressure makes the assuming of any single value for the lift, however carefully selected, an assumption liable to large error.

There are two hypotheses in the editorial. First, "that the lift * * * * is around 3/32 inch (0.094) for all valves in normal condition," and second, that "any maker will guarantee a valve of any size to lift 3/32 inch (0.094 inch) when the valve pops and to stand at that height as long as the pressure is maintained." Irrespective of what safety-valve makers may be able or care to guarantee, the error of these assumptions as applied to valves as they exist and are actually put upon boilers is very great, which is apparent not only from the tests cited, but from the figures given by manufacturers themselves.

The advocacy of "low" lifts and the generally admitted existence of so-called "high" lifts, brought out in the discussion at the A. S. M. E. meeting, indicate further that a uniformity of lift results for the same size of valve not only does not exist, but is not sought for nor desired by the different manufacturers of safety valves. In view of this lack of uniformity it would seem wise to leave the determination of valve-lift values to the manufacturers themselves as essentially their own proposition. On the other hand, the question of valve-capacity rating is of vital importance to and must be considered by users, insurers, designers and makers of steam boilers.

Obviously, in a formula as suggested in the editorial there can be no distinction corresponding to the great existing variation of valve lifts and under such a formula valves with 0.031-inch lift must receive the same rating and specifications as valves with 0.094- and 0.14-inch lifts. In assuming a given lift, as there done, not only are the valves whose lifts are less than the assumed value overrated, resulting in the liability of over-pressures, but using it with valves whose lifts are greater than that assumed a boiler would be over-safety-valved, which magnifies the strain on the boiler due to that cause, if such exists, as suggested at the A. S. M. E. meeting. And these errors, resulting from the use of a formula similar to that in the editorial, are not small enough to be negligible, for with the most carefully selected assumed average lift they amount to as much as 150 per cent. each way.

The only adequate method, therefore, is to require manufacturers to state definitely the lift of their valves, verify it upon them and then rate them accordingly, by the use of a capacity formula which includes a term for the lift. Adopting a rule as suggested in the editorial and having manufacturers to qualify under it with unknown lifts, which in cases are but one-third of that assumed, would mean a deliberate throwing away of the evidence of valve-lift research recently conducted by a number of independent parties, including the United States Government at Annapolis.

The inadequacy of such rules as that suggested in the editorial has already been recognized by the safety-valve committee of the American Railway Master Mechanics' Association, which in its report of May 18, 1908, cited a variation in the safety-valve lifts of nine different makes of valve of from [illegible] to [illegible] inch, and recommended a capacity rule (based upon heating surface) which includes a term for the effective area of valve opening, obtainable only by determining the valve lift.

And last, the added complexity of the rule as given in the editorial over that containing a term for the valve lift is very slight, especially if the constant recommended in the latter is changed [illegible] per cent. to the [illegible] formula given:

$$D = [illegible]$$

whereas that of the editorial is

$$D = [illegible]$$

Frank C. [illegible]

New York City.

Gas Power Blowing Equipment at Gary, Ind.

Essential Mechanical and Operative Features of the Indiana Steel Company's New Gas Engine Installation for Blowing Furnaces

The almost exclusive adoption of gas engines at Gary for blowing the furnaces, as well as for electric service throughout the mills, represents the first decisive step in American steel manufacture toward full recognition of the development in gas-power equipment which has been going on for the last ten years. Outside of German practice, which has been so conspicuously successful, the only forerunners of this great undertaking in America are the gas-power plant of the Lackawanna Steel Company, at Buffalo, and the more or less experimental application by the United States Steel Corporation in the vicinities of Pittsburg and Chicago. It is not to be expected that so important a property as the Gary works would permit of the least uncertainty in the matter of gas-power application if such uncertainty existed, and it is, therefore, fair to assume that the experience of the United States Steel Corporation has been signally successful.

No. 3 Gas Blowing House

In a detailed study of so large a property, the subdivision of the work into the most important groups becomes imperative, and following the general order in which the Gary property has been completed, the No. 3 gas blowing house calls for first consideration. The first of the three gas-power houses to be placed in commission is typical of the general construction employed in the No. 1 and No. 2 blowing houses which are to follow. The systems of blast control, air starting, ignition, water supply, lubrication and organization of operatives are the same as contemplated for the other plants.

This No. 3 blowing house is located at the extreme northern end of the power property, next to the lake front, and is shown in the general photograph, Fig. 1, which embraces all those parts of the furnaces and contiguous buildings which have been put into operation. This view includes, at the extreme left, Nos. 11 and 12 furnaces, which are in operation, preliminary washers and the No. 3 blowing house in the foreground. At the extreme right is shown the storage-battery building and the north end of the electric-power house, which will next be put into commission and the general features of which have been described in previous articles. The third group of furnaces, Nos. 9 to 12, and the first to be put in operation, served by the No. 3 blowing house, will be duplicated in the first, second and fourth groups now under erection, Nos. 5 to 8 to be served by No. 2 blowing house and Nos. 1 to 4 by No. 1 blowing house, these being provided for at the southern end of the property. Thus there will be virtually three independent groups of furnaces, of which the northern is in every sense typical. These groups will only be connected by means of a 5-foot gas main extending between the various blower houses and operating somewhat as an emergency tie line. The air-blast lines for each group are, however, not interconnected, as in the case of the gas supply. Practically every operating function of these groups is, therefore, independently complete with the exception of the low-service water supply and the air-compressing plant by means of which the gas engines are started, this being located at a central point in the electric station, as later noted.

FIG. 1. GENERAL VIEW NORTH END OF GARY WORKS, NOS. 11 AND 12 FURNACES, WITH NO. 3 BLOWING HOUSE

The general assembly drawing, Fig. 6, shows in plan and elevation one of the eight gas blowing units, together with air blast, water, gas, air, exhaust and compressed-air mains. Each of these will be referred to in detail later. Figs. 3, 4 and 5 show general views from both gas and air ends of the end units. The building is laid out with 26 bays, 23 feet wide, aggregating about 600 feet in length and 104 feet in width. All the units are spaced 46 feet between centers, including two steam blowers.

It is to be expected that in so large an undertaking some steam reserve would be installed, which is the case, and, moreover, steam is a necessity for starting the furnaces. For each group of furnaces there is a plant of 16 water-tube boilers which supplies steam to a pair of steam blowing engines in No. 3 blowing house; a pair of 2000-kilowatt steam turbines in the electric house; a steam-turbine-driven pump in the pump house; fire pumps; hydraulic pumps and steam for miscellaneous purposes around the plant, such as steam coils for oil-settling tanks and for preventing the holder, preliminary washers and gas valves in the various distributing lines from freezing during cold weather. This boiler house is fitted for burning blast-furnace gas. This same steam reserve will be provided in each of the blowing houses to be built, as well as the electric houses, so that nothing short of a general disablement will cause the ever-dreaded stoppage of blast at the furnace tuyeres.

The blowing house contains eight gas blowing units aggregating in capacity 265,000 cubic feet of free air per minute, and in addition, two 45,000-cubic foot steam units. The layout contemplates that for each pair of furnaces three gas units will be required with a spare, the steam unit being held entirely in reserve. These 450-ton furnaces each require 44,000 cubic feet of blast per minute. As each blowing unit supplies 33,000 cubic feet of free air per minute the proportion of capacity will be evident. For the returning gas a cleaning plant capable of handling nearly 176,000 cubic feet per minute is required. The gas for the hot-blast and steam-boiler plant is only partially cleaned in the dust catchers and preliminary washers, which remove the greater part of the heavier foreign matter.

It is estimated that about 30 per cent of the blast-furnace gas produced is required in the stoves, leaving 70 per cent available for outside purposes, or deducting 10 per cent for boilers and loss in washing, somewhat over 60 per cent for gas power. Consequently the secondary cleaning plant of tower and Theisen washers needs to take care of only about 105,000 cubic feet per minute. This corresponds to the capacity of seven tower and Theisen washers, leaving one unit of each in reserve. This amount of purified gas, which now averages about 95 B.t.u. per cubic foot and will approximate 90 B.t.u. after the furnace burdens have assumed their normal condition, will develop 66,000

plant as a whole. The general disposition of parts is clearly shown in Figs. 4 and 5, Fig. 4 being taken from the power end of the near engine and Fig. 5 showing more clearly the Slick rib and driving gear. These large units are set down to the floor level with openings 17 feet wide between supporting piers to provide access to the exhaust valves. This works out quite favorably, giving a depressed floor between the two sides, 5 feet below the main floor, with galleries running along the cylinders at the floor level, as shown in Fig. 7. This avoids entirely the bad feature of an exhaust-valve pit, which was encountered in early attempts to locate the engine at the floor level. Underneath this depressed floor, which is of steel plate, run the exhaust-pipe lines.

the inlet and the exhaust valves at each end are driven from a single eccentric, as usual with the large Westinghouse double-acting engines. This gear permits setting the valves so that the exhaust and inlet periods overlap, which makes possible a more perfect cylinder filling than would otherwise be possible and also a certain amount of scavenging due to the inertia of the incoming and outgoing columns of gases.

The piston rods are interchangeable, end for end, so that in case of necessity they may be transferred from one cylinder to another. The pistons are secured in place by external nuts forced up and turned off flush with the piston face. The piston itself is cast in a single piece, symmetrical in section about both axes and without

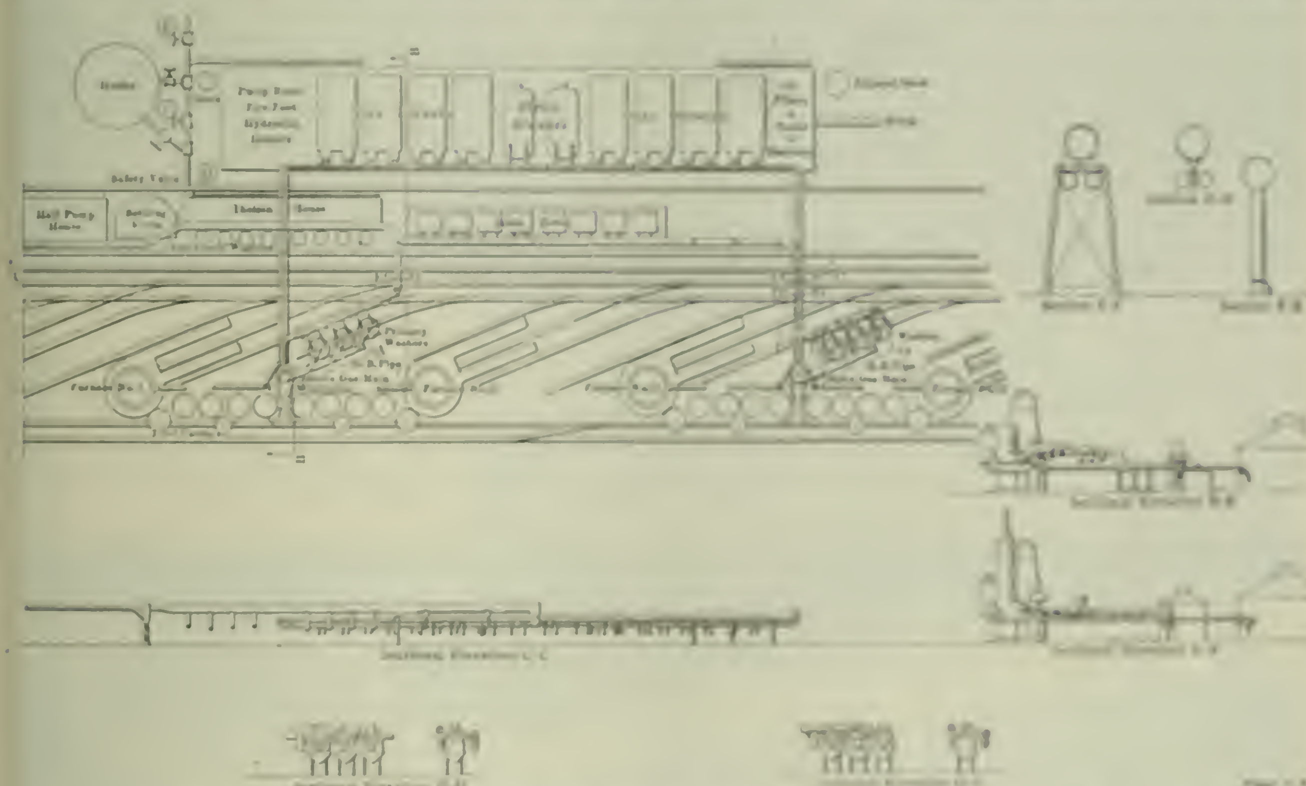


FIG. 2. GENERAL VIEW OF SOUTH GROUP OF FURNACES, SHOWING ARRANGEMENT OF WASHING PLANT, BLOWING HOUSE, PUMP HOUSE, ETC.

indicated horsepower in gas-engine cylinders well loaded, which is more than sufficient to operate the blowing house and half of the electric house. The tower washers are a modification of the Zschocke type.

The Blowing Unit

As the details of construction of the Westinghouse horizontal double-acting gas engine have been described in previous articles*, it is only necessary to review here certain of the essential features which have the most important bearing on the successful operation of the

The engine itself is in all respects identical with the builder's standard design for a 3000-kilowatt electric unit. It works on the four-stroke cycle and is double-acting, with a compression pressure of 200 pounds at full load. No attempt at special methods of scavenging or constant compression has been made, although the valve design permits of this to a certain degree, if desired. The lay shaft is located on the outside, supported on pedestal bearings independent of the engine. This arrangement avoids the use of spiral-gear drive for the lay shaft, which is driven by spur and bevel gears, each provided with a floating collar to equalize the wear and practically eliminate back lash. It will be noted that both

headers, plugs, or cored ribs. Fig. 9 shows this construction. The liner is supported from inside the opening, as shown. This construction places the inner wall or hub of the piston under direct compression, relieving the bolting strains in the rod considerably. These rods are not corrugated or otherwise compensated for deflection, which is hardly desirable, and just sufficient to keep the packing rings free. All rod packings are of the standard metallic-ring type, are water cooled, but lubricated by the force-feed system.

The air and gas pipes are entirely separate from the cylinder body (see Fig. 8), approaching the valve chambers at the top from opposite sides so that the mixing of gas and air is not perfect until the

*POWER AND THE ENGINEER for April 28 and December 8, 1908.

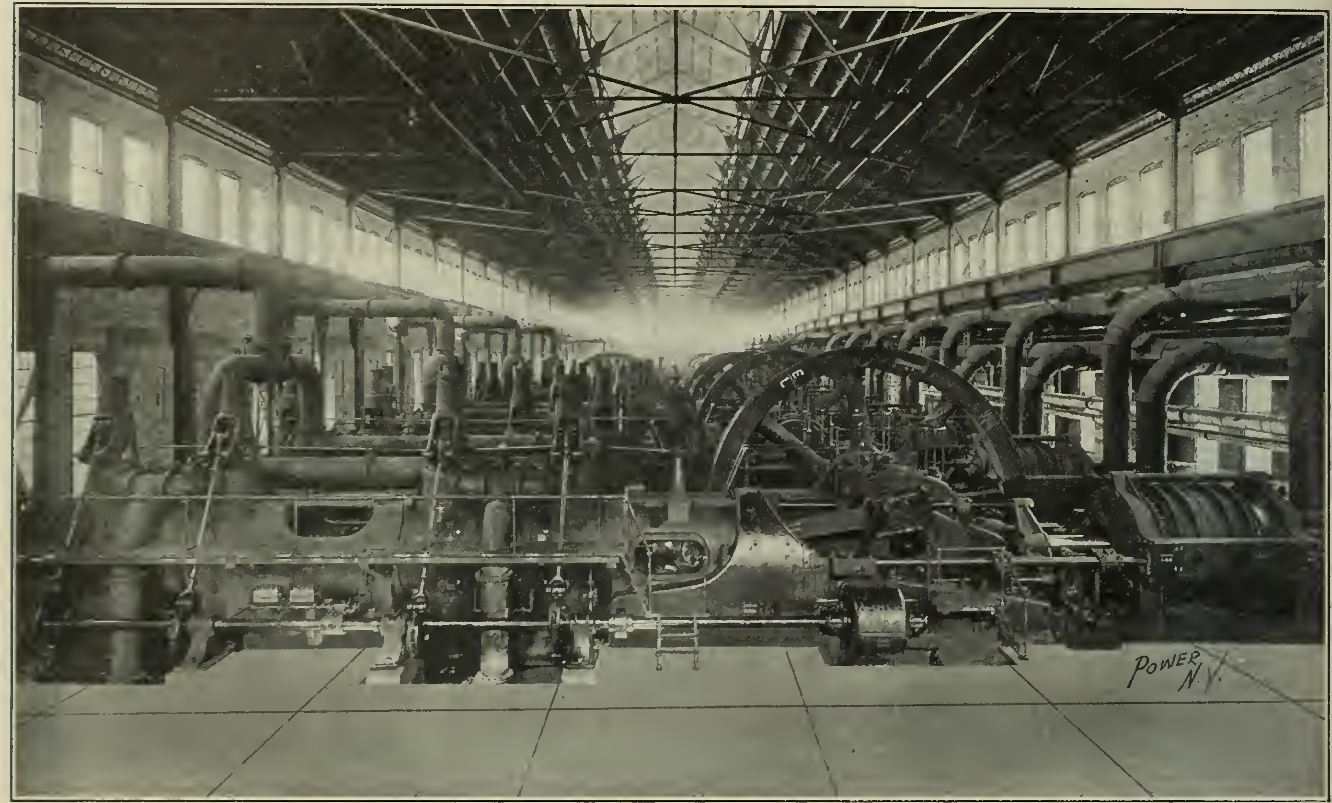


FIG. 3. GENERAL VIEW OF INTERIOR OF NO. 3 BLOWING HOUSE FROM SOUTH END

inlet valve is reached. Although Fig. 8 shows solid cylinder and jacket walls, they are cut apart at all openings and bushed.

Cooling System

Fully one-third of the cylinder jacket consists of a removable band around the center of the cylinder, so that easy access can be had to the remotest jacket spaces. The advantage of this feature has been demonstrated by previous experience of the builders with the clogging of cylinder jackets by deposits from muddy cooling water. A mud ring is provided at the bottom of each cylinder exhaust jacket which may be quickly slipped off without disturbing the exhaust-valve cage, thus opening the entire jacket space for clean-

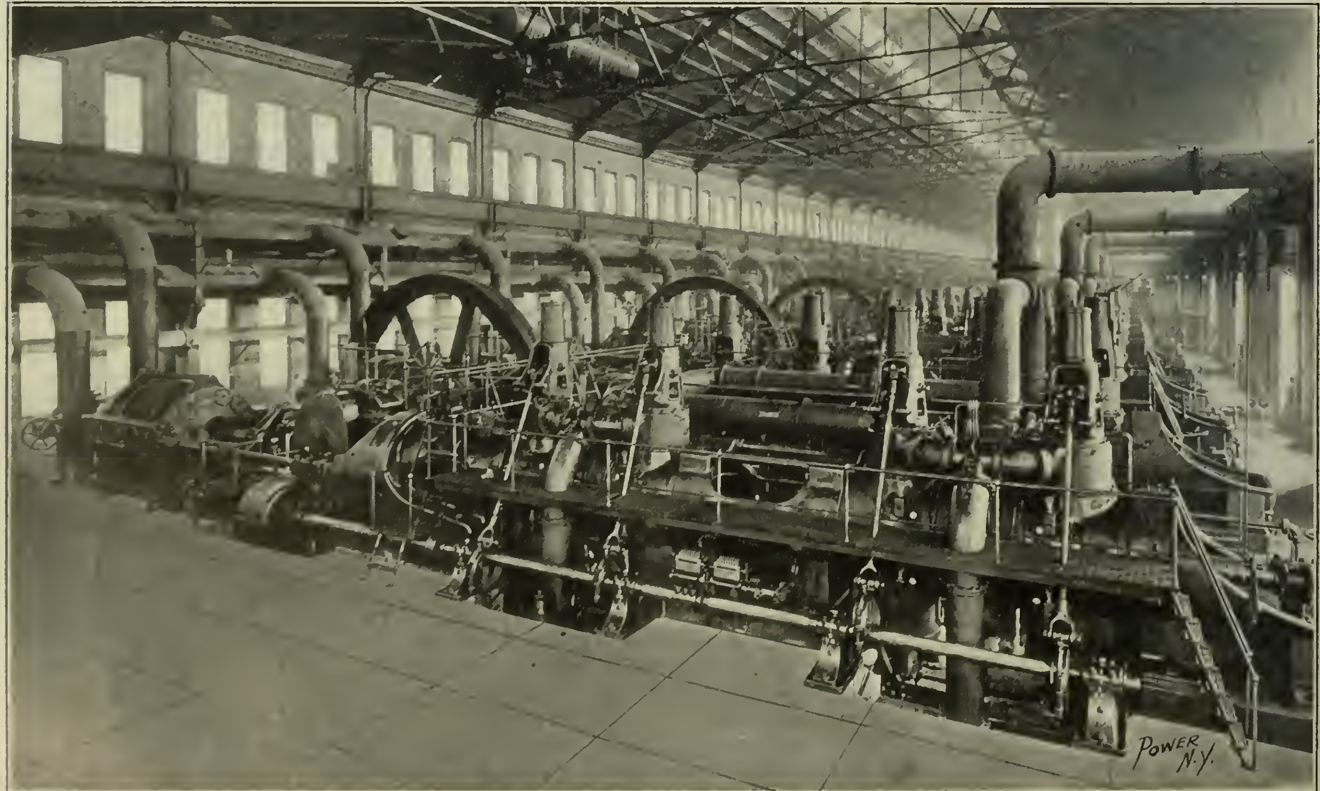


FIG. 4. GENERAL VIEW OF UNITS FROM POWER END

ing with a hose. Cooling water is provided at a pressure of about 35 pounds for all the parts from a 16-inch main running the length of the building. A single valve controls the supply to each side of the engine and plug valves in each water circuit are provided so that the rate of flow, once set, need not be changed. These separate circuits serve all the important parts, each having a visible overflow so that the quantity and temperature of the jacket water in any circuit can be determined at any time. Each exhaust-valve circuit has a separate overflow. Being insignificant in amount, the water is wasted, but other circuits are arranged in series as far as possible. Cylinder-jacket water enters first through the exhaust-cover chambers, escaping into the cylinder at the bottom, just under the exhaust port—the hottest part—ascending around the cylinder jacket to the top, where it overflows, always keeping the jacket full. To economize water farther, the pistons and heads are supplied in series on the countercurrent principle. After passing the front and rear heads of the forward cylinder in series, the warm water enters the piston rod at the middle crosshead, thence through the piston and out at the front end. In all cases, water enters at the bottom and overflows at the top of the chamber to be cooled so as to keep the parts full. This series system provides a fairly even temperature at all four packing glands, which would be impossible if both pistons were in series—one hot and the other cold. Telescopic supply pipes are used at the intake ends of the piston rods instead of knuckle joints.

Exhaust Pipes

The four individual exhaust connections for each cylinder enter a 30-inch exhaust manifold (one for each side) which communicates with an 8x10-foot brick tunnel running the full length of the building and discharging into a 100-foot stack at each end. This tunnel has an arched brick roof, but is not otherwise protected against the possibility of [illegible] explosions. All waste discharge water from the engine jackets drains into the exhaust tunnel (see Fig. 6) and serves to cool the exhaust gases and thereby to reduce their volume and consequently the back pressure on the engine. It will be noted from Fig. 6 that deflecting [illegible] are provided at each entrance to the manifold, which gives the exhaust gases a definite direction and thereby reduces the resistance of exit. Means for sealing each of these manifolds while men are working on the engines is provided in the form of a dip at *D* which may be filled with water and thus operate as a [illegible] seal. A drain valve controls this and also a seal for the jacket overflow. During cold weather the engine exhausts [illegible] run dry in order to utilize the heat for warming the building.

Gas Supply

Along the west wall of the building a 7½-foot steel gas main rests on structural wall brackets and communicates to each blowing unit through a 24-inch supply pipe equipped with a gate valve and a pressure-regulating butterfly valve, as shown in Figs. 4 and 6. The latter is required to reduce the pressure of the gas delivered to the engine exactly to atmospheric so that air and gas may be drawn into the engine at the same pressure and thus have the same proportion as determined by the respective inlet-valve settings. The butterfly valve is operated automatically by a small gasometer shown at the rear of the engine and in Fig. 10, which communicates with the supply pipe on the engine side of the butterfly valve. Similar butterfly valves located at the entrance of each inlet valve enable the operator to adjust the proportion of gas and air to any desired value to suit the quality of the gas.

Air Intake

An especially neat feature is the method [illegible]

[illegible]

Compressed-air System

[illegible]

FIG. 5. [illegible]

[illegible]

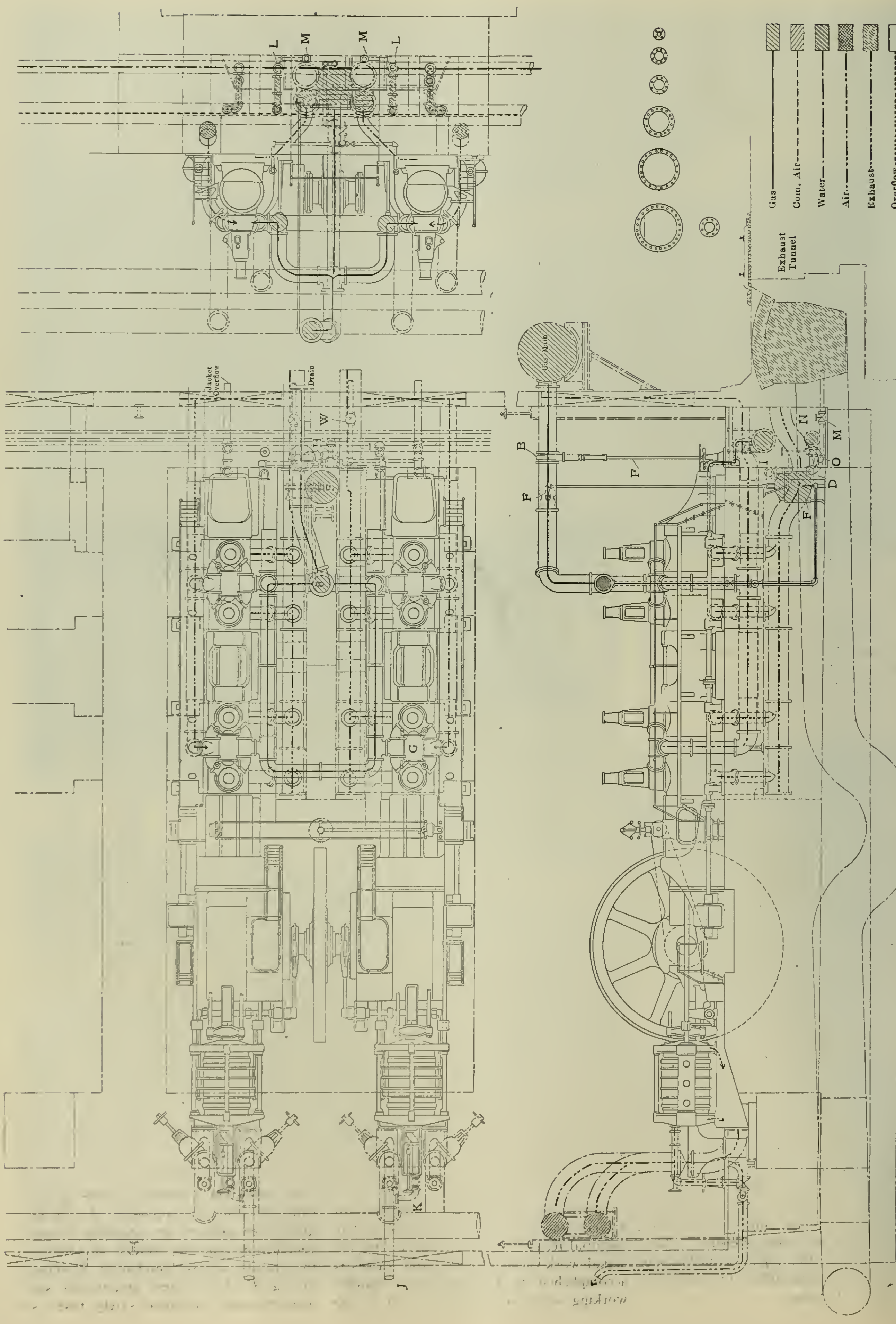


FIG. 6. GENERAL PLAN AND ELEVATION OF COMPLETE BLOWING UNIT

that a short-circuit of any one will not affect the others.

Both electrodes are insulated from the cylinder body so that a double ground is necessary to complete a short-circuit of an igniter. Grounding, however, usually occurs from sweating inside. Consequently, vents to the atmosphere are provided (see Fig. 12).

The make-and-break system is used exclusively on these engines. Although the igniter is standard with either mechanical or magnetic trip gear, the Gary engines are entirely equipped with the latter in for the field magnets of small bipolar dynamos and motors of rectangular outline. Being in series with the igniter, the magnet winding serves for the spark coil.

Ordinarily, the igniters receive current at about 110 volts from a small motor-generator set supplying each of the engine panel boards. The motor-generator is driven from the alternating-current bus-bars of the electric-power station. It is, of course, highly probable that this distant source of supply will sometimes be cut off by accident. In anticipation of such an accident connections have been equipment. Whereas in the early days it was one of the most uncertain.

LUBRICATION

Both the cylinder and the engine oils are handled by automatic systems, grease cups being used only on small, slow-moving parts, such as links, valve-gear cams, etc. In the design of the oiling system, provision has been made for the strictest economy in oil consumption and reliable feeding. For this purpose, the continuous-return system is used with set-

FIG. 7. VIEW BETWEEN ENGINE CYLINDERS

order to avoid the excessive complications arising in the provision of three sets of igniters mechanically driven. The usual rotary timer, driven from the engine lay shaft, is used. It is thoroughly protected by an iron casing and runs in oil. By rotating the casing through a few degrees, as indicated by a graduated scale, the ignition may be advanced or retarded while the engine is in operation. The magnetic trip, which has recently been perfected, is shown in Fig. 12 in contact with the igniter stem. The electromagnet inside is of the so-called iron-clad type used provided with the storage-battery house nearby, and automatic apparatus is being constructed which will instantly throw the engine ignition circuits over to the storage batteries in case of trouble with the regular supply. And as the north and the south sections of the blowing house will be separate in this respect, the possibility of a complete shutdown is [illegible] remote. With all igniter wiring run in a protected conduit and thoroughly insulated with suitable [illegible] and [illegible], the ignition system becomes one of the most reliable parts of the engine tling [illegible] filters and pumps in series. The system [illegible] is equipped with a [illegible]-gallon storage tank, resting upon the lower chords of the roof trusses, as shown in Fig. 4. From this point oil is distributed by gravity to the different parts on each blowing engine at a positive static head of about 15 feet. A simple valve controls the supply to each side of each unit and the various bearings are served by four groups of sight-feed lubricators. When these are once adjusted for the proper rate of flow, they need not be changed, so that the work required of maintain proper lubrication on these large engines is very small.

All the engine oil is returned to a common header leading to the basement filter plant, first reaching a group of three settling tanks 15x3¼x4 feet deep, where it is heated by steam coils and the sludge allowed to separate out (this sludge is caught and used in other machinery around the works). Next, a pair of vertical separating tanks removes the last traces of water. Finally the oil passes to a pair of special filters, from which it is pumped through a meter back to the roof tank. The fresh make-up oil is drawn from a 25,000-gallon tank which is large enough to take the entire contents of a railroad tank car (run in on the siding). As a precaution, a second 25,000-gallon tank is provided for overflow or storage.

Cylinder lubrication is taken care of by automatic force-feed pumps driven from the engine lay shaft and embodying the special feature that the eight individual circuits leading to various parts of each engine cylinder (including rod packings and exhaust-valve stems) are accurately timed so that oil is delivered into the cylinder only just before the end of the exhaust stroke. This allows two complete strokes of the piston before combustion takes place, during which the oil is effectively spread over the surface of the cylinder. The result of this system is that oil is injected only in small quantities and at the most effective moment. The cylinder-oil circuits run about 12½ drops per minute on the large engines, at full speed; the packings take somewhat more and the exhaust-valve stems about half that rate. It is contemplated in the completed plant to serve all of these cylinder-oil lubricators (32 in number) from a central point, putting a small meter in each feeder line to determine the rate of oil consumption. The oils used at present are "Red Engine" oil and "Diamond A" cylinder oil, both mineral oils.

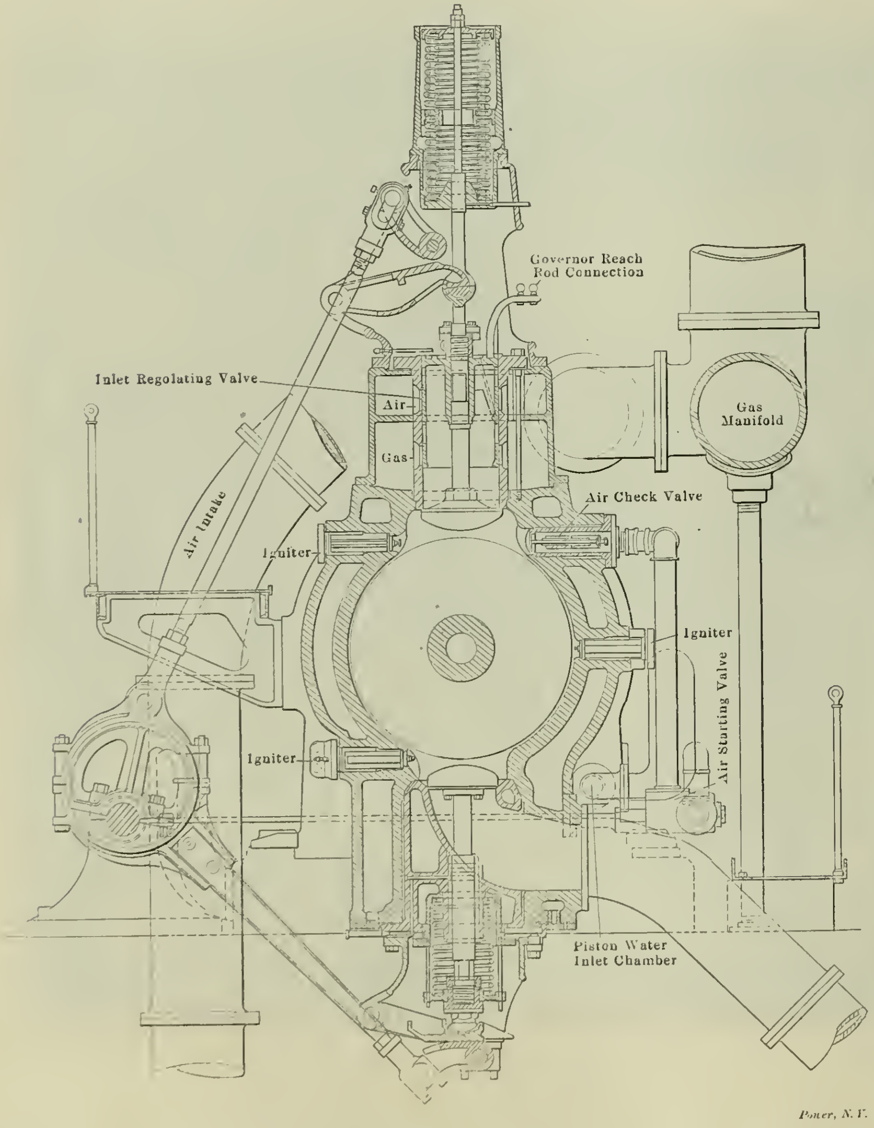


FIG. 8. DETAIL CROSS-SECTION OF GAS ENGINE THROUGH VALVE CENTERS

Gas Cleaning

This plant differs from those in the Pittsburg district in that the closed-top type of furnace is employed, that is, with no explosion door. All of the large piping is designed to withstand the maximum pressure which has been found to be produced by the explosion of a perfect mixture of blast gas and air uncompressed. Relief vents are, however, provided at several points in the open water seals of the primary, secondary and Theisen washers, so that an explosion in the furnace not damped out in passing through the tortuous passages of hot-blast stoves and piping would be relieved at one of the above-mentioned vents.

FIG. 9. 42-INCH ONE-PIECE GAS-ENGINE PISTON

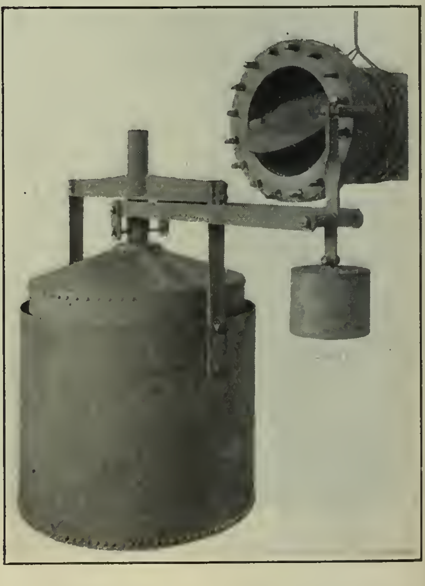


FIG. 10. GASOMETER PRESSURE REGULATOR SHOWING METHOD OF OPERATING BUTTERFLY IN GAS INLET

The dust catchers are of standard construction, but the primary washers are an improved type of Mullin washer, consisting of a central conical distributor suspended about 1 inch above the surface of the water, which is maintained at a constant level by an open overflow. The edges of this cone are deeply fluted, resembling in plan the shape of a starfish, so that a relatively great surface is presented to the gas, which is forced to spread out in a thin sheet over the surface of the water. Here the greater part of the suspended dust is deposited and drawn off below. In the tower static washers the gas is forced to ascend through a latticework continuously wetted with Korting sprays. It is also passed through several sheets of falling water obtained by conical baffles arranged in series at the base of the washer, replacing the individual baffle washers usually provided. In the Theisen washer house, final cleaning is accomplished, and the gas delivered to the mains with only 0.02 of a grain of foreign matter per cubic foot of gas. This is ample for gas-engine work, and actually exceeds the purity of the air at times at the engine intakes in the Pittsburg district. A similar cleaning plant at the Bessemer works has shown gas as clean as [illegible] grain at times, averaging [illegible] grain, while a slip in the furnace increases this considerably.

All of the overflows from the water seals of the primary tower and Theisen washers are returned to settling basins 20x40 and 12 feet deep, arranged so that the heavier material has an opportunity to settle out and may be reclaimed. A central division wall divides each basin into two compartments, one of which may be in use while the other is being cleaned.

As the Theisen washers normally deliver gas at 5 to 7 inches pressure, it is evident that if a break should occur in the supply main or its own water seal there would be danger of air being pumped into the holder, resulting in an explosive mixture. To prevent this, a large butterfly valve is installed between the Theisen washer house and the holder, which may be closed in such an event while the holder would then receive gas through the main from the blower house below.

In case the holder should leak or otherwise be out of order, large gate valves geared down for hand operation are installed in both the inlet and the outlet risers with a third valve in a bypass between so that the holder may be entirely cut out of service, the gas system then relying on the holder below, at No. 2 blowing house. Another butterfly valve in the holder intake line is arranged to close automatically when the holder has reached its upper limit.

Operating Force

Much of the ultimate success of the Gary installation depends directly upon the efficiency of the operating force. Although as many of the more perfunctory operations have been taken out of the hands of the operators by the use of automatic appliances, yet a high order of intelligence is required in the few men [illegible] contact with the care of the plant. These men must use their heads more than their hands. It may be supposed that so large a plant would require an army of men to operate it, but such is not the case. In normal operation, the No. 2 blowing house will be in charge of a chief engineer for

FIG. 11. DETAILS OF AIR-INTAKE [illegible]

each operating watch. Each engine crew will consist of an engineman and two oilers, the oilers will handle the blast valves during furnace operation, and the water, gas, oil and air valves when starting up, with the engine driver in direct charge at the throttle. This makes a

FIG. 12. [illegible] AND MAGNETO [illegible] OF ENGINE

[illegible] crew of [illegible] to tend the [illegible] 25,000 horsepower of gas engines. Considering that much of the [illegible] work occurs in operating the valves of the blowers, the amount of labor required for these engines is small, and in the case of the [illegible] power house even this would be reduced.

DATA ON NO. 2 BLOWING ENGINE

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
Length of blowing tub over all	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
Diameter of cylinders	[illegible]
Length of stroke	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
Piston rod	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
Piston speed [illegible]	[illegible]
Compression, per sq.in. [illegible]	[illegible]
Piping, [illegible]	[illegible]
Piping, [illegible]	[illegible]
Piping, [illegible]	[illegible]
Piping, [illegible]	[illegible]
Piping, [illegible]	[illegible]
Piping, [illegible]	[illegible]
Piping, [illegible]	[illegible]
Piping, [illegible]	[illegible]
Piping, [illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

New York Civil Service Examinations

The New York State Civil Service Commission announces the following examinations to be held on March [illegible]

Assistant [illegible] engineer, State and county hospitals and institutions; [illegible] and maintenance when employed in institutions. Candidates must have had two years' practical experience as [illegible], boilermaker, [illegible], fireman, engineer or electrician, including at least one year in the operation of stationary engines or electrical machinery. Subjects of examination and relative weights: Practical questions on the operation and repair of steam engines, boilers, steam-heating apparatus and electrical machinery, [illegible]; experience and personal qualifications, [illegible].

Chief engineer, [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]. Subjects of examination and relative weights: [illegible] [illegible] [illegible] [illegible] [illegible].

The commission recently [illegible] a new form of application for competitive examinations, and candidates are advised not to use blanks of issues printed before [illegible]. The new blanks may be obtained by addressing the Commission at Albany, N. Y.

Safety Valves

Continuation of the Discussion of the Subject before the American Society of Mechanical Engineers at Its February Meeting

Albert C. Ashton,

of the Ashton Valve Company, said that in his opinion what is most needed today is not necessarily a safety valve of greater capacity, but rather a better understanding of the proper proportioning of safety valves to boilers, for which there is no rule universally recognized and adopted. Mr. Whyte's paper touches upon this point and cites some recent tests made to determine the comparative capacities of pop safety valves on the market. While these tests show what the so-called new style high-lift valves will accomplish under certain favorable conditions, they do not prove that high-lift valves so made are a success in all applications. High lift is conducive to pounding upon the seat and to the lifting of water, and Mr. Ashton cited instances which had come to his knowledge where the use of valves having abnormally high lifts had been disastrous.

If high-lift valves were for a certainty an improvement, safety-valve manufacturers generally would change their designs, as can be easily done, and make nothing but high-lift valves. There may be some virtue in making valves with a lift a little higher than, say, 1/16 of an inch. but to make them with a lift of ⅛ of an inch, as appeared to be the trend of Mr. Darling's paper and of Mr. Lovekin's remarks, the speaker considered to be excessive and not advisable for general application.

Such being the situation, it was of little value, in his mind, to discuss the question of the capacities of safety valves, for whatever valve is desired the manufacturers can produce; but the speaker did hope that the society would interest itself in the question, which is of interest to the engineering profession, as to what is the best and most practicable schedule or formula that can be safely adopted for general use in determining the capacity of relief that safety valves should give on various-sized boilers at various pressures.

A. B. Carhart,

superintendent of the Crosby Steam Gage and Valve Company, devoted his remarks largely to springs. A safety valve should be designed by calculating the total spring load required to be exerted upon the disk when the valve is closed, then the suitable amount of further compression needed for vertical lift of the disk when the valve opens, with a reasonable allowance for a reserve of further possible free movement of the spring in compression, and thereupon determining the dimensions of the spring that will carry this load at its point of greatest efficiency, with due regard for flexibility, sensitiveness with accurate adjustment, and durability in service.

Within the limits of elasticity the deformation or deflection or compression is proportional to the force or pressure which produces it, and in a spring of given dimensions equal increments of force or pressure applied will produce equal amounts of compression. For example, if it requires a total load of 2000 pounds to compress a given spring having a total possible compression of one inch so that its coils are solid, with no farther deflection possible, a load of 1000 pounds would cause this spring to shorten one-half of that amount, or one-half inch, and each 100 pounds of load more or less would cause a shortening or lengthening of one-twentieth or 0.05 of an inch.

The compression of a spring at a given load is proportional to the number of coils, and the simplest way to increase the total compression or movement is to lengthen the spring. This increase of compression in proportion to the increasing number of its coils is independent of the total load which the spring will carry, and does not affect that question. If a load of 1000 pounds will compress a spring of certain diameter dimensions one-half of its total possible compression, or one-half inch, then a spring of the same diameter but twice as long and having double the number of coils would be compressed by the same load one-half of its total movement, or one inch. A load of 1500 pounds would compress either spring three-fourths of its total possible movement and likewise either spring would be compressed solid under a load of 2000 pounds. But the action of the two springs in safety-valve service would be very different, for the longer spring would have its power exerted through a greater distance.

The total amount of compression of a spring for a given load may be increased by increasing the number of coils of the same diameters and pitch and thus increasing the total free length; by reducing the cross-sectional area of the rod; or by enlarging the overall diameter; or all or any of these dimensions at the same time. If the spring be excessively long in proportion to its diameter and pitch it may bend or buckle instead of compressing in a straight thrust, and if the number of coils be too great the reaction of the spring sets up an oscillation, which not only permits but aggravates the undesirable and destructive chattering of the valve. If the spring be too short, not only is the reaction too sudden but the active free coils form a smaller proportion of the total length. It is not possible to distribute pressure at the ends of the spring exactly even upon the coils, and the spring compression is greater on one side than on the other, transmitting an undesirable side thrust to the disk guides. If the pitch is too steep the fiber stress upon the steel is enormously increased, and the rod is fractured or a permanent set takes place. If too many coils are put into a fixed length of spring there will not be sufficient free space between the coils to permit the necessary movement, and when the pitch is thus too flat the spring will have insufficient reactive power or force because of the inadequate strain or fiber stress put upon the steel. The spring must have sufficient force to make the valve open and close promptly and positively and keep the seat tight, not only to give prompt relief but to prevent the constant simmering and leaking which cuts and destroys the seats and permits the deposits of lime solids upon any exposed threads. The requirements of positive control and extreme lift are thus to a large degree contradictory.

Under no conceivable conditions of actual service can sufficient steam pressure be brought upon the disk of a pop safety valve to compress the spring so that the coils would be solid, if it has been in any way reasonably designed for its original fixed load; and the additional spring compression due to the lift of the disk to produce the valve opening to relieve the boiler is comparatively little, possibly 0.08 of an inch, or commonly and preferably less, and never under any conditions to amount to 0.18 of an inch or, say, 3/16 of an inch in the extreme.

If after the fixed-load pressure is reached the spring has still 15/32 of an inch of unused possible compression, of which less than 3/32 of an inch will be required to accommodate the desired lift of the valve, there will still be 12/32 or ⅜ of an inch before the spring will go solid; therefore, the valve spring can be properly designed to carry its set load at much more than half of its total free compression and more nearly to its solid condition than would be wise with a car spring. I believe it to be proper to proportion the spring so that the set load is carried somewhere near two-thirds or three-fourths of its total free compression, proportioning the length and dimensions of the spring so that the total free movement will be sufficient to make the remaining unused compression of the spring ample for the lift of the disk, and a safe margin beyond.

As in making boiler tests the head bolt may be set down until the spring is solid, and if the valve is fitted with a lever the spring may at times be compressed solid by that means, I would not consider it proper to use in a valve with a lever, any spring that would not safely take a solid test without showing any permanent set or strain.

As to the fiber stress, experience shows that springs may best be stressed from 60,000 to 75,000 pounds per square inch at the fixed load which should compress the spring to about 70 per cent. of its total possible free movement. The remaining movement should be three or four times the lift of the valve in opening. Springs wound of bronze are notoriously inefficient and unenduring, and their depreciation and permanent set at comparatively low fiber stress more than counterbalances any possible advantage of slow corrosion. The torsional elasticity and power depend not upon the tensile strength as much as upon the temper and resiliency. Therefore, some of the new alloy steels have proved disappointing for this service.

The spring must have sufficient compression to afford the amount of valve opening fixed upon as reasonable and practicable, yet be kept within the least amount of movement that will satisfy these demands, for every spring has considerable eccentricity, depending upon the pitch and proportion of the coils; and, under the increasing compression or extension as the valve opens or closes, the ends have a movement which may be likened in some degree to the actions of the free end of a fire hose under pressure. The side thrust due to this twisting and untwisting eccentricity is transmitted to the valve disk and increases rapidly with each fraction of increased lift or opening of the valve.

Large movement of the spring in compression is undesirable. It is but a necessary means to an end; an evil to be kept within minimum limits. It would be an advantage if a satisfactory discharge area of the valve could be attained with even less spring compression than at present. The large lift of the disk is not a measure of capacity, but of inefficiency, for that valve which releases the steam with the least proportional lift or spring compression is to that degree the more efficient for its purpose, and at the same time more safe and reliable. The greatest cause of the sticking of the valve, when it does occur, is not corrosion of the seat face, but the binding friction of the disk guide against the sides of the well or throat of the valve. This cocking or binding effect can be decreased by any modification of design which will reduce the diameter of the cylindrical guide, or which will bring the guiding surface close to the plane of the seat, both of which would reduce the moment of the friction or cocking stress. Any device which reduces the lift of the disk and the spring movement to the least possible amount will also reduce the eccentric spring action and its effect, and, of course, any valve design which requires or contemplates an unnecessarily large lift or compression disadvantageously magnifies this effect.

In the well known annular type of valve the area of the disk open to the constant pressure of the steam is approximately only four-fifths of the total initial area of the disk under load in the bevel-seated form of valve having the same diameter and seat circumference. Therefore, the use of the familiar annular flat-seated valve is the logical way to reduce to a minimum all the difficulties of spring seating, especially where the space available for the spring is absolutely limited by the overall dimensions permitted by locomotive builders and boilermakers; for the spring need thus be of diameter and strength to carry only four-fifths of the load necessary in the lip type of valve, the vertical lift and spring compression require to be only 0.7 as much, or for the same lift will give one and a half times as much discharge area.

No preliminary lift is required to relieve the overlap of an adjusting ring, for the work of giving to the disk its sudden pop lift is performed by an auxiliary steam discharge bypassed through the central passages. This bypassed or auxiliary discharge adds its volume to the main discharge capacity and leaves an absolutely unrestricted and unthrottled free escape for the main flow of the released steam directly to the open air without any tortuous expansion chamber or deflecting ring. The outlet is across a flat seat which not only utilizes the full vertical lift, but gives a discharge opening of cylindrical form with efficient rounded edges, and has the further advantage of being impossible to jam or stick, and is easily refaced by rubbing on a face plate instead of grinding to a bevel; and as the disk can be made entirely without the ever cocking and sticking guides, the efficiency of the spring can be thus aided and utilized to the greatest possible degree.

Nearly every engineer of education and experience would be qualified and ready to suggest at least one apparently simple and more or less obvious improvement in the design of safety valves or springs, but nearly every such possible detail will be found to be already old. Almost every conceivable design or modification has been the subject of a patent, and most of these have been thoroughly tried with much expense and enthusiasm before being condemned and discarded. The various subterfuges of double or separate springs, one more flexible than the other, spiral springs of increasing diameter whose first movement in compression is rapid until the smaller and stiffer coils are brought into action; springs suspended in all sorts of universal bearings, and every method of end bearing and fitting have all been tried and abandoned by almost every maker and user of safety valves but are periodically redesigned or discovered by some new designer or inventor and brought forward for consideration again and again. Before any such expenditure are advocated a study of the file of long-expired patents would be enlightening and interesting.

E. A. May

of the American Radiator Company, of Chicago, discussed the safety valve as related to low pressure, house-heating boilers.

Whether a safety valve should be raised open to exhaust all the steam generated by the boiler at its maximum capacity or whether it should vary only for the pressure and above a predetermined point would appear to offer opportunity for profitable discussion, and until this point be established there can be no standard for general practice which can safely be used by all manufacturers of low-pressure boilers.

Rarely, if ever, has a safety valve on a low-pressure boiler been called upon to exhaust all the steam generated when running under its full steam-generating capacity. In the majority of heating plants the full amount of radiation is almost always in service condensing a large percentage of the steam generated, and even when the radiation is all cut out there is still circulation through the piping.

Practically every heating boiler has its damper regulator which when properly set checks combustion when a pressure of about two pounds is reached, so that maximum capacity is impossible.

Chimney conditions in the majority of heating plants are such that it would be almost impossible to drive the boiler to its maximum steam-generating capacity.

In practically all house installations at least two of these conditions exist, and in a majority all three are present, so that to select a valve large enough to exhaust all the steam which might be generated by the boiler under ideal conditions would mean a valve out of all proportion to actual requirements.

As far as the experience of the writer goes, it would seem apparent that with the average house-heating plant of cast-iron boilers the safety factors would be practically as follows:

First: Rate of combustion, eight pounds hourly on a maximum of [illegible] pounds.

Second: Chimney, [illegible] per cent.

Third: Operating pressure of safety, fifteen pounds.

It was the speaker's opinion that if valve manufacturers would indicate in addition to the size of the valve the capacity at its different adjustments for exhaust steam it would help conditions materially, not only from the standpoint of the boiler manufacturer, but for those whose duty it is to inspect the safety valve and it would farther materially aid in the matter of legislation.

It is undoubtedly true that valves can be designed and sold on their exhaust capacity without regard to their specific size; that is owing to the variation in design one valve might have a larger diameter with lesser lift than the other, while their capacity for exhaust would be identical.

If, however, the law specifies that for a certain evaporative power, at rating, of boiler a certain exhaust capacity should be maintained in the valve, each manufacturer could then determine for himself the proper valve to use.

The speaker wished to correct a possible wrong impression left by a remark of Mr. Darling. The committee appointed by the Franklin Institute to formulate a rule adopted its own unit and prepared a formula for safety valves, the results of which were exactly similar to the French rule, so that while they may not have known the factors on which the French rules were formulated, their own rules, formulated from their own data, brought it back exactly to the same result.

H. O. Pond,

engineer and superintendent of piping for Westinghouse, Church, Kerr & Co., said, in part, that the engineer about to design a boiler installation finds himself confronted by an array of rules, covering the application of safety valves, no two of which will give the same result, and the correctness of any of which may be questioned. In the past this has not been as serious a menace to life and property as it has become recently. For a number of years past the tendency has been to force boilers farther and farther beyond the standard ratings, and to get the maximum possible capacity out of a boiler installation; so that valves which may have been of the right size for boilers operating at low ratings undoubtedly would not be correctly proportioned for boilers forced to capacities as high as 200 per cent. of their rating.

The use of the superheater has also introduced an additional factor which must be considered when deciding upon a safety-valve installation.

The absolute absence of reliable data relative to safety-valve operation and the proportioning of valves for a given service was brought very forcibly to his attention something more than a year ago in connection with the design of some special boilers of large capacity equipped with superheaters. When asked for data relative to capacities of their valves none of the manufacturers was able to furnish any definite information.

No two manufacturers use just the same lift for valves of the same "catalog" size, nor are the sizes of seat, muffle ring and ports the same. These points must necessarily affect the discharge through the valve and they are not properly considered in the present rules governing safety-valve practice.

He agreed with Mr. Ashton that the lift of the valve is not the essential thing; the thing to be determined is how much steam any given valve will discharge under particular conditions. "That particular piece of information is one that none of the manufacturers up to tonight has been willing to give us, because they have not made the tests. There are some other tests being conducted and some being prepared at the present time which will give us more definite data on which we can base the proportioning of the safety valve."

F. L. Pryor,

professor of experimental engineering at Stevens Institute, has submitted the following since the meeting:

The information that the writer secured in some tests which he made some time ago in conjunction with Professor Jacobus to obtain the blowing-off pressures of safety valves, when tested with water and when tested with steam, may be of interest.

A standard 4-inch pop safety valve set for 125 pounds was mounted on a 4-inch pipe and so connected that either steam or water under pressure could be admitted to the valve.

In all the tests the pressure required to open the valves was determined by subjecting it alternately to steam and water pressure, the set of the valve being the same for the steam and for the water in each pair of tests. The water was at a temperature of 100 degrees Fahrenheit.

One set of tests was made over a period of fifteen days, the test of one day being with steam and the following day with water, and so on until the series was completed. The lapse of time between tests was allowed to insure that the valve had obtained its normal condition of temperature, etc. In a second series of tests the valve was tested at three different settings on the same day, viz., 104, 131 and 159 pounds, the spring and valve being in each case cooled in cold water before taking the measurement for the water-pressure test.

The third series of tests was made with the valve at a number of different settings from 105 to 165 pounds, one measurement being made directly after the other, no precaution being taken to insure that the valve had returned to its normal temperature before the next test, except that before operating with water pressure a considerable amount of water was flushed through the valve.

The results obtained in all the tests were in practical agreement and indicated that the blowing-off pressure with steam and with water did not differ to any great extent, although the pressure to blow off with water was higher than with steam.

In the case when the valve was allowed to cool for twenty-four hours the water pressure required to open it was about 3½ pounds higher than the steam pressure.

In the tests where the valve was cooled thoroughly with water the pressure with water was about 3 pounds higher than the steam.

In the rapid-change test the water pressure amounted to about 2.6 pounds more than the steam pressure.

In all tests the steam and water pressure recorded was that at which the valve was in full operation. In the case of the steam-pressure test there were two testing points below full-open pressure, which also have been noted: When the valve began to leak, which occurred about 2 pounds below the final blowing-off pressure, and with the rate of flow suddenly increased, which was about 1 pound below maximum.

Prof. Edward F. Miller,

of the Massachusetts Institute of Technology, said that while the weight of steam to be discharged through a locomotive safety valve need be only a small proportion of the steam generated by the boiler, as Mr. Whyte says, in the case of stationary boilers the safety valves must be able to take care of the entire capacity of the boiler.

The sudden closing of the emergency stop valve on an engine or a turbine, by instantly stopping the demand for steam, compels the safety valves to discharge, for a time at least, as much steam as the boilers were generating at the instant that the valve closed. He had seen plants where, on account of insufficient safety-valve discharge, the pressure went up 15 pounds above the blowing pressure of the safety valves. He believed that the correct way to figure a safety valve was to make the discharge area of the valve or valves sufficient to handle all of the steam that the boiler can make at its maximum rate of coal consumption. This amounts to making the size of the safety valve depend upon the grate area, the weight of coal burned per square foot of grate per hour and the evaporation per pound of coal burned.

The weight of steam flowing through an orifice with a slightly rounded entrance may be figured quite accurately by Napier's formula (sometimes called Rankine's formula), the accuracy of which for commercially dry steam has been shown by tests made under pressure varying from 30 to 150 pounds.

The discharge per second through an orifice with a sharp edge at the entrance, such as would be the case in a safety valve, has been found from actual tests on valves to be 0.95 of the amount figured by the Napier formula.

The opening needed in a safety valve may be figured as follows:

G = Grate area,
R = Rate of coal consumption per square foot of grate per hour,
9 = Probable evaporation per pound of coal under actual conditions,

$$\frac{G \times R \times 9}{3600} = \text{Weight of steam made per second.}$$

Equate this to Napier's formula and solve for A:

$$\frac{G \times R \times 9}{3600} = 0.95\,\frac{A \times P}{70};$$

$$A = \frac{G \times R \times 9 \times 70}{3600 \times P \times 0.95}.$$

The area of the opening through a safety valve is equal to the inner circumference of the seat times the effective lift. For a valve with a seat at an angle the effective lift is equal to the lift multiplied by the cosine of the angle which the seat makes with a horizontal.

For a 45-degree angle the effective lift is 0.707 × lift. Calling D the inner diameter of the valve, the opening is

$$\pi \times D \times lift \times 0.707$$

Substituting this for A:

$$\pi D \times lift \times 0.707 = \frac{G \times R \times 9 \times 70}{3600 \times P \times 0.95}$$

If the lift of the valve is $\frac{1}{10}$ of an inch,

$$D = \frac{G \times R \times 9 \times 70}{3600 \times P \times 0.95 \times \pi \times 0.707 \times 0.1} = \frac{G\,R}{P \times 1.206}.$$

If the lift is 0.05 instead of 0.10, the valve diameter D is doubled. Doubling the pressure will make the same valve with the same lift taking care of double the weight of steam. Illustration:

Grate area = 25,
Coal consumption = 18 pounds per square foot-hour,
Pressure = 120 pounds absolute.

$$D = \frac{25 \times 18}{120 \times 1.206} = 3.1$$

Pressure = 150 pounds absolute,
Grate area = 50 square feet,
Coal consumption = 25 pounds per square foot-hour,

$$\frac{50 \times 25}{150 \times 1.206} = D = 6.9 \text{ inches}$$

A valve as large as this would be replaced by two of equivalent capacity, and two valves of 4.88 inches diameter would give the same discharge with the same lift.

F. J. Cole,

consulting engineer for the American Locomotive Company, submitted a paper read by Mr. Pomeroy, quoting from a letter written by a prominent locomotive builder abroad to the effect that when the Ramsbottom duplex safety valves were introduced into the London & North Western railway, in 1868, they were made 3 inches in diameter at the seat each, and that size has been perpetuated notwithstanding the fact that boilers have nearly doubled in capacity and the pressures have increased 50 per cent. On the other hand, they have constructed boilers of a capacity of no more than that with which the two 3-inch valves were used, with two seats of duplex valves of 4½ inches diameter.

While it is desirable that definite rules should govern this matter, it is quite evident that peculiar conditions governing the draft on locomotives, the same necessity does not exist for safety-valve regulation as in the case of marine or stationary boilers, the action of the exhaust automatically taking care in a large measure of the generation of steam.

Locomotive boilers are carefully constructed with a factor of safety ranging from 4 to 5; they have an ample margin of strength and there is no cause for alarm even if the pressure does go temporarily 25 pounds above the normal blowing-off point.

With steam at 200 pounds pressure the temperature is about 387 degrees Fahrenheit; at 225 pounds the temperature is about 397½ degrees, or 10½ degrees higher. If the pressure temporarily goes 25 pounds above the normal it means that the entire mass of water has been heated 10½ degrees higher than before, and it is altogether probable that with this increase in pressure and temperature most all of the radiant heat in the firebox has been absorbed.

The writer was in favor of a thorough investigation of the subject, looking toward the formulation of definite and authoritative rules for the application of safety valves to locomotives, and invited attention to the following suggestions to be considered in their preparation:

First, diameter, number and kind of safety valves to be based on their capacity for discharging pounds of steam per second at different pressures.

Second, the maximum amount of steam which a safety valve may be required to discharge when the throttle has been suddenly closed after the fires had been urged to be based on the square feet of adjusted heating surface, so that the relieving valves [illegible] the [illegible] kinds of heating surface, which [illegible] water tubes, [illegible] long and short boiler tubes [illegible] [illegible] to their lengths and [illegible] for different spacing of tubes [illegible] be taken into consideration, or what would be simpler, some approximation of average value of heating surface, corrected to account for difference in length and spacing of tubes, the firebox heating surface in this case to be considered as a certain percentage of the whole for all sizes of locomotives.

Dr. Charles E. Lucke,

of Columbia University, had one idea to offer which he thought was not of very great value. It had occurred to him, in connection with some work, one of the boiler and not directly on the safety valve, that there is another element in this safety-valve question which, while it may be of minor importance, ought to be considered, and that is the time element. He had studied to a considerable degree rapidly rising and rapidly falling pressures, and believed as a result of these experiments, which have extended over many years, that it is possible in a closed boiler under pressure for a sudden increase in pressure to occur and go far beyond what any safety valve may be set for, even momentarily, and it may seem that because this excess is only momentary and measured in fractions of seconds it is of no consequence, but it seemed to him that, by reason of its suddenness, it is of far more consequence.

A suddenly applied load cannot be resisted by the same metal under strain as well as a steady load, and if by any reasonable series of circumstances the pressure in the boiler should suddenly rise, then the time element will enter. He did not say that it is possible for it to do so, but it may; and consideration of the subject may reveal more chances for this to occur than have been apparent in the past. If the pressure does suddenly rise it will go higher than the safety valve is set for before the valve opens, and will cause the boiler to [illegible]. Whether this is of any consequence in practical safety-valve work he did not know, but if it is the subject may be studied experimentally.

Professor John H. Barr

suggested that there is another point along the same line as Dr. Lucke's thought: [illegible] in the design of [illegible] the safety valves [illegible] of the [illegible]. If a boiler is [illegible] with a [illegible] according to 150 pounds pressure, and the pressure is suddenly [illegible], what [illegible] to the boiler? That is what [illegible] [illegible].

[illegible] of boiler explosions and [illegible] [illegible], will realize the necessity of [illegible] safety valves that are [illegible] [illegible] [illegible] [illegible] [illegible].

Garland P. Robinson,

State inspector of locomotives for the Public Service Commission of New York, said the problem in locomotive work appears to be what proportion of the maximum evaporative capacity of the boiler must be provided for. Present practice seems to show that it is necessary to provide for about 50 per cent. of the maximum evaporation.

The commission with which he is connected has collected reliable data on about 7500 locomotive boilers. During the past week he had calculated the valve capacity of 1000 of these boilers for the purpose of finding the average practice of safety-valve equipment. The greatest variations have been noted; for instance, boilers using 180 pounds pressure with valves of 1/16-inch lift have two 3-inch valves to take care of an evaporation from 1750 to 3350 square feet of heating surface. Again he found two 2½-inch valves used to take care of from 900 to 1900 square feet of heating surface. These cases represent whole classes and not individual boilers. Therefore, it would appear that no rule has been followed to determine the size of valve required.

In his opinion a formula based on the heating surface and providing for 50 per cent. of the maximum evaporation of the boiler will give satisfactory results for locomotives in freight and passenger service.

If the angle of the valve seat is 45 degrees we have

$$A = \pi D \times l \times 0.707,$$

where

A = Effective area opening of the valve,

D = Diameter of valve,

l = Lift of the valve,

0.707 = Cosine of 45 degrees.

Combining this with Napier's formula,

$$A = \frac{P \times 3600}{W \times 70},$$

the flow of steam per hour =

$$116 \times l \times D \times P.$$

Also,

Heat surface × evaporation per square foot of heating surface per hour = evaporation of boiler.

Combining we have:

$$\text{Heating surface} \times E = 116 \times l \times D \times P,$$

or

$$D = 0.05 \frac{H\ S}{l \times P},$$

where E = 7 pounds, or 50 per cent. of the maximum evaporation per square foot of heating surface per hour.

He had checked 1000 boilers and found the constant to be 0.0441 for present practice. Included in the 1000 boilers, however, are a number which are evidently under safety-valved, as the constant in their case is only 0.024. Eliminating this class of boiler, the constant for average practice is about 0.05, as given in the formula. He believes valves calculated by this formula will be of satisfactory capacity for road engines; also, if valves for freight engines are calculated by the formula with the constant 0.035 instead of 0.05, they will be of sufficient capacity.

William Boehm,

of the Fidelity and Casualty Company, was particularly interested in the statement of Dr. Lucke regarding the element of time. He did not know of any case of boiler explosion due to insufficient safety-valve area. The trouble about a boiler explosion is that after it occurs it is almost impossible to determine the cause; there is not enough of the boiler left. If a safety valve is too large it may, of course, relieve suddenly too great an amount of steam and in so doing cause a water hammer, and that water hammer may cause a violent explosion of the boiler. He believed that the correct method of proportioning safety valves was to determine the quantity of steam to be handled, rather than to take the heating surface as a basis.

President Smith

said that the possibility of the valve being too large has entered into the question in France. He did not know what the law is now, but several years ago the maximum size of the valve was limited as well as the minimum size.

H. C. McCarty

Reference has been made to the difficulties developing out of too large a safety valve, and too large a safety valve must be construed, he believed from experience, as one with too great a lift. Several of the speakers had referred to hammer blows. Hammer blows are the result of extraordinary lift, resulting not only in the destruction of the valve, but in damage to the boiler.

No suggestion has come to the notice of his company (the Coale Muffler and Safety Valve Company) in the years of their experience in producing the valves which they do, that any advantage would be gained in locomotive service by increasing the lift above that usually followed by the majority of the manufacturers; in fact, they had found the contrary to be the case. It is true that the lifting of water and the destruction of the valve have been clearly demonstrated in practice. Beyond this he believed that there is a more vital and more serious element of difficulty. Any disturbance of the water level, especially in the modern locomotive boiler, is a serious problem confronting every man who is responsible for locomotive maintenance. We aim to work the driest steam possible through the chests and cylinders and through the throttle, which is located at the highest point possible. His observation had been that any agitation of the water will lift water through the valve or cause it to pass through the throttle, if the throttle is open at the time.

The location of valves seems to be overlooked in many instances by designers. One speaker has referred to the placing of the safety valve on the dry pipe. Their experience indicates that the connection between the valve and the boiler should be at a point as high as the clearance will permit, and with the shortest possible intermediate connection.

M. W. Sewall,

of the Babcock & Wilcox Company, suggested as the two items that need to be considered: How much steam can the boiler make? How much steam will your safety valve deliver? If these two items are considered, the diameter and the lift, the approach to the safety valve and the discharge from the safety valve can all be readily taken care of, and when they are settled one maker can make a big-diameter barrel and small lift and another a small-diameter barrel and big lift, just to suit their own conditions or their own tastes, and when they come to place them on the market the one that comes out ahead will be the best for its own manufacturer.

George I. Rockwood

thought that it was obligatory upon Dr. Lucke, now that he had "thrown that scare into us," to state what his experiments were that lead him to believe the sudden generation of pressure in boilers possible. Mr. Darling's demonstration that the lifts of valves vary up to 300 per cent., making an enormous difference in the steam discharged, ought to interest the boiler-insurance companies, and he did not see why these companies had not conspired together in some such way as do the ordinary fire underwriters—have a laboratory of their own and find out the conditions which affect the design of safety valves and devices in general that are used about the boiler plant, and then lay the law down to the several manufacturers and deliberately "Approve" their devices (and spell the approve with a capital A), and not write insurance where those devices are not used. That is the club that is most successful in producing splendid apparatus for fire protection, and he thought it would be equally effective as applied to steam-boiler protection. If Mr. Boehm, of the Fidelity and Casualty Company, never knew of an explosion of a boiler being due to an inefficient safety valve, then the speaker did not know what the agitation of the evening was about, but doubtless that is a view which is subject to modification.

A. A. CARY

agreed with Mr. Carhart that the small-lift motion spring is certainly the safest. He called attention to his discussion in the December, 1901, meeting of the society, of the subject of springs, and said that the diameter of the spring should be to the diameter of the wire about as 7 to 1, and may possibly be reduced as 5 to 1, but that is not good practice for pop safety-valve springs. He saw no good reasons for using wire of square section and thought the round section safer. An extension spring would be safer than a compression spring.

Care should be used in safety valves for use with superheated steam to see that they are not subjected to temperatures above 450 degrees. In the Cary process, invented by his father, the spring was subjected to a temperature just above that point (the point of recalescence), and it would hold the shape to which it was bent. All of the "set" must also be taken out of the spring before it is put into use.

A. D. RISTEEN

of the Hartford Steam Boiler Inspection and Insurance Company, indorsed Mr. Rockwood's suggestion of an experimental laboratory for the underwriters of boiler risks, and pledged his influence to that end, but when Mr. Rockwood suggested that they try to lay down the law to the manufacturers and owners of boilers, he thought he had suggested a task from which the insurance companies might shrink.

F. L. DUBOSQUE,

of the Pennsylvania Railroad Company, congratulated the company upon the fact that if they had not learned anything else that evening they had learned the reason for the adoption in the United States laws of a formula that has caused marine engineers more trouble than anything else for the last few years. From the fact that one of the speakers of the evening had laid so much stress upon this formula, and from the fact also that it was exhibited among the formulas thrown upon the screen, it may be looked upon with confidence. He hoped no one would be deceived by it; it was the poorest formula ever established.

He had had a little experience with it a short time ago. The formula as incorporated in the United States laws leaves in the hands of the inspector the decision as to how much coal shall be burned per square foot of grate. In determining the size of the safety valve he knew from actual experience that a particular boiler could not burn more than 16 pounds of coal per square foot of grate area. He figured accordingly that it required a [illegible]-inch safety valve. They sent their plans forward to the inspector and he said: "You are wrong; this boiler will burn [illegible] pounds of coal per square foot of grate area and it requires a [illegible]-inch safety valve, and the nearest size is [illegible] a valve fully 50 per cent. larger than is actually required to be used on the boiler."

L. D. LOVEKIN,

the author of the formula, assured Mr. DuBosque that he had had quite a little to do with boilers in the design of boilers for different steamships in the United States service and had interviewed hundreds of engineers, all of whom, with the exception of Mr. DuBosque, had complimented him upon that formula. Everybody knows that any boiler safety valved on 1 square inch of valve for 3 square feet of grate for a Scotch boiler and 1 square inch of safety valve for 6 square feet of grate area for a water-tube boiler is both ridiculous and absurd. Whenever he had said a boiler would evaporate so much water and submitted the design, he had never had an inspector return the boiler for additional safety valves. The United States Navy authorities, with all their experience, together with several prominent authorities abroad, have agreed upon a lift of 1/8 of the diameter of the valve.

In the present discussion there seems to be a misconception as to what constitutes high lifts. He did not think there was a safety-valve manufacturer in the room who cared to see a safety valve lift 1 inch, no matter how large it is. His rule was based on the proportion which the lift bears to the diameter and it falls on 1/8 of an inch for a 4-inch valve, and, therefore, the largest valve approved for naval work, 4½ inches, would not have so excessive lift under that formula.

DR. LUCKE

in response to Mr. Rockwood's request said that he had never seen the pressure rise in a steam boiler in the way to which he had referred, and did not believe that it could rise in that manner, but that if it does so rise the effects described will be those so produced; he had seen it arise from other causes.

MR. CARHART

thought that there is one way in which safety valves should not be rated and that is by the area of the disk or of the inlet connection, for in every case the outlet discharge depends in proportion to the circumference of the valve seat and the circumference will, of course, increase in proportion to the diameter while the inlet and disk areas will increase in proportion to the square of the diameter. The lift [illegible]

[illegible] assumed to be sufficient to lift [illegible] valves, with [illegible] considerations; [illegible] is the actual performance in practice. If there is any appreciable difference in specific cases it will generally be found that the larger valves lift less than the smaller ones. This is as it should be from the general point of view, for prompt and quiet action, durability of the valve and safety of the boiler. The larger valves have less weight of moving parts, less momentum, less heat, springs of more tractable proportions, and may safely lift higher.

Valves should not be rated in discharge area alone. The discharge area would be different for every pressure and would be dependent upon the care taken in maintaining the resiliency of commercial springs. It would be at best a theoretical amount arrived at by a formula which might be amended by any designer or salesman to suit the exigencies of every contract, price or specification of capacity. This would introduce formulas confused by odd sizes and leave the engineer at the mercy of the representations or misrepresentations of selling arguments. The standard sizes, familiar by practice to all engineers, now denote the size of the inlet-pipe connection which must be provided on the boiler. If different designs of valve have different apparent or claimed efficiencies, allowance can be made for this in the judgment of the engineer. The actual lift or discharge areas of valves should be determined and reported upon after impartial tests, conducted by competent and disinterested engineers, under conditions of scientific accuracy and fair precautions, where each valve is intelligently regulated to work within its proved intended limits.

FREDERICK SMITH

In rating a valve by its diameter, do you use the small diameter of the inside or the larger diameter on the outside of the seat?

MR. CARHART

We always use the small diameter of the inlet equal to the same pressure when the valve is closed.

PHILIP G. DARLING

Mr. Mac said that the Franklin Institute committee [illegible] in the adoption of their rule by a method of [illegible] [illegible] of the French people who introduced the rule. That is, he [illegible] they made their rule [illegible] [illegible] was right theoretically, and then they increased it by 50 per cent. and after that they considered it to be right as a factor of safety. It seems to me that [illegible] of the two [illegible] after [illegible] rules that have considerations.

NATHAN PAYNE

pointed out that the only profound issue in this discussion is that there has been no standard measurement of any safety valves probably to date, and whether we take a high-lift valve or a low-lift valve what we should do is to get some formula therefor measuring what one is offering when he offers a "4-inch" valve, what it will do and whether it is good for a 100-horsepower boiler or a 200-horsepower boiler.

The Shunted Ammeter

BY CECIL P. POOLE

The simple series-connected ammeter, the winding of which is merely inserted in one leg of a circuit and takes the full current, is readily understood by the average engineer. The current flows through the winding just as steam or water flows through a valve or other device inserted in a pipe. The shunted ammeter, however, is not so readily understood by beginners in electrical work, as indicated by numerous letters of inquiry received by the editorial department of this journal.

Fig. 1 is an elementary diagram of the connections of a shunted ammeter and its shunt. The latter consists of a conductor *S* of accurately known resistance, usually fastened to two relatively massive terminal blocks; the circuit wire in which the current is to be measured is cut and the two ends attached to the terminal blocks of the shunt; consequently the shunt forms a part of the circuit carrying the current to be measured. Also attached to the terminal blocks are two small flexible conductors, the other ends of which are connected to the terminals of the instrument; these conductors are twisted together, forming the flexible cord used with portable incandescent lamps, voltmeters, etc., although the diagram shows widely separated leads from the shunt to the instrument.

The instrument, though called an ammeter, is really a voltmeter of small range, usually around 50 millivolts; that is to say, an electromotive of 50 millivolts or fifty one-thousandths (one-twentieth) of a volt applied to its terminals will carry the needle to the extreme limit of the scale. The scale of the instrument, however, is marked in amperes instead of volts, the shunt being proportioned to suit the desired range.

Suppose, for example, that the instrument and shunt are designed for a "full scale" reading of 50 amperes. This means that when 50 amperes flow in the main circuit, the voltage at the terminals of the instrument must be 50 millivolts, in order that the needle may be deflected to the end of its scale. Ignoring the resistance of the "ammeter," which is relatively high in most cases, the resistance of the shunt conductor *S* must be one-thousandth of an ohm in order to show a difference of potential of 50 millivolts at its terminals when 50 amperes pass through it, because

Volts ÷ Ohms = Amperes,

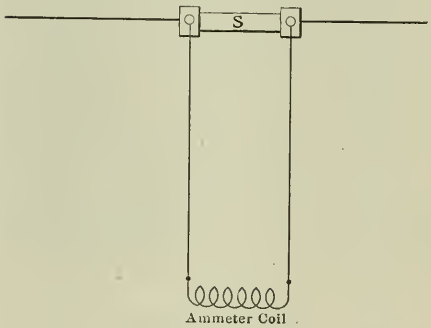
and consequently

Amperes × Ohms = Volts.

In the case mentioned, therefore, when 50 amperes pass through the circuit, there will be 50 millivolts at the instrument terminals and the needle will be carried to the end of the scale; this point is marked 50 amperes, instead of the 50 millivolts which the instrument is really measuring. When 25 amperes flow through the shunt, the voltage at its terminals will be

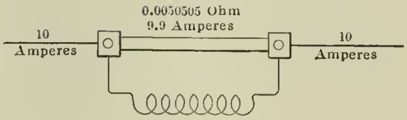
$$25 \times 0.001 = 0.025$$

volt or 25 millivolts, and the needle will point to "25" on the scale, and so on. In this case the scale would be marked exactly as it would be to indicate millivolts, because the number of amperes in the main circuit would always be exactly



Power, N. Y.

FIG. 1



Power, N. Y.

FIG. 2

the same as the number of millivolts at the terminals of the instrument.

No matter what the range of the instrument in amperes may be, however, the voltage at its terminals will be 50 millivolts when the full current is passing. The same instrument may be used, therefore, for any current range by changing the shunt and the scale on the instrument. For example, suppose the maximum current "capacity" were 1000 amperes. Then the resistance of the shunt would have to be 0.00005 ohm in order that Amperes × Ohms should equal 0.050 volt at "full scale" current in the main circuit. With 1000 amperes flowing, therefore, the potential at the terminals would be $1000 \times 0.00005 = 0.050$ volt or 50 millivolts, and the needle would be deflected to the end of the scale, which would be marked "1000," instead of 50 as in the first case; with 500 amperes, the potential would be $500 \times 0.00005 = 0.025$ volt or 25 millivolts, and the needle would stand at the point which was marked "25" in the previous case, this point being marked "500" on the scale now used. So on, through the whole list of "ammeter" capacities. The relation between the current in the main circuit and the deflection of the needle is determined entirely by the resistance of the shunt conductor.

The resistance of a millivoltmeter requiring 50 millivolts for full scale deflection is from ½ to 1 ohm, according to the design of the instrument. When used to indicate currents of 100 amperes or over, the resistance of the instrument is so high with relation to the shunt that it is ignored. For smaller ranges, however, the resistance of the instrument is considered by the more careful manufacturers. For example, if the full scale reading is 10 amperes and the instrument requires 50 millivolts for full scale deflection and is of ½ ohm resistance, the resistance of the shunt conductor should be 0.0050505 ohm; the joint resistance of the shunt and the instrument winding would then be 0.005 ohm, and with 10 amperes flowing in the main circuit the voltage at the terminals of the shunt and the instrument would be 0.050 volt, or 50 millivolts, as required. Of the total current, 9.9 amperes would flow through the shunt and 0.1 ampere through the instrument. This set of conditions is represented diagrammatically in Fig. 2. If the resistance of the instrument were ignored in this case and the shunt were made of 0.005 ohm resistance, the joint resistance of the two would be 0.00495 ohm and in order to get a full scale deflection the current in the main circuit would have to be 10.1 amperes instead of 10. This is an error of only 1 per cent., and would not be very serious. It is too large, however, to satisfy a maker who strives for as high a degree of accuracy as is commercially practical, and such a maker would probably make the shunt of 0.00505 ohm resistance. Then the joint resistance of the instrument and the shunt would be 0.0049995 ohm (assuming perfect connections and other conditions) instead of 0.005, and the error would be insignificant.

The resistance of the flexible cords leading from the shunt to the instrument is so low that the error caused by it cannot be measured by ordinary instruments. In many shunted ammeters of low range the shunt is mounted in the case which contains the meter mechanism and winding; separate connections are therefore unnecessary. When the shunt is separate, however, as indicated by the simple diagrams herewith, it is necessary that the flexible cord connecting the instrument to the shunt should be very firmly secured at both ends; any looseness of connections will cause the instrument to indicate falsely by reason of the increased resistance of the branch circuit passing through the instrument, the error being of the nature of indicating a smaller current than is really flowing in the main circuit.

Some Useful Lessons of Limewater

How Coal Burning Makes Carbonic-acid Gas; Why Fire Must Be Lighted before It Will Burn; What Causes Fire Heat; Expansion and Contraction

BY CHARLES S. PALMER

Coal Burning Makes Carbonic-acid Gas

Here is a clean, common fruit jar. Pour into it some filtered limewater and shake it up. There is no especial change, for the air in the inside of the jar is much the same as that on the outside of the jar; although if you let the limewater stand in the jar for a few minutes, you will see that its surface becomes covered with that thin white skin, or "pellicle," of plain insoluble carbonate of calcium. You can observe this better if you pour out several tablespoonfuls of the limewater into a common glass tumbler and let it stand on some dark surface, say a piece of black paper. Soon the thin white skin of plain carbonate of calcium will form over the surface, and this will remind you that the air about us carries some of this carbonic-acid gas, about one part by volume in three or four thousand of the air. When considerable of the plain carbonate of calcium has formed by exposing the filtered limewater to the air, just clear it all up with a drop of hydrochloric or nitric acid; if you look carefully, you may see a little bubbling, as though you were treating some bits of marble with the strong acid.

Now, rinse out the jar, and hold down into it a burning common wood splinter. In a few moments remove the burning splinter and pour into the jar a few tablespoonfuls of filtered limewater. Clap over the mouth of the jar a piece of common cardboard for a cover, and shake it well. You will note the same white, milky precipitate of plain carbonate, and you will be ready to study it with new questions and answers.

Now repeat the experiment of the last lesson, where you tried to find out the parts of the air, and where you used sulphur or phosphorus; only in this case use shavings, paper and the like. You will find that the experiment will work, but it will be slower than in the case where you used the phosphorus, or the sulphur, or the match ends. The products of burning the shavings or the paper will not absorb nearly as readily as the burnt products from the phosphorus or the sulphur. Indeed, although there is the same loss of bubbles of air, at the first, from the same expansion by heating the air in the jar, and although there is about the same amount of oxygen burnt out of the air, yet the absorption by the water in the jar in the case of the paper or shavings is not nearly as great as in the case of the sulphur or phosphorus. But if you replace the plain water in the wash dish with a solution of filtered limewater, then you will get about the same results as you got in the case of burning sulphur or phosphorus over plain water. The reason is, of course, that the acid-like stuff from the burning of sulphur or phosphorus is easily soluble in plain water; and the stuff from the burning of the shavings or paper, while not soluble in plain water, is nevertheless easily soluble

FIG. 1

in limewater. Try all this and you will get the facts. Now for the explanation.

The Union of Things Unlike

We have seen that in general unlike things unite with each other. Thus acids unite with bases and bases unite with acids; but bases do not unite with bases, nor acids with acids. It is much like the marriage of male with female and of female with male, but with the comparative indifference of male for male and of female for female. It is this principle of the union of unlike things that guides us in chemistry. Now to go back to the experiment: you could test the limewater with litmus, and you found that it turns it blue; that is all right, for the limewater is an alkaline base. You also found that the water solution from the burning of the sulphur or the phosphorus, or the match ends, turns litmus red; and that is also all right, because the substances formed are acid-like.

But, in the case of the carbonic gas from the burning of wood, paper or coal (we call it carbonic-acid gas, although it affects litmus very feebly), we have to reason back to prove that the carbonic gas is an acid. We reason this way: Limewater is a base. Carbonic gas unites with limewater and is therefore unlike limewater; consequently, it is an acid, carbonic-acid gas. But there is also another side to this proof. That is that acids will displace acids and bases will displace bases. We find that this principle works well, for we can drive off the carbonic-acid gas which has been absorbed by the limewater, by any strong acid, such as hydrochloric acid or nitric acid. It will be well for you to make quite a quantity of this same plain carbonate, by blowing your breath (which is the burnt carbonic-acid gas from the body furnace) into some filtered limewater; let it settle, and then pour off—"decant off," the books say—the liquid from the sediment. Then take the sediment and treat it with a few drops of hydrochloric acid; the chlorine of the hydrochloric acid will displace the C-O-two (CO_2), carbonic anhydride, or carbonic-acid gas from the plain carbonate of calcium, making calcium chloride ($CaCl_2$), C-a-C-l-two. So by reasoning backward and forward, we can prove that as this carbonic gas unites with bases like lime, and as it is displaced by acids like hydrochloric or nitric, [illegible] therefore it is an acid, carbonic-acid gas.

Where the Carbonic-acid Gas [illegible]

But we have had [illegible] still more about this colorless gas [illegible] which black coal gives on burning, and where it hides itself. Here is a tall jar; a large fruit jar will do. Pour into the bottom some powdered marble, or some common cooking soda (each are "salts" of this same carbonic acid, one with the base lime, or calcium oxide, and the other with soda proper, the oxide of the metal sodium). Now prepare several bits of candle strung on a wire like that shown in Fig. 1. [illegible] the jar (one candle can be cut into several pieces). Now pour in some strong acid, like hydrochloric acid. You will see the lively foaming, or "effervescence," as the books call it. That is the giving off of the invisible carbonic-acid gas. Now this is a heavy gas; that is, heavy as compared with the air, which, of course, is and must be the standard gas, because the air always surrounds us, and we are much like human fish walking about in this invisible ocean of atmosphere. As the carbonic-acid gas comes off in the jar, being a full-fledged gas it displaces some of the air from the jar. But being a heavy gas, it displaces it from the bottom first; and so, if you are successful with your experiment, you will see the lowest candle go out, because it cannot burn in this carbonic-acid gas. Then the next higher candle will go out, and so on to the top. If you have enough marble dust, or soda, and acid, you can literally flood the candles in order from the bottom to the top.

But this is only the beginning of what you can do with this heavy gas. You treat it as though the jar were full of a light invisible liquid. Thus you can take out the candles strung on the wire, light them again, and set them in another clean and empty jar. Now take up the first jar, which is full of the invisible carbonic-acid gas, and pour it slowly (Fig. 2), for it will not pour quickly like water, into the second jar with the relighted candles. You will see them flicker and tremble as their flames are choked or drowned by the inpouring heavy gas. If you have ordinary luck, you will extinguish some of the lower candles, and you will clearly prove to yourself that this gas is a heavy gas which follows the laws of heavy liquids insofar that it displaces the lighter air. Later, when we get to the study of the very light gas, hydrogen, you will try that the other way, and you can pour it *upward* in the air, from one jar to another; and in that case you will test it by the flame, for hydrogen burns in the air.

Now there is one more test that you want to try again, if you have not done so already; for you will devise many experiments for yourself, and try your own ideas all the time. The test is to see what litmus, red and blue, will do in some strong water solution of carbonic-acid gas, like the "fizz" water or common "soda water." You will find that the litmus will probably turn red; but if you take the litmus paper out of the water and let it dry in the air, the volatile carbonic-acid gas will be driven off from the litmus by the nonvolatile red acid of the litmus, and the litmus will probably go back to blue. But it is possible that only *one* of the slips of litmus paper will go back to blue; because, if one of the slips was already red when you put it into the solution of carbonic-acid gas, and if it was colored red by some strong acid, such as sulphuric or nitric, or hydrochloric, then such a slip of red litmus paper may remain red in the strong solution of carbonic-acid gas, and may still remain red when taken out of the water; while the other slip of litmus paper, which was blue to start with, but which was turned red by the carbonic-acid gas solution, will probably turn blue again on standing in the air. This is only to show that no fixed rule can be given to the exclusion of the free use of one's brains. We must think in all things, and while the principles given may be accurate and correct, yet their use and application may require some thinking.

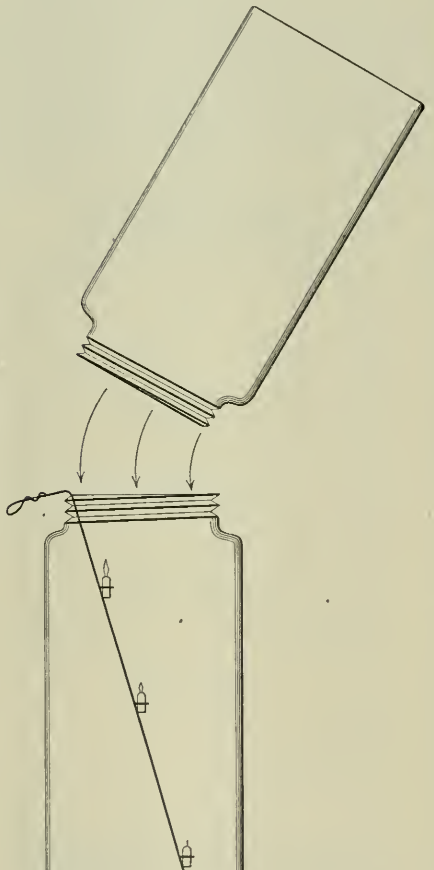


FIG. 2

But we have learned that the gas from the burning of coal, wood, or paper is mostly carbonic-acid gas; and that it comes from the union of the carbon of the coal, wood or paper, with the oxygen of the air.

Why a Fire Must Be Lighted Before It Will Burn

The fact that you may have the grate of a stove or furnace well cleaned out, that you may have the fire materials laid in order, from the shavings and kindlings and the wood to the coal, that you can have all this with the draft open and the free-flowing air all about ready to seize on the fuel, and yet there is nothing doing in the way of real fire, is a matter of everyday experience. In fact it is so common that its meaning and significance may easily escape the attention which they deserve. Why does fire material have to be *kindled* before it will burn? That is the question. It must be connected with the heat given off, because when the fire is once hot, we can kindle any amount of fuel from it.

The explanation of this curious necessity for kindling any combustible, from the match that we light by the slight friction heat of a quick stroke to the gas that burns with a hot flame, or to the still harder coal, is that all matter is made up of *groups* of chemical units. The group is called a "molecule;" and the chemical unit is called an "atom." Thus, the molecule of hydrogen is written H_2, and is called H-two; that is, there are two chemical units or atoms of hydrogen in the molecule group H-two. Similarly, the gas that comes from heating coal, and which burns with a blue flame, is called carbon monoxide (carbon one oxide), CO, and read C-O; that is, there are in the molecule group one atom of carbon and one atom or chemical unit of oxygen. Similarly, in the air the oxygen is found as molecule groups of O_2, called O-two, and the nitrogen as N_2, called N-two. Some molecule groups of chemical units or atoms contain two, some three and some four, five, six, or many more of the atoms or chemical units.

What Causes the Heat of Fire

Now, the heat from a fire is caused by the atoms of the various molecule groups falling together to make new molecule groups; and yet, before the chemical units, or atoms, can fall together in the new combinations, they must be free to come together. It is a case of "off with the old love, before on with the new." So it takes quite a degree of heat to shake the atoms loose from the old molecule groups before these same atoms can be free to fall together into the new molecule groups.

If you should ask how it is that we know that matter is made up of these molecular groups and that these molecules are themselves made up of still smaller atoms or chemical units, it would take some time to give all the proof. But you can begin to convince yourself right here that all matter has a "grained" structure. Thus, think what it means that common salt, for example, can be dissolved in water, can be passed through the pores of the finest filter paper, and can be evaporated down to dryness and recovered—all this shows that the lump of salt is made up of very small pieces which separate from each other in the solution in water, and which pass in droves through the pores of the paper and come together again; and yet in all this we have not got into the inside of the molecular groups of common salt, each of which is made up of NaCl, read N-a-C-l;

that is, each molecule of common salt consists of one atom or chemical unit of sodium (the metal back of all the soda compounds) and one atom of chlorine. But the molecule, salt, is a thing by itself, and it consists of atoms; and similarly every kind of matter consists of atoms united into molecules. The study of these unions of the atoms of each element as they make up the molecules of this and that substance is analysis. Analysis is called "qualitative" if it tells us *what* the *kind* of atom is in each substance, analysis is called "quantitative" if it tells us *how much* there is of each substance. You see that one is led to the study of the molecule and the atom from this fundamental fact that fuel ready to burn will not burn until the atoms of the molecular groups are torn asunder from the old molecules and made "free" to unite with the oxygen atoms, which must be also torn asunder from each other to burn the fuel, in making new molecules. Thus, the very fact of kindling a fire implies a difference between molecules and atoms.

Expansion and Contraction

It will be some time before we can take up very much of the proof for the molecular theory of matter and, beyond that, of the atomic theory of the molecules of matter; but you can be getting your mind in shape to handle some of these curious notions by asking yourself such simple questions as these: What happens when bodies expand with heat and contract with cold or pressure? What happens when any substance expands and contracts? All matter, in general, expands with heat and contracts with cold or pressure; what happens when matter expands? What happens when matter contracts? Whether it is a solid, a liquid, or a gas, the question is the same in kind, but you can think more clearly if you make this simple definite experiment. Take a ball of some metal, iron or brass will do, and then make a ring of metal of such size that the ball at common temperature will just pass through the ring of metal, Fig. 3. It would be better if we could afford to have some metal like gold, platinum or nickel which will not rust nor oxidize on heating; but the iron will show the principle. Now heat the ball so that it will not pass through the metal ring. What has happened to the ball of metal? If you could weigh the ball, cold and hot, you would find that there is no difference in weight, only some slight rusting; but the test has been tried with balls of gold and platinum which do not rust nor oxidize by heating in the air, and it has been found that there is no difference in weight, hot or cold. Then there is no more matter in the ball whether it is cold or hot; heat then neither adds to nor takes from the weight or "mass" of a body. Now if the ball of metal weighs the same cold or hot, if there is no more matter when it has expanded, what is the expansion?

Clearly, the expansion is the separation of small parts that are too small to be seen or felt, but there must be these small parts just the same, and it must be the separation of those small parts which shows on the outside as expansion of the whole ball. Similarly, it is the approaching of these small parts that makes the ball contract. Then the ball, though solid, is made up of small parts, that must be separated from one another by some degree of space; these approaching and receding parts are the molecules, and these molecules are made up of still smaller parts, the chemical units or atoms. It will take you some time to get used to this kind of thinking, but it will pay you for it leads not only to clearer ideas regarding the nature and structure of the kinds of matter about us, but it also leads us to some practical ways of attacking and analyzing the water that goes into your boiler, the fuel that you burn under the boiler, the ashes that you shovel away, the iron that makes up the boiler and con-

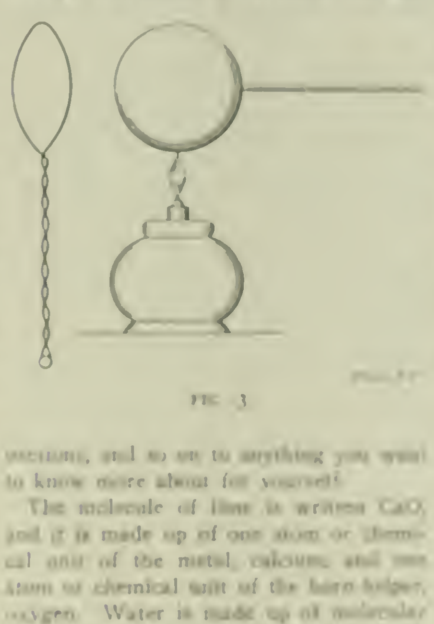


FIG. 3

stituents, and so on to anything you want to know more about for yourself.

The molecule of lime is written CaO, and it is made up of one atom or chemical unit of the metal, calcium, and one atom or chemical unit of the born helper, oxygen. Water is made up of molecular groups, which are composed of the chemical units told in the short form, H_2O (H-two-O); that is, two chemical units or atoms of hydrogen and one atom or chemical unit of oxygen; and so it goes. All this tracing of chemical composition means but one thing, and that is that at the bottom of analysis there must be the atoms, little bodies which have a weight fixed for each element, and hence called the "combining weight" or "the atomic weight." The tables of the atomic weights which are found in every textbook of chemistry will begin to have a new meaning for you, for they stand for the atoms which Mother Nature has fixed for each of the elements. As far as we know, all the atoms of any particular element have the same combining or atomic weight, different from the atomic weight of any other element: 1 for hydrogen, 16 for oxygen, 40 for your friend calcium, 14 for nitrogen, 35.5 for chlorine, 32 for sulphur, and so on. The simple statement of these atomic weights tells a story of its own, but it all was born from that old friend, the quicklime which has got you on the run and which will not let you stop until you learn a little of the special story of calcium and of the larger novel of chemical analysis. This story must be worth learning, for it helps to make "gray matter," and it will put you on your feet a little stronger and make you more ready to hold your own in the procession that starts from your barrel of lime.

Conservation of Natural Resources—Engineering Societies' Meeting

There will be a special meeting on March 24 under the auspices of the four national engineering societies, American Society of Civil Engineers, American Institute of Mining Engineers, American Institute of Electrical Engineers, American Society of Mechanical Engineers, on the general subject of "The Conservation of Natural Resources." The following program will be presented by representatives of the four societies:

"The Conservation of Water," by John R. Freeman, A. S. C. E.

"The Conservation of Natural Resources by Legislation," by Dr. Rossiter W. Raymond, A. I. M. E.

"The Waste of Our Natural Resources by Fire," by Charles Whiting Baker, A. S. M. E.

"Electricity and the Conservation of Energy," by Lewis B. Stillwell, A. I. E. E.

Spring Meeting of the A. S. M. E.

The spring meeting of the American Society of Mechanical Engineers will be held at Washington, D. C., May 4 to 7, inclusive. The local headquarters will be the New Willard hotel, rooms in which may be secured by members two weeks in advance—not later. The detailed program cannot be announced yet. Among other plans it is proposed to furnish members a condensed handbook of the most interesting points in the city with needed information, and excursions will be organized. The University Club of Washington has extended an invitation for the members to [illegible] of its rooms and privileges.

[illegible] April [illegible], inclusive, [illegible] [illegible] exhibition [illegible] Mechanics' Hall, Worcester, [illegible]

POWER
AND THE ENGINEER

DEVOTED TO THE GENERATION AND TRANSMISSION OF POWER

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March 2	42,000
March 9	37,000
March 16	37,000

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Contents

Coal Weights

A manufacturing concern recently adopted a method of checking its coal weights and found that it was receiving considerably less coal than it was charged for, one barge load being some sixty tons short. The management refused to pay for more than was received, and the coal company brought suit to recover the full amount of its bills. Testimony was offered to the effect that it was the general custom to accept "railroad weights" in billing and settling for coal delivered, after which the attorney for the coal company announced: "Your Honor, the plaintiff rests his case;" whereupon the court immediately responded: "The plaintiff has no case."

Not a word of testimony had been offered to show that the amount delivered agreed with that for which bills had been presented, and if the current practice is anything like that which the attorney for the coal company tried to establish, it will be well for others to put some kind of a check upon their coal receipts.

Safety Valve Formulas

Attention is called to the communication from Philip G. Darling on page 511 of this issue. The formula which he criticizes appeared in our issue of March 9, and assumed that safety valves in general, whatever their diameter, are designed to lift between one-sixteenth and three-thirty-seconds of an inch.

The formula was suggested as an improvement upon that now used by the United States Board of Supervising Inspectors of Steam Vessels, which is based upon the assumption that valves lift one-thirty-second of their diameter, and which gives the result in area instead of directly in the number of inches of diameter required. The bringing out of the fact that large valves lift no more than small ones eliminates the necessity of using the diameter twice, and makes possible the simple expression proposed, in which the result is obtained in inches of diameter without the use of roots or powers or the conversion of areas into linear dimensions.

Mr. Darling's formula also expresses the results in terms of the diameter, is practically as simple and avoids any assumption in regard to the lift by making the lift itself a factor of the formula. This is safer unless the assumption that any valve will lift at least five-sixty-fourths of an inch without dangerous increase of pressure is warranted. Many of the valves which Mr. Darling has tested have not lifted this amount at the popping pressure.

It was not intended, in the editorial proposing the simplified formula, to detract from the credit due to Mr. Lovekin, the author of the formula now in use. His formula is rational, and would be correct if the assumption upon which it is based, that the lift varies in the chosen proportion to the diameter, were true. The papers and discussion at the meeting of the mechanical engineers seemed to show that the assumption was unwarranted. It was a common assumption in the engineering bodies which had given the subject the most attention, even greater proportionate lifts being assumed by responsible official boards, and Mr. Lovekin is entitled to the credit of having substituted a rational formula for the archaic and inadequate one based only upon grate surface in use at the time.

Receiver Drop

It has been aptly said that the facts evolved by practice would fulfil the predictions of theory—if the theory were right—and the facts correctly stated.

The theory must, however, be complete as well as right. One does not condemn as a scientific lie the academical demonstration of Carnot that the most efficient diagram for a heat engine to make is one in which expansion is carried to the back pressure, and compression to the initial, although few engineers would try to carry out the cycle so suggested in the real cast-iron cylinder, with its heat-absorbing properties, with compression processes which are of considerably less than one hundred per cent. efficiency, and with an investment which must be made to yield the utmost per unit of interest and overall charge.

It is also quite true, from a thermodynamic standpoint, that the greatest amount of work will be got out of a pound of steam when there is no free expansion, as in the receiver of a compound engine, i.e., when the diagram from the high-pressure cylinder ends in a point. That this is found to be not the fact when it is tried should not upset one's confidence in the academical demonstration, which is plain and incontrovertible, so far as it goes, but should set one to looking for the disturbing cause. One does not deny the universality of the law of gravitation because a penny falls faster than a feather, but mentally clears the situation of all disturbing influences, such as air resistance, before he applies the law.

What the causes and conditions are which produce results at variance with the abstract truth that free expansion results in loss we do not know. Here are a couple of facts:

Some years ago an engineer operating a pumping engine with fixed cutoff discovered that when the receiver pressure was changed there was also a change in the speed of the engine. Reducing the receiver pressure increased the speed and increasing the pressure reduced the speed.

In another instance, with a horizontal cross-compound condensing engine with fixed cutoff on the high-pressure cylinder, a reduction of pressure in the receiver from fifteen pounds to three pounds was accompanied by an increase of about eight per cent. in the amount of work done by the engine.

Cast Steel Flanges

A correspondent asks if there is any standard for cast-steel flanges. We do not know of any. The diameters and drilling are usually in conformity with the standard for cast-iron flanges described on page 796 of our issue of May 19, 1908. Those who use cast steel to save weight and material will make them lighter; those who use it for greater strength will usually use the same patterns that they do for cast iron.

Buying Coal on the B.t.u. Basis

How do you buy your coal? Do you buy it on its past reputation, or upon the advice of some other user? Do you accept as absolute truth the assurances of the selling agent as to the number of B.t.u. contained per pound and the percentages of ash and volatile matter? Do you have a "proximate" or perhaps a quantitative analysis made? Do you buy it on the basis of the highest number of heat units per dollar, or do you make evaporative tests and select a coal giving the highest evaporation per dollar?

Of these various ways of determining what coal to buy, the two last enumerated may be considered as the really practical methods. What is wanted is a coal which will evaporate the largest possible number of pounds of water per dollar's worth and leave the least possible amount of ash to be carried away. Evaporative tests should give this information and the results obtained should, with careful work, be approximately accurate, more especially as the sample coal is burned under the boiler and on the grates on which the purchased coal is to be fired. In this regard, however, much depends on the fireman and a great deal upon maintaining the same boiler conditions throughout two consecutive tests. The load on the boiler, the draft and the condition as to cleanliness of the heating surface are very irregular, and a variation in any one of the three, or in the thickness of the fuel bed, might easily make a considerable difference in the results of the test.

Buying coal on the B.t.u. per pound basis would appear to be a step in advance, just as practical as and more accurate than the evaporation method, as it obviates all the errors entering into a practical boiler test. Besides, taking a small sample of coal and burning it in an atmosphere of oxygen in a bomb calorimeter is much simpler and easier than to conduct a test requiring several hundred pounds of coal and extending over a considerable period of time. From the data obtained in the calorimeter test, which are the readings of the thermometer, the B.t.u. per pound of coal can be most readily computed, and the result is in practical form, giving in a nutshell the exact information wanted by the busy man. For instance, the engineer, in reporting an engine test to the manager, does not give him the diameter of the cylinder, length of stroke, number of revolutions per minute and mean effective pressure and leave it to his judgment as to whether or not the engine is overloaded. He may give him these data, but the indicated horsepower is by all means incorporated in the results, and this one figure is exactly what is wanted, as it is really a summation of all the other data, and means more to the manager and engineer as well. Much the same may be said of the British thermal unit when used to express the commercial value of a fuel. The busy manager or engineer has not the time to delve into the hydrogen, nitrogen and carbon contents of the fuel or, perhaps, the percentage of ash and moisture, and in some cases may lack the ability to read an intelligent answer in these figures. The B.t.u. put the whole or greater part of the facts in concrete form and give something tangible by which to compare the various coals.

It cannot be claimed that the B.t.u. method is perfect, for like most other methods it has its faults. The sample taken may not fairly represent the coal, but in any case a poorly taken sample will give dissatisfaction no matter how complete an analysis is made. Another objection which might be raised is the higher price usually demanded when coal is bought on this basis. The mine owner is not sure that his coal will have a uniform value throughout the year, even when taken from the same mine, and as a sinking fund to make good any forfeit he may be obliged to pay if the quality should drop below contract specifications, the price is raised ten to twenty-five cents per ton. This addition to the price is not exorbitant, and if the mine owner can afford to take the risk for so small a sum, why cannot the buyer?

Some precaution is necessary, however, in using this method. Two coals may contain nearly the same number of B.t.u. per pound and one may not evaporate nearly as much water as the other, due to its high volatile content. For instance, Pocahontas coal, which is high in carbon and low in volatile, and contains about 14,700 B.t.u. per pound, will evaporate approximately ten pounds of water; Illinois coal of 11,000 B.t.u., which is high in volatile, will evaporate but little over six pounds of water. Consequently, a comparison by the B.t.u. method would not truly determine the relative values of the two fuels. Restricting the comparison to the same or similar coals would obviate this objection, that is, this method could be used with accuracy to compare different grades of Pocahontas or Illinois coals, and either one of these two coals might be compared with others of similar quality. With hard coals the B.t.u. comparison should be even more accurate, as the hydrogen content bears a small ratio to the total combustible, and there is no such necessity of distinguishing between the heating values of carbon and hydrogen.

It would then appear that the chief trouble with the B.t.u. method is to obtain a representative sample. There is no good reason why the sample should not fairly represent the coal to be delivered, and just as soon as the sampling is put on this basis and the mine owners can be induced to adopt this method of selling without raising the price materially, the B.t.u. basis, on account of its simplicity and accuracy, is likely to be generally adopted.

New York's Opportunity

Speaker Wadsworth, of the New York Assembly, in a recent address on "Forest Preservation and Conservation of Water Supply," had the following to say about New York State's opportunity:

"The report of the water-supply commission proceeds to show that with complete utilization of all storage possibilities an eventual development of horsepower would be attained exceeding the present development by 100 per cent., and this without taking into consideration the Niagara and St. Lawrence rivers. And they estimate that as a result of the failure of the State to install a comprehensive system of water storage, twelve million dollars' worth of energy is running to waste annually in this State, and the great bulk of that in the rivers rising in the Adirondack region.

"I submit that it is unreasonable, short-sighted and absurd to allow four-tenths of one per cent. of the State's forests to stand in the way of this great increase of prosperity which lies ready at our hands. In my judgment the State should build these storage reservoirs recommended by the water-supply commission, and should absolutely control them for all time; and I am of the further opinion that a plan can be devised by which the State can derive an income fairly sufficient, in a comparatively short space of time, to pay the cost of constructing the dams and reservoirs and have a considerable surplus to go into the State treasury for the support of the general government. [illegible]"

Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

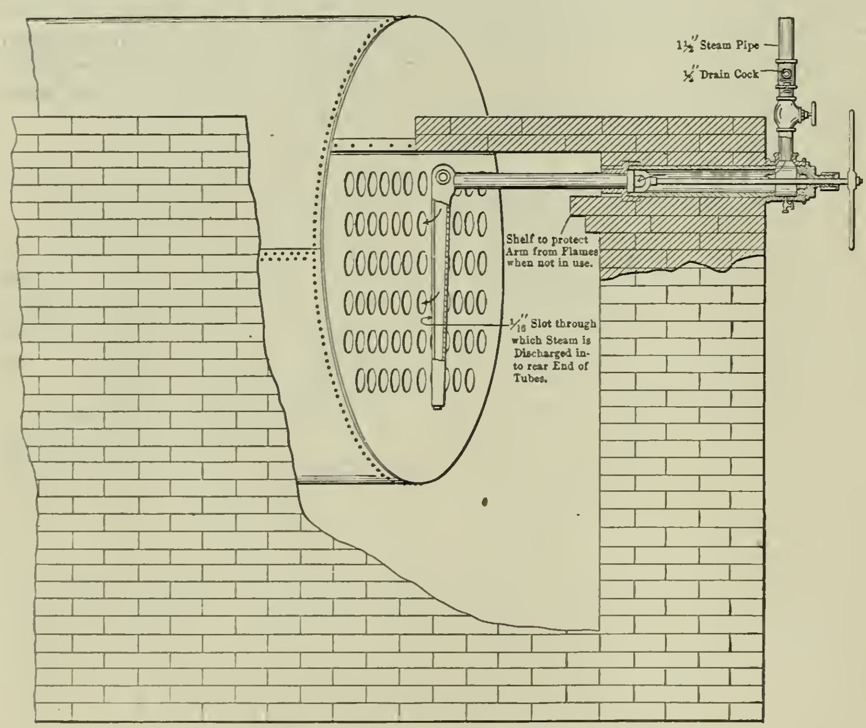
The "U. S." Tube Blower

This is a device for blowing soot out of boiler tubes *with* the draft. A casing passes through the rear wall of the boiler setting, and a T-shaped cast chamber outside the wall receives a 1½-inch supply pipe. Directly under this pipe in the chamber is a drain cock to dispose of the condensation, and on the end of the chamber is a stuffing box, through which the handle rod passes to an inner tube which just fills the casing.

On the end of this tube is a hollow cast-iron arm, one-half the diameter of the boiler in length, having a 1/16-inch slot its entire length on the side toward the boiler. By pushing the rod endwise this arm is pushed close to the rear end of the tubes into which the steam is delivered in a thin sheet. By means of a handle secured to a rod the arm may be revolved so it reaches all of the tubes.

The blower can be used while running, and when not in use the arm is pulled back and placed in a horizontal position on a shelf, where it is not exposed to the heat.

This tube blower is manufactured by the U. S. Specialty Manufacturing Company, People's building, Pittsburg, Penn.



POSITION OF U. S. TUBE BLOWER WHEN IN USE

"Anti-Rust"

A preparation which has been successfully used for preventing rust is known commercially as "Anti-Rust," prepared for the market by F. L. Melville, 192 Front street, New York City. This product is semiliquid in form, easily applied and not affected by changes of temperature, it is said. It is readily removed from the surface treated without resorting to the use of benzine or other cutting agents. "Anti-Rust" is said to have given good results under all manner of severe tests, notably in the protection of iron from the corroding influence of salt water and in long continued open-air tests.

Little Giant Tube Cleaner

The "Little Giant" tube cleaner, which is made by the Poole Manufacturing Company, 310 Broadway, Albany, N. Y., is shown herewith. It is a mechanical cleaner, the head of which is driven for-

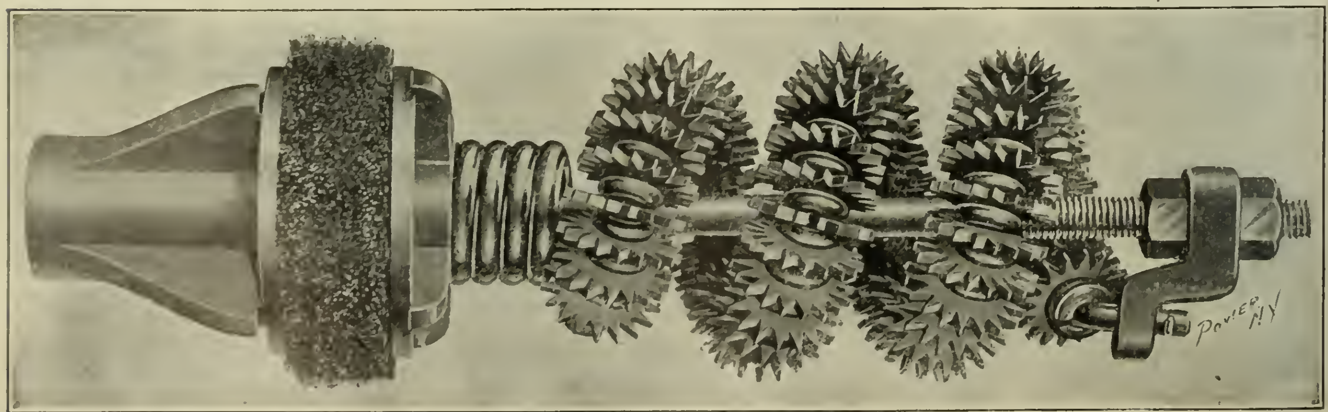


FIG. 1. TYPE OF CLEANER USED IN FIRE-TUBE BOILERS

ward by a spline shaft set in the hollow shaft of a rotary engine.

Fig. 1 shows the type of cleaner used with fire-tube boilers. The spiral portion is composed of small cutters which cut the scale, while the brush at the inner end pushes the loosened deposit out of the tube.

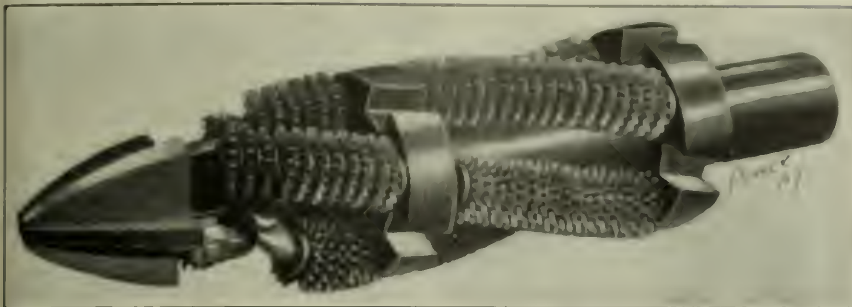


FIG. 2 CLEANER USED FOR WATER-TUBE BOILERS

Fig. 2 shows the cleaner for water-tube boilers. This cleaner is composed of a number of cutting wheels, and a cutting head. The cutting wheels, as they are revolved in the tube, remove the scale or accumulation by coming into direct contact with it. It is claimed that this cleaner does its work in a remarkably short time and is very effectual in its operation.

Ames Alloy Sheet Packing

A new kind of high-pressure sheet packing has been placed on the market, known as the Ames alloy high-pressure sheet packing, manufactured by the United States Indestructible Gasket Company, 16 South William street, New York City.

This packing, as its name implies, is ordinarily made in sheet form in thicknesses of 1/64, 1/32, 1/16 and 1/32 inch and up to 48 inches wide, but other thicknesses may be had. It is suitable for use on flanges, valves, steam chests, etc., or where the ordinary type of sheet packing is used.

It is claimed that this packing does not melt under about 700 degrees Fahrenheit and that it has been tested up to 6000 pounds pressure, which would make it suitable for the highest steam or hydraulic work. It is claimed that it does not stick to flanges or patches when the joint is broken, and that it will not disintegrate, dry out nor crack if subject to months or years of standing in stock or service. It is also claimed that it is suitable for use in contact with oils, acids, heat, gas fumes and steam, and is waterproof. It is easily cut, it only being necessary to make a pin scratch on each side of the packing which, when bent, easily breaks to the desired shape.

The Zenith Rear End Flue Blower

Herewith is illustrated a new flue blower to be attached to the combustion chamber, and which is arranged to be withdrawn from the influence of the hot gases when not in use. The device is made by the Zenith Manufacturing Company, of Duluth, Minn., and its construction is shown in Fig. 1.

It consists of a hollow casting with a packing nut at each end through which passes a hollow rod having a handle attached. The inner portion of the rod, which has a length equal to the radius of the tube sheet, is perforated with holes corresponding to the tubes of the boiler and swings on a steam-tight joint. The steam enters the joint to the hollow rod and, by turning the handle, all the tubes are cleaned by a jet of steam, and the soot is blown out in the same direction as the draft in the boiler.

Fig. 2 shows the blower in operation on a return-tubular boiler, and Fig. 3 shows it withdrawn from the combustion chamber. When not in use all parts of the apparatus are removed from the influence of the heat and gases, and a disk on the end of the blower closes the aperture through which the swinging joint is inserted. F. M. Harmon, 80 East One Hundred and Seventeenth street, Cleveland, O., is agent for the Zenith blower.

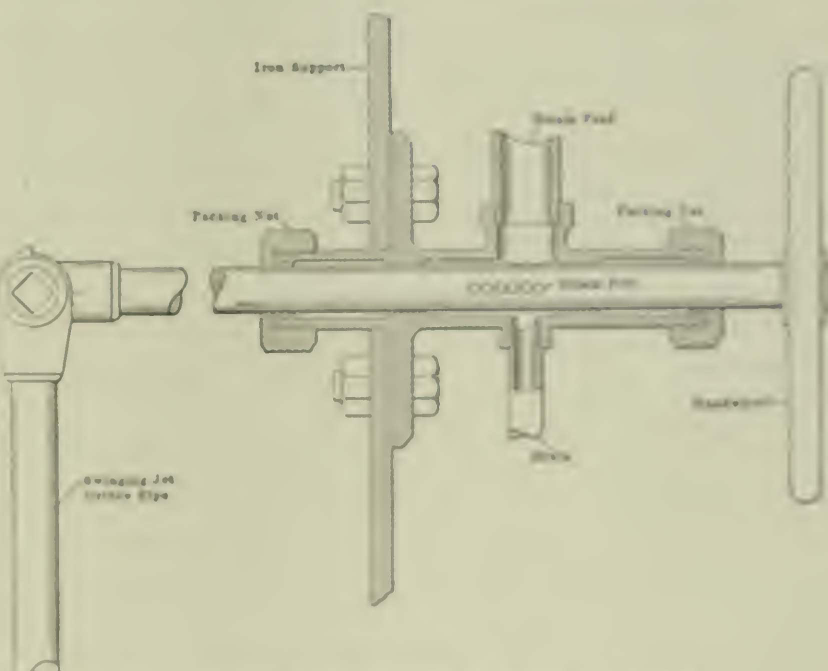


FIG. 1. DETAILS OF CONSTRUCTION OF ZENITH FLUE BLOWER

FIG. 2

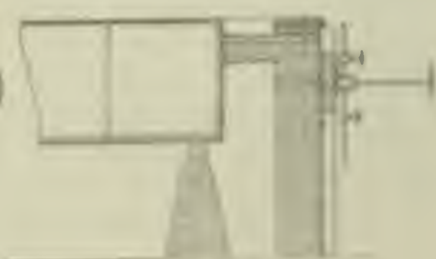


FIG. 3

At the fourth meeting of the Brooklyn Polytechnic Institute student section of the A. S. M. E., George A. Orrok lectured on "The Gas Engine; Its Mechanical Features."

Ladies' Night in Brooklyn

Brooklyn Association No. 8, National Association of Stationary Engineers, held a social session on Saturday evening, March 6, to which the ladies were invited, in the rooms of the association; and as many more of the fair sex came than were expected the rooms were overcrowded. The next ladies' night should be held in a larger hall. Frank Martin acted as master of ceremonies and introduced the following entertainers: "Bert" Self, Frank Corbett, "Joe" McKenna, "Billy" Murray, "Jack" Armour, "Dan" Quinn, Harry Elder, "Joe" Matier, Charles Kronland, "Jack" Tracy, N. H. Kenney and G. J. Sullivan. Refreshments were served.

James O. Westberg was chairman of the committee of arrangements.

Business Items

The Ohio Blower Company, of Cleveland, Ohio, includes among its recent sales three oil separators, eight steam separators and six cast-iron exhaust heads.

The American Fire Brick Company, Spokane, Wash., has given an order to the Minneapolis Steel and Machinery Company for a 20x42 heavy-duty Twin City Corliss engine, to be installed in its new plant at Mica, Wash.

Recent large orders taken by the Crocker-Wheeler Company, of Ampere, N. J., include eight generators of various types, with capacities ranging frm 50 to 800 kilowatts; eight motors for printing presses, three for elevators and a 40-horsepower induction motor.

"High-grade Petroleum Grease Lubrication" is the title of a 4-page (with stiff paper covers) pamphlet just issued by the Keystone Lubricating Company, of Philadelphia. It is devoted to contrasting some of the advantages, or disadvantages, in the use of oil for lubrication with those of grease.

The engineer of the Schauss Manufacturing Company, Toledo, Ohio, W. F. Brubaker, writes to the Buckeye Boiler Skimmer Company, South End, Toledo, Ohio, and says: "The floating skimmers you placed in our McNaull boilers are certainly all right. I ran six weeks without cleaning, and on opening the boilers I was surprised to find clear water in the bottom of the front water leg, which I expected to find half full of mud. The boilers were absolutely clean all through."

The DuBois Iron Works, manufacturer of DuBois gas engines and steam and power pumps, has been awarded the contract for the complete equipment and installation of the pumping station for the Clarion water works, Clarion, Penn., the machinery purchased consisting of one 150-horsepower Du Bois tandem natural-gas engine geared to a million-gallon pump, one 50-horsepower unit for driving the air compressor and one centrifugal pump, together with the necessary fittings, etc. The plant is an auxiliary to the present steam-pumping equipment, which will eventually be replaced by a duplicate of the new gas-engine-driven unit. The engines and pumps will work against a head of 685 feet, pumping through 4000 feet of 10-inch main to the standpipe. A complete new power station is being erected. The DuBois works has also been awarded the contract for a 160-horsepower Twin tandem gas engine, direct-connected to 100-kilowatt generator, for the lighting plant of the seventy-fourth regiment armory at Buffalo, N. Y.

The sales organization of the Northern Electrical Manufacturing Company has, for the purpose of economy, been consolidated with that of the Fort Wayne Electric Works, Fort Wayne, Ind. The Northern company has in the past confined itself to the manufacture and sale of direct-current apparatus, while the business of the Fort Wayne company has consisted very largely of alternating-current apparatus. In putting these two lines of product into the hands of one combined sales organization they are adding greatly to the efficiency and capability of each salesman, and are also making it more convenient for the public. They wish to make it particularly clear that the manufacture of present designs will be continued and that particular attention will be given, as in the past, to manufacturing and carrying at Madison a large stock of repair parts as well as completed machines. They confidently expect the result of this arrangement will be greater satisfaction to their joint customers and a steady increase in the volume of business of the respective plants.

New Equipment

A. H. Deiters and B. Davis, owners of the electric-light plant at Dickinson, N. D., are considering plans for erecting an addition and the installation of two more boilers.

The Terre Haute, Indianapolis & Eastern Traction Company, Terre Haute, Ind., is planning to increase the output of plant. New steam turbine boilers, etc., will be installed.

The Albert Lea (Minn.) Light and Power Company has planned extensive improvements at its plant which will include installation of new generator, transformers, boilers, etc.

Help Wanted

Advertisements under this heading are inserted for 25 cents per line. About six words make a line.

AN ENGINEER in each town to sell the best rocking grate for steam boilers. Write Martin Grate Co., 281 Dearborn St., Chicago.

WANTED—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. Address "M. M. Co.," POWER.

WE WANT REPRESENTATIVES to handle metallic packing in Pittsburg, Cleveland and Cincinnati. National Metallic Packing Co., Oberlin, O.

WANTED—For the engineering department of a manufacturing establishment building hydraulic machinery, a young man, college graduate with one or two years' shop and drawing room experience; one that will develop into an engineering salesman. State age, experience, education, wages to start, and send samples of drawings. Box 9, POWER.

Situations Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

MANAGER, sales manager or traveling commercial engineer; 20 years' experience electrical and mechanical lines. M. F. Harwood, 20 Howard Place, Jersey City, N. J.

POSITION WANTED anywhere by engineer with Massachusetts license; experienced hotel and power station work, a.c. and d.c. generators, absorption and compression ice machines. Box 10, POWER.

YOUNG MAN, four years' technical college training in department of mechanical engineering, wishes to hear from consulting engineers' establishment desirous of such a man to enter their services. Box 8, POWER.

Miscellaneous

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

WANTED—Second-hand, 60-cycle, single phase motors, ½ to 5 H.P., 110 or 220 volts. The Edgerton Electric Lighting System, Edgerton, Ohio.

PATENTS secured promptly in the United States and foreign countries. Pamphlet of instructions sent free upon request. C. L. Parker, Ex-examiner, U. S. Patent Office, McGill Bldg., Washington, D. C.

IN ORDER TO SETTLE an estate, an attractive opportunity is open to a party with $150,000.00 competent to fill responsible position either in the scales or manufacturing department, to purchase an interest in a well and favorably known, profitable machinery manufacturing plant located in Pennsylvania, with an office and established trade in New York City. Address "Executors," Box 3, POWER.

For Sale

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

150 HORSEPOWER tandem compound Corliss engine in good order; 16' wheel; 24-in face. F. W. Iredell, 11 Broadway, New York.

FOR SALE—One 9x12 Armington & Sims automatic high-speed piston slide valve engine. Can be seen in operation until April 1. Studer Bros., Apple Creek, Ohio.

FOR SALE—20x48 Wheelock engine and two 72"x18' high pressure tubular boilers in good condition cheap. Address "Engineer," Box 2, Station A, Cincinnati, Ohio.

SECOND-HAND MACHINERY FOR SALE—Engines, milling, linseed and cotton seed oil mill machinery. Write us for description and prices. Indiana Machine and Supply Co., 203 Ingalls Building, Indianapolis, Ind.

ONE 14x36 Vilter Corliss engine, with 7 tandem air compressor; one 14x36 Nagle Corliss engine. Can be seen under steam. Guaranteed in first-class condition; selling on account of change in equipment. Ontario Silver Co., Muncie, Ind.

Alphabetical Index to Advertisers

Characteristics of the Turbine Pump

A Study of the Design and Operation of Centrifugal Pumps by Means of Curves Characteristic of the Head, Power, Efficiency and Speed

BY FREDERICK RAY

The modern centrifugal pump has taken a position of ever-increasing importance among the various types of pumping machinery of the world, and in the last few years its field of usefulness has increased from one of limited extent and small importance to one that embraces almost every pumping service. While as already stated, the recent achievements of the centrifugal pump have been great, there is every reason to believe that the future holds in store still greater ones than have yet been recorded.

Since the modern centrifugal pump is the growth of a very few years and is the result of scientific design on the part of a few engineers, among the general engineering public there is still to be found a great deal of ignorance as to the real merits, capabilities and limitations of this type of pump.

CHARACTERISTIC CURVES

It is the purpose of this article to bring out and discuss various points in the design and operation of centrifugal pumps that must be clearly understood in order properly to select the most suitable type of pump for any particular service and to operate it most efficiently when in service. The operation of almost any type of machine can be most easily illustrated and understood by means of plotted curves showing the relations between the variables entering into the problem under consideration. With the centrifugal pump [illegible] tion between capacity and power, and one between capacity and efficiency.

Fig. 1 shows such a set of curves derived from the test of a [illegible] single-stage turbine pump operating at the constant speed of [illegible] revolutions per minute, a photograph of which is shown in Fig. 4. In this case the curve marked "Head" shows the variation of total head, which is the sum of the heads on the suction and discharge of the pump as the capacity is increased [illegible] up to the maximum quantity of water that can be forced through the pump with the discharge wide open. The curve marked "Brake Horsepower" shows the variation in the power required to [illegible] the pump [illegible] as the output is increased, while the curve marked "Efficiency" shows the variation in the efficiency of the pump under the same conditions.

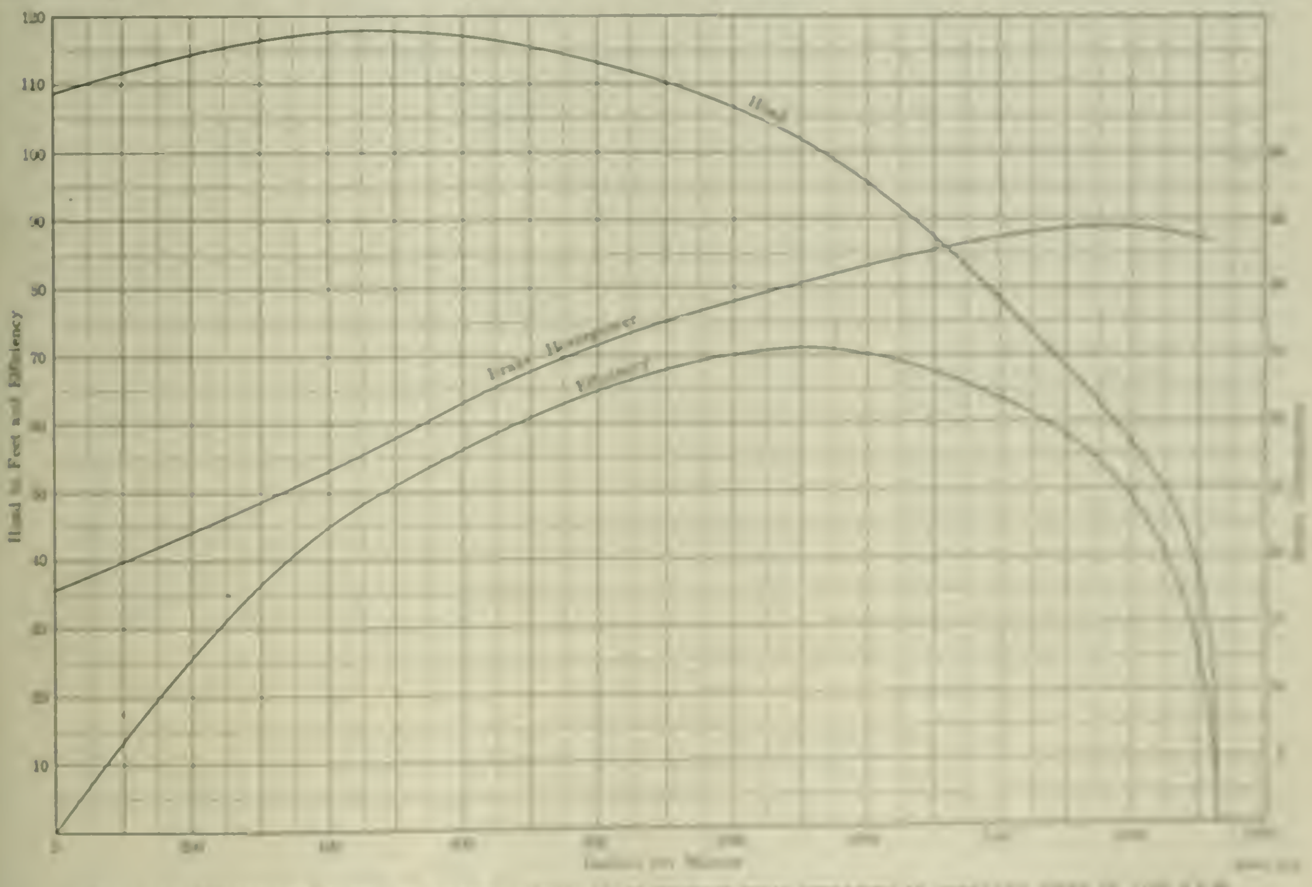


FIG. 1. CHARACTERISTIC CURVES OF [illegible] SINGLE-STAGE TURBINE PUMP OPERATING AT CONSTANT SPEED OF [illegible] R.P.M.

Head Curve—From this curve can be obtained the total head against which the pump is capable of delivering any given quantity of water when operated at a speed of 1125 revolutions per minute, and conversely, if the pump was operated at this speed and gages on the suction and discharge were read, it would then be possible to determine the amount of water being pumped. In addition to this, directly below the point on the curve representing the head would be found a point on the curve of brake horsepower giving the power being consumed; and in the same vertical line a point on the efficiency curve would show the efficiency with which this power was being utilized. It is thus plain that if a pump can be tested in the shop or elsewhere, where suitable apparatus is available, and a similar set of curves plotted from the results, a complete guide is obtained for the efficient and satisfactory operation of the pump in actual service.

Examining the head curve, it is seen that with the discharge closed, when the water in the pump is simply being revolved around, the head generated amounted to 109 feet. As the discharge valve was gradually opened, this head increased until at a capacity of 500 gallons per minute the head amounted to 118 feet, and from there on it gradually decreased until at 930 gallons per minute it again amounted to 109 feet. Thus for every point on the head curve between these limits, there are two different capacities at which the pump can operate.

From the foregoing it might appear that there would be some unstableness about the operation of the pump within these limits, and so there would be if it was not for the balancing action of pipe friction, which usually amounts to a considerable part of the total head. It is readily seen that if the pump was discharging directly into a large standpipe, so that the pipe friction was negligible, and the top of this standpipe was gradually raised until the total head became slightly over 118 feet, the discharge would immediately cease, and it would be impossible again to start it until the head was reduced below 109 feet. If, however, the static head was less than 109 feet, then by introducing friction into the discharge, by throttling, until the head became 118 feet, there would be no such sudden decrease in the capacity, as this friction head being a function of the capacity, automatically maintains a running balance, and by adjusting the throttle it is possible to operate the pump at any point on the curve with absolute stability. As the proper head to operate this pump against is about 100 feet, where the maximum efficiency is obtained, there would consequently be under such conditions none of the above difficulties.

On following this curve still farther, it is seen that the head drops to zero when a capacity of 1730 gallons per minute is reached, at which point the whole of the head generated by the pump is consumed within the pump itself and none is available for useful work.

Power Curve—This is also of great importance as the efficiency of the pump and the cost of operation depend directly upon the power consumed. In addition to this the power curve furnishes the data from which a proper selection of the driving motor can be made, and shows the load that the motor will have to carry under any condition.

In Fig. 1 the power curve shows that it required 18 brake horsepower to drive the pump at a speed of 1125 revolutions per minute with the discharge entirely closed, and from this point the power gradually increased, as the capacity was increased, in nearly a straight line until it reached a maximum of 44.5 brake horsepower at a capacity of 1550 gallons per minute. It then decreased slightly to 43.5 brake horsepower at the full capacity of the pump. From this it may be seen that it would be impossible to overload a motor of 40 or 50 horsepower to any great extent, by either a stoppage or breakage of the discharge pipe. Since at all points below 1550 gallons per minute the power decreases with a decrease in capacity, power may be saved by throttling the discharge so as to allow no more water to flow through the pump than actually required. Beyond the point of maximum power it would be more economical to let the pump discharge as much as possible, but as this point is rather beyond the proper operating conditions and the gain or loss in power is slight, this point would not be of much importance in this case.

There are, however, some designs in which the power curve would reach a maximum at a point corresponding to the normal working capacity, or even less, and under these conditions a power curve might be of considerable importance as a guide to economical operation.

Efficiency Curve—The efficiency is generally the one point about a centrifugal pump which receives the particular attention of the purchaser, with the result that most manufacturers are using every effort to produce pumps of the very highest efficiencies. High efficiency is naturally a desirable feature, but the other characteristics are often of nearly equal importance.

In Fig. 1 the efficiency curve starts from zero, at zero capacity, which must always be the starting point, as the pump does no useful work until it discharges water, although it consumes power which is entirely wasted in friction. As the capacity increases, the efficiency gradually increases until it reaches a maximum of 71 per cent. at a capacity of 1100 gallons per minute and then decreases to zero again at the full capacity of the pump, where again there is no useful work performed, as the head against which the water is pumped is zero. This particular curve shows many desirable features

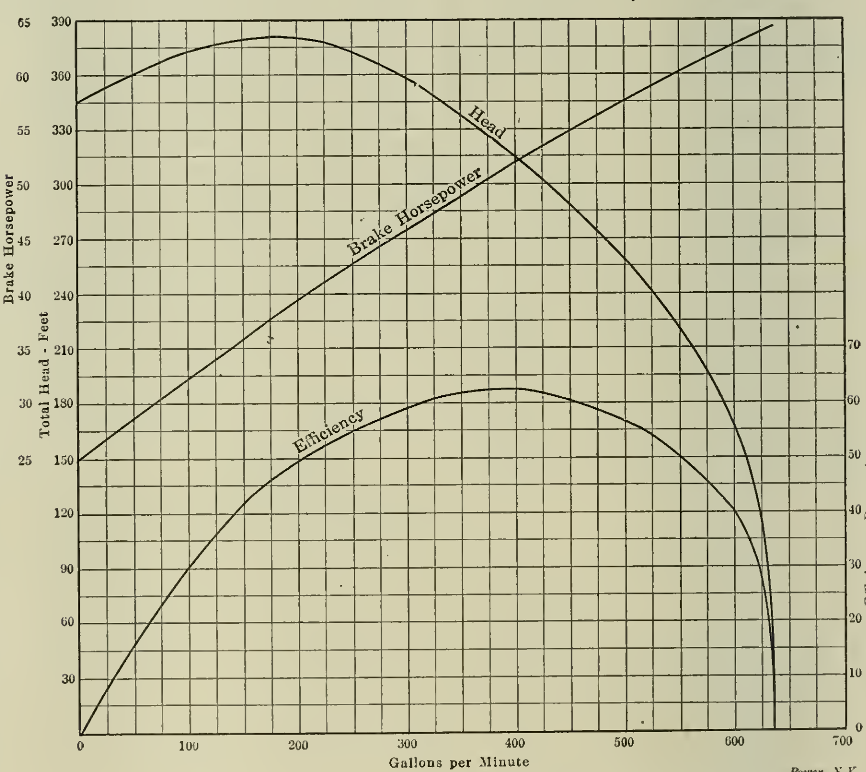


FIG. 2. CURVES FROM 5-INCH THREE-STAGE PUMP WITH SPEED OF 1788 R.P.M.

in its general form inasmuch as it has a steep inclination at its beginning with a flat top and a steep ending, and incloses a large area. Steepness at the beginning shows that the efficiency comes up quickly as the capacity increases, while a flat top and a steep ending show that the efficiency is maintained high over a wide range. Since the average efficiency is obtained by dividing the area below the curve by the length of the base, it follows that the greater the area for any given length, the greater is the average efficiency. The average efficiency in this case is 50.6 per cent. which is considered by the writer to be considerably above the ordinary for these conditions.

each at a pressure of nearly [illegible] pounds; and it would even be possible to get three very good streams at a pressure of [illegible] pounds. Such a range as this should certainly be sufficient to meet the conditions that would be apt to occur at any fire, and is much superior to what could be obtained with a positive displacement pump of the same normal capacity, especially if driven by a constant-speed motor. In addition to this the power curve shows that the motor could only be overloaded 7 per cent. if all the hose lines should burst, and the head curve shows that if all the nozzles were shut off no injurious pressure could result. The efficiency of 62.5 per cent. obtained with this pump,

[illegible] per cent. while the other characteristics retain a desirable form.

Fig. 5 shows the characteristics of the standard [illegible]-inch two-stage Underwriter pump which has a normal capacity of [illegible] gallons per minute against a pressure of [illegible] pounds. In this size of pump the efficiency is over [illegible] per cent., but otherwise the curves show the same general form. Fig. 6 is a photograph of this pump direct-connected to a [illegible]-horsepower direct-current motor, and shows the fittings furnished with the pump as called for by the Underwriter specifications.

These curves, which have been plotted from actual tests, show clearly that the centrifugal pump is well suited for fire

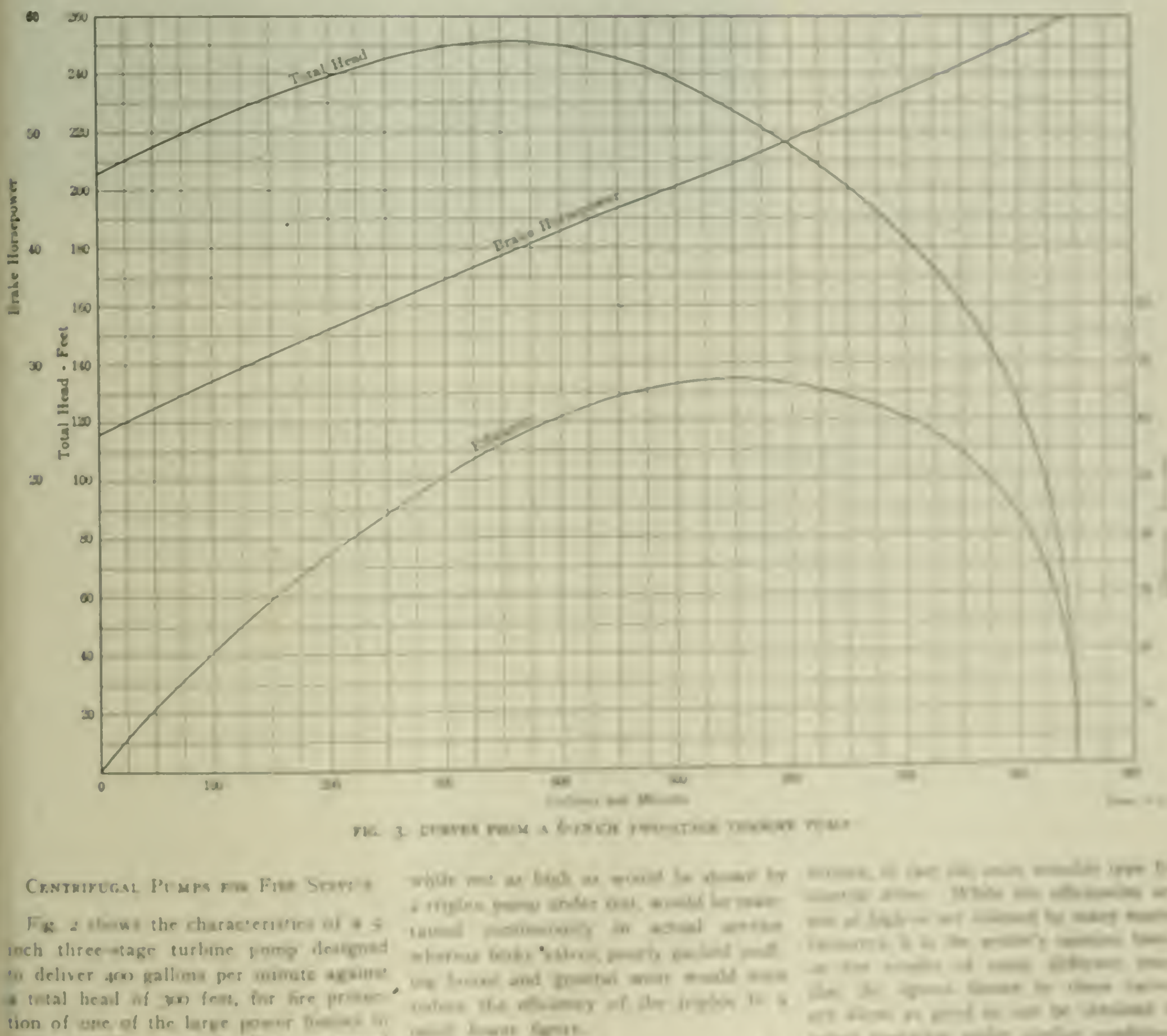


FIG. 3. CURVES FROM A [illegible] TURBINE PUMP

CENTRIFUGAL PUMPS FOR FIRE SERVICE

Fig. 2 shows the characteristics of a 5-inch three-stage turbine pump designed to deliver 400 gallons per minute against a total head of 300 feet, for fire protection of one of the large power houses in Chicago. The pump is direct-connected to a 60-horsepower 60-cycle induction motor, operating at a synchronous speed of 1800 revolutions per minute. The head curve of this pump shows that it would deliver one fire stream of 250 gallons per minute at a pressure of 160 pounds, two streams of about 200 gallons per minute each at a pressure of 125 pounds, two streams of 250 gallons per minute

while not as high as would be shown by a triplex pump under test, would be maintained permanently in actual service, whereas leaky valves, poorly packed stuffing boxes and general wear would soon reduce the efficiency of the triplex to a much lower figure.

Fig. 3 shows the characteristics of a 6-inch two-stage turbine pump designed for [illegible] gallons per minute, against a pressure of [illegible] pounds, for standard Underwriter conditions for this size of pump. Fig. 4 is a photograph of this pump direct-connected to a [illegible]-horsepower motor. From Fig. 3 it may be seen that the maximum efficiency has increased to

[illegible] While the efficiencies are not as high as are claimed by many manufacturers, it is the writer's opinion, based on the results of many different tests, that the figures shown by these curves are about as good as can be obtained in actual practice under similar conditions [illegible]

The [illegible] of the centrifugal pump for fire service was [illegible] several years ago [illegible] sign and installation of pumps for this service, with the result that centrifugal pumps whose design and manufacture have been passed on and approved by the Underwriters are accepted by them for fire protection on an equal basis with any other type of pump. This has led to a considerable demand for such pumps, and from present indications it will not be many years before the centrifugal will be the leading type of Underwriter pump.

With the exception of Fig. 1 all the curves shown are taken from pumps that were designed for fire service, but they are equally applicable to the usual design of pump for similar conditions. They are all very similar in their general form and represent a design of impeller that is well adapted to give high efficiency under the usual conditions that have to be met by such pumps. It is often necessary, however, to meet special conditions where sometimes the maximum head must be kept to within a few per cent. of the normal working head and at other times just the reverse is wanted, and by suitable design either of these conditions can be readily fulfilled. A pump designed to meet the first of these conditions would in general have a greater maximum capacity and a power curve of greater steepness and range than those illustrated. The point of maximum efficiency would also be apt to occur at a greater capacity. For the second condition the

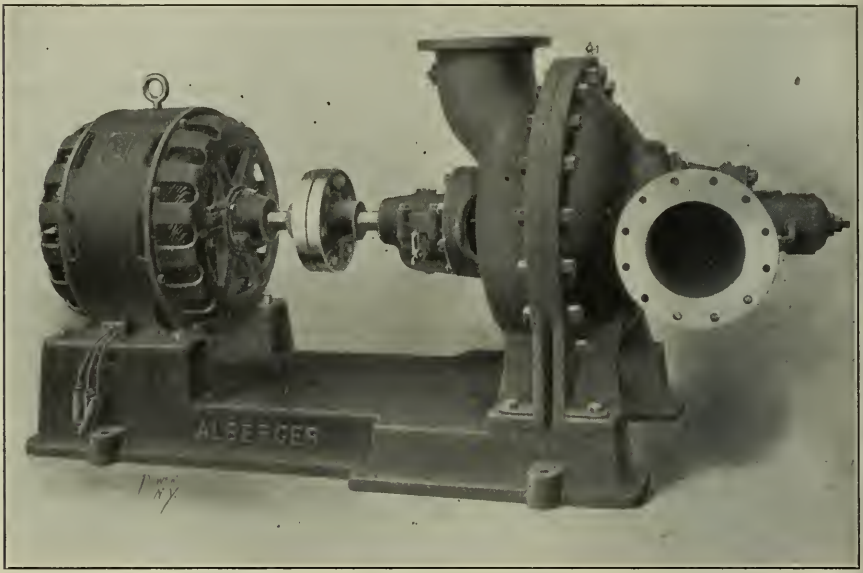


FIG. 4. ALBERGER 10-INCH SINGLE-STAGE TURBINE PUMP

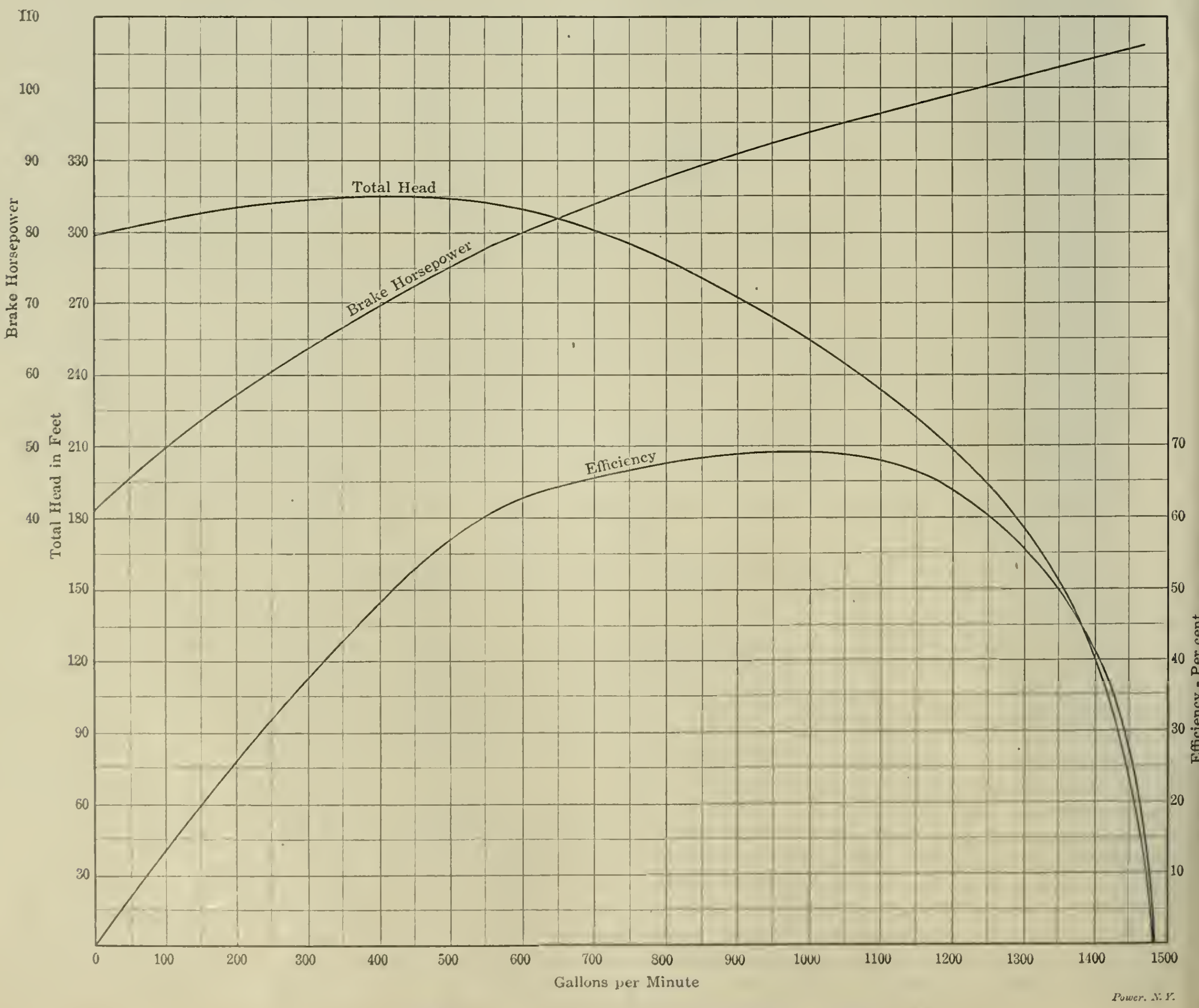


FIG. 5. CURVES FROM 8-INCH TWO-STAGE PUMP WITH SPEED OF 1400 R.P.M.

maximum capacity would be less, the power curve would become more nearly horizontal, showing a greater consumption of power at zero capacity and less at maximum capacity, while the point of maximum efficiency would occur at less capacity. From this it is seen that a horizontal head curve means a steep power curve, while a steep head curve results in a horizontal power curve.

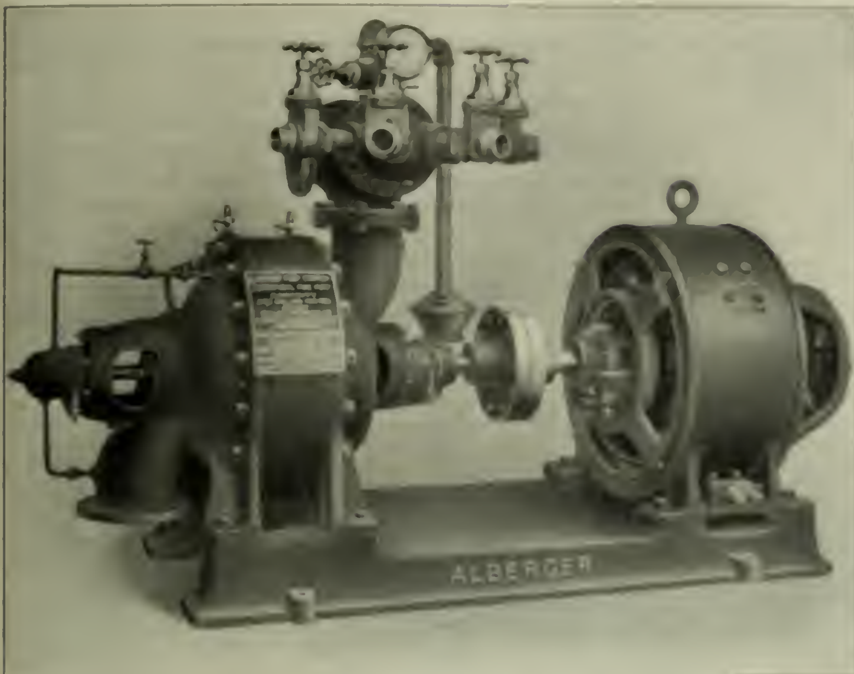


FIG. 6. TWO-STAGE 8-INCH UNDERWRITER FIRE PUMP

REGULATION OF CAPACITY AND HEAD

Another point of great importance is the regulation of the capacity and head of a centrifugal pump. There are three methods of doing this: by varying the speed, by throttling the discharge and by varying the number of stages. Varying the number of stages in a single self-contained pump is the most complicated and troublesome to work out in a satisfactory manner, and is practically used only in connection with mine-sinking pumps which are used under widely varying heads. This method is very satisfactory where the additional stages are contained in a separate pump independently driven, and is much used for city water-works service where increased pressure is required for fire service. Where the extra stages are contained within the same pump, it is almost impossible to make the design so that the idle impellers will not be churning in water, and without accomplishing this, this method of regulation is not of much value.

Throttling the Discharge—The results to be obtained by throttling are

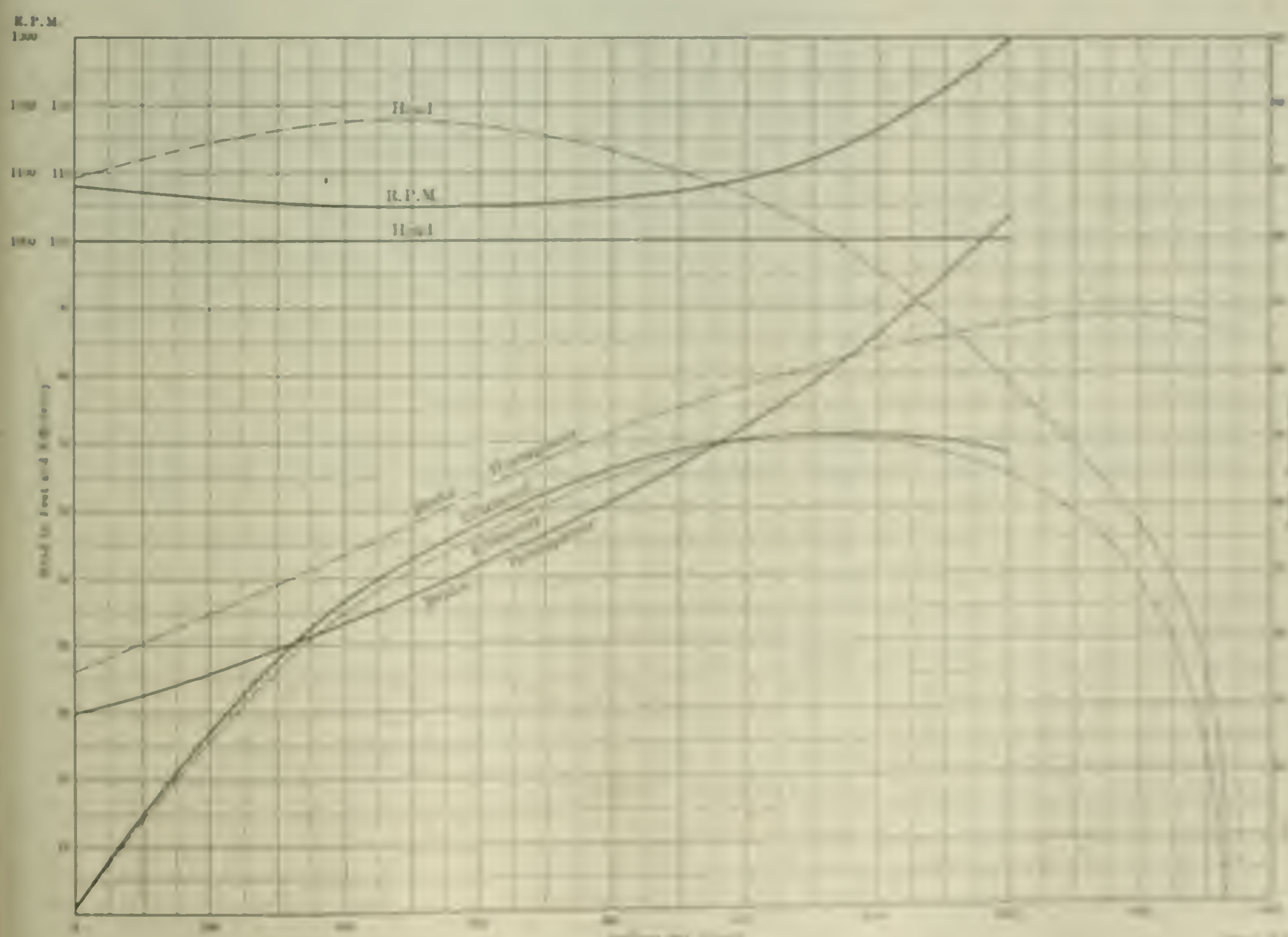


FIG. 7 [illegible]

shown by the curves already given. Thus for any given speed the power used depends only on the quantity of water flowing through the pump, since the head that the pump generates depends only on the quantity being pumped. This head can be utilized or wasted in the throttle valve as may be necessary, but whichever way the head is utilized the action of the pump is the same. If all the head is utilized the efficiency with which the water is being pumped is given by the corresponding point on the efficiency curve, but if any of the head

$$0.65 \times \frac{100}{113} = 57.5 \textit{ per cent.}$$

This same result can be obtained by calculating the water horsepower of 800 gallons per minute against 100 feet and dividing by the corresponding brake horsepower from the curve. By making similar calculations on the several curves that are illustrated it can be readily seen that the objection to this method of regulation is the considerable loss in the efficiency of pumping that results therefrom.

mark instead of the curve shown in Fig. 1. There has also been introduced a new curve marked "R.P.M." which gives the revolutions per minute required for any given capacity against the constant head of 100 feet. The power and efficiency curves are also changed, as is apparent by a comparison with the original curves reproduced in dotted lines.

On looking at the speed curve, it is evident that to generate a head of 100 feet without delivering any water requires a speed of about 1080 revolutions per minute. As the capacity is increased the

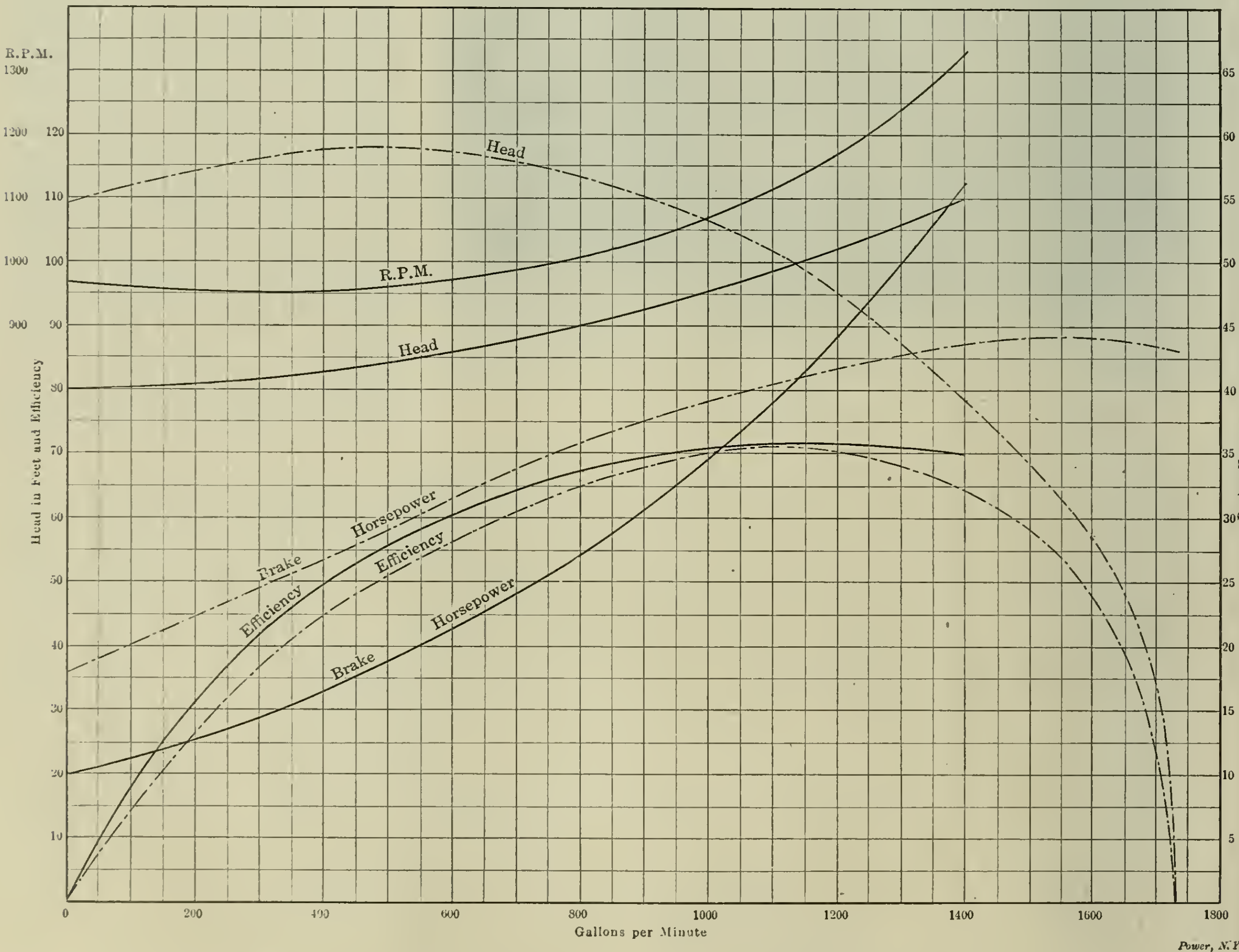


FIG. 8. SINGLE-STAGE 10-INCH PUMP OPERATING AGAINST A COMBINED STATIC AND FRICTION HEAD

is being wasted in the throttle valve the above efficiency must be multiplied by another factor whose value is the ratio of the total head utilized to the total head generated. To illustrate this point with an example, take Fig. 1 and assume that this pump is operating against a steady head of 100 feet and that it is required to find the efficiency with which it is possible to pump 800 gallons per minute. From the curves it will be seen that the efficiency of the pump itself is 65 per cent. and the total head generated is 113 feet. Consequently the efficiency of pumping is

Speed Variation—Undoubtedly the best method of regulating the capacity of a centrifugal pump is by means of speed variation, and as the proper selection of the method of control is of great importance, it seems well worth while to discuss the matter thoroughly.

Fig. 7 shows the characteristics for the same pump as those in Fig. 1, derived from the results there illustrated on the assumption that the total head remains constant at 100 feet while the capacity is varied by varying the speed. On this assumption the head curve becomes the horizontal straight line at the 100-foot

speed required gradually decreases until it reaches a minimum of 1050 revolutions per minute at a capacity of 450 gallons per minute, which also corresponds with the point of maximum head under constant-speed operation. From this point on, the speed gradually increases until at a capacity of 1130 gallons per minute it has reached a value of 1125 revolutions per minute, at which point the original head curve crosses the 100-foot mark, as would be expected. As the capacity is still further increased, the required speed increases at a more rapid rate until at a capacity of 1400 gallons per minute it becomes 1300 revolutions per minute and would continue to increase in the same curve until the maximum capacity of the pump is reached, beyond which it would be useless to go farther as it would be impossible to pump more water at any speed whatsoever.

The power curve is seen to have changed its form materially, becoming much steeper, so that the power at capacities less than 1130 gallons per minute is considerably less than at constant speed, while at greater capacities it increases rapidly. Below the intersection with the former power curve the power required is less, due mostly to the fact that less work is being done by the pump, but also due to the better efficiency with which the work is done, as is shown by the efficiency curve. Beyond this intersection the increase in power is entirely due to the increased output of the pump, since from the efficiency curve it may be seen that the efficiency under these conditions is considerably better than at constant speed. It is seen by comparing the new with the old power curve that it would take as much as 25 per cent. more power at some points to drive the pump at constant speed and decrease the capacity by throttling than would be necessary to secure the same capacity by means of speed regulation. The efficiency curve is flatter with as high or higher efficiency at every point and consequently includes a larger area, thus giving a greater average efficiency throughout the range of capacity of the pump.

The conditions illustrated in Fig. 7, which were based on the assumption of a constant total head, are the least adapted to show a saving in power by means of speed regulation, and they are also conditions that practically never occur in actual practice inasmuch as there must always be some frictional resistance to every pumping system making use of pipes to convey the water. In fact in the usual installation the pipe friction generally amounts to at least 10 to 20 per cent. of the static head at normal capacity, and for many services the total head is composed entirely of frictional resistance.

As an illustration the curves in Fig. 8 have been drawn from the data of Fig. 1 based on the assumption that the total head is 100 feet at a capacity of 1130 gallons per minute and that this head is composed of 80 feet static head and 20 feet friction head. Since the frictional resistance varies as the square of the capacity, the head curve can be drawn at once as shown. Having the head curve the speed curve can be drawn and it may be seen that for capacities less than normal the speeds are lower than required for the conditions in Fig. 7. For capacities greater than normal the speeds are higher. The power curve is of the same general shape as in Fig. 7, but steeper, showing that at capacities less than normal still less power is used, while for greater capacities more power is necessary. Under these conditions it is seen that nearly 60 per cent. more power would be required at some points to drive the pump at constant speed and regulate the capacity by throttling. The efficiency curve shows as good or better efficiency at every point and a higher average efficiency throughout.

When the head is entirely of friction, regulation by speed variation becomes even more important if economical results are desired. Under these conditions when the capacity is zero, the head is also zero and the speed required is likewise zero. It will also be found that the capacity will increase directly as the speed, and the head generated by the pump and required to overcome the friction varies as the square of the speed. The efficiency will be found to be nearly constant at all speeds and consequently the efficiency curve would be nearly a horizontal straight line. Therefore, if the frictional resistance is known at any capacity, the head curve can be drawn at once. The speed curve follows immediately, and if an efficiency curve has been determined at any constant speed, the efficiency curve for those conditions can be constructed. The power curve can be derived from these curves, and it will be found that the power varies as the cube of the speed. Since the head varies as the square of the speed and the capacity as the first power of the speed, the output of the pump in work varies as the cube of the speed and is directly proportional to the power input.

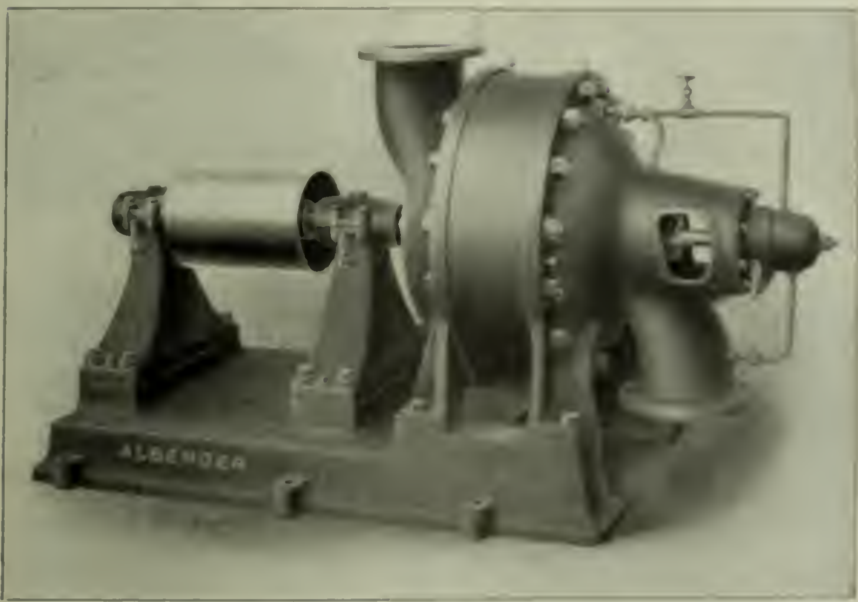


FIG. 9. BELT-DRIVEN PUMP

From the previous illustrations and examples it would appear that the most efficient method of capacity regulation of a centrifugal pump is by means of speed variation. Even in the case where the number of stages is varied, the variation in head or capacity resulting therefrom can only occur in jumps or steps and speed variation is necessary to obtain regulation between these steps. For conditions similar to those illustrated in Fig. 8, which are representative of the majority of cases, a speed variation of 10 per cent. above and below normal will be found to be ample to give all the regulation that is required. This amount of variation can usually be obtained at very slight expense with either electric-motor, steam-turbine or steam-engine drive, and the power saved would in most cases pay for the additional outlay in a very few months of operation.

There are also other reasons which make it desirable to have some variation in the speed permissible, the principal reason being the difficulty of accurately estimating the friction loss in one [illegible] system. There are so many variable factors entering into this problem, such as age of pipe with the resulting incrustations in the interior, effect of elbows, bends and other fittings, that no one can hope to calculate the friction exactly. The average run of engineers who have had no particular experience in this line almost invariably underestimate the friction loss, while those of more experience estimate the results so closely [illegible] not allow enough to insure being on the safe side.

The result of the first method is that when the pump is installed it is found to be short on capacity which on the application of gages to the suction and discharge is found to be due to the head being greater than that for which the pump was designed. If the speed cannot be increased, the only way out of the difficulty is to design a new impeller for the pump, and in some cases where the first impeller was as large as could be used in the pump, it might be necessary to purchase an entirely new pump.

The second method tends toward a pump designed for a head greater than actually exists, with the result that on installation the pump discharges too much water, the motor consumes too much power and the efficiency is low. The pump designer generally aims to be safe on capacity so that usually the pump is a little over capacity at the required head. In designing a centrifugal pump it is difficult to obtain results within a few per cent. of the calculated, and in fact two pumps made from the same design seldom operate the same, owing to differences in castings and machine work. Generally the error from this source, in a standard pump with which the designer is perfectly familiar, would not be serious, and an error of 5 per cent. or less either way in the capacity at the stipulated head should be considered satisfactory for commercial work. These errors are entirely eliminated by a small variation in speed either way from normal, and on this account alone, provision for speed regulation is well worth the expense of procuring.

Mechanical Features

While it is of great importance that the characteristics of any given centrifugal pump should be suitable for the work it is to do, it is of equal importance to have the mechanical design properly carried out. The most important mechanical features of a centrifugal pump are probably the shaft and bearings. The shaft must first be of sufficient size to transmit the necessary power from the coupling to the impeller. As it is also required to support the impeller or impellers in practically a central position at all speeds, it must have the necessary stiffness, so that neither the weight of the impellers nor the centrifugal forces due to their slightly unbalanced masses will deflect it to any appreciable extent. It must also be properly supported in bearings of such design and size that perfect rotation of the shaft will be maintained for a long period of use. Such bearings must be entirely separated from the water passages of the pump, as otherwise it is impossible to maintain lubrication and prevent the grit and sand carried by the water from entering the bearings.

A thrust bearing should also be provided on every centrifugal pump, as no matter how perfectly the thrust is balanced in the design, it will be found in practice that there will always occur a slight thrust one way or the other, and as wear on the impeller occurs this thrust is apt to increase. A properly designed marine type of thrust bearing will easily take care of any such thrust. In fact out of several hundred pumps designed by the writer during the last three years, all of which were similar to the illustrations and provided with the marine type of thrust bearing, there has yet to occur a single case of thrust difficulty.

Another part requiring particular attention is the stuffing box. This should be of ample depth and diameter, so that at least six to eight rings of good-sized packing can be accommodated. The stuffing box on the suction side should always be water-sealed, as otherwise it is impossible to prevent the entrance of air if the pump has much suction lift.

The impellers and diffusion rings in pumps operating under high heads should always be of bronze, as the action of even the purest water on these parts when made of cast iron soon corrodes them away. This action seems to be a chemical one, as it generally occurs at points where no erosion whatever is shown, and furthermore the water has practically no effect on bronze, which would not be the case for ordinary wear.

Flexible couplings should be used between the driving motor or engine and the pump, as otherwise a slight lack of alinement between the two will cramp the shaft so that the bearings will heat and cut out, or they may even bind the shaft tight. Even with flexible couplings the shafts should be in absolutely perfect alinement, as otherwise in time more or less needless wear will be caused on the bearings. Flexible couplings also allow the motor armature to take its proper position in the magnetic field, while any thrust on the pump is taken care of by itself. In addition to these various constructive details, the general design of the pump should be as pleasing and symmetrical as possible without sacrificing any point of utility.

New Power Plant of the L. S. Starrett Co., Athol, Mass.

The recently completed power plant designed by Charles T. Main, mill engineer and architect, Boston, Mass., for the Starrett company comprises a boiler room and coal pocket in one building and engine, generating, condensing and feed-water heating equipment in another. Between these buildings is a small pond, the water level maintained by a concrete dam which practically connects the two portions of the power plant. Through the dam is a tunnel, 170 feet in length, which serves as a duct for carrying both steam and water piping, the steam being carried 400 feet from the boilers to the engines.

FIG. 1. THE NEW STARRETT POWER HOUSE

FIG. 2. COAL POCKET

The boiler room and coal pocket occupy a building triangular in shape and measuring approximately 220 x 150 x 115 feet. The boiler room extends across the end and is about 47 feet in width with a clear hight of about 35 feet. The coal pocket occupies the rest of the building with the exception of the space required for the feed and fire pumps, feed-water well and chimney.

The boiler equipment consists of four Babcock & Wilcox 500-horsepower boil-

[illegible] horsepower primary heater, and back to the boilers. These pumps draw their water from a well which is fed from the pond through a [illegible]-inch pipe fitted with a sluice gate operated from the well-room floor. The fire pumps are also supplied from this well. When necessary, water may be drawn from the city mains at [illegible] pounds pressure.

The engine-room equipment comprises a Brown [illegible]-inch horizontal cross-compound condensing engine direct-con-

[illegible]

FIG. [illegible] [illegible]

ers in batteries of two, with [illegible] room for an extra battery. The chimney is of the Custodis type, of [illegible] feet inside diameter, with an air space and an outside diameter of 16 feet 2 inches at the base. It is 175 feet high from the boiler-room floor. Two [illegible]-inch Warren duplex outside-plunger pumps fitted with a [illegible]-inch joint discharge pipe force the boiler-feed water through the tunnel to the engine room and thence through a [illegible]

[illegible]

The Plunger Hydraulic Elevator

Hand-rope Control for Freight Elevators; Pumps and Connections Used with "Safe Lifters;" Locking Device for Plunger Elevators

BY WILLIAM BAXTER, JR.

Hand-rope Control

Regarding plunger elevators controlled by a simple hand rope and valve there is little information to give except in the matter of manipulating the rope. The valve proper is made substantially the same as this type of valve for other forms of hydraulic elevator, but the distance through which the hand rope is pulled to make a start or stop is slightly greater for the high-speed cars than it is with cable elevators. The reason why the hand rope has to be moved through so great a distance is not, as may be supposed, that the effort necessary to move it may be reduced, but that the valve may not be closed too rapidly by the movement of the elevator car as it approaches the upper or lower landing. In slow-running elevators the stretch of the hand rope upon which the stop balls are fastened passes through the car and by manipulating this rope the elevator is controlled. In high-speed cars both stretches of the hand rope pass through the car and both are handled to control the movement. The advantage of this latter arrangement will be made clear by reference to Fig. 309, which is a vertical elevation of a fast-running plunger freight elevator. The stretch *B* of the hand rope is the one ordinarily used to operate the car, and this is pulled down to cause the car to ascend, and pulled up to cause the car to descend. It will be obvious, however, that if the rope has to be pulled down, say, 15 feet to make the car run upward at full speed, the operator would have a hard time doing it unless he were extremely quick in his movements; the first pull of the rope might not draw it down more than 3 or 4 feet, which would be sufficient to set the car in motion at a fair rate of speed, but not at the maximum, and the operator would have great difficulty in pulling the rope down farther because the car would be running upward. By starting the car by the aid of the stretch *C* of the hand rope the case will be very different, because this side must be pulled upward to make the car run upward; therefore, all that is necessary is to give the stretch *C* a slight upward pull, and then hold on to it until the car attains full speed. To prevent moving the rope too far a stop is fastened on the stretch *C*, and this runs between two stationary stops set at the proper points; hence, if in starting the operator desires to run up at full speed all he has to do is to pull the stretch *C*

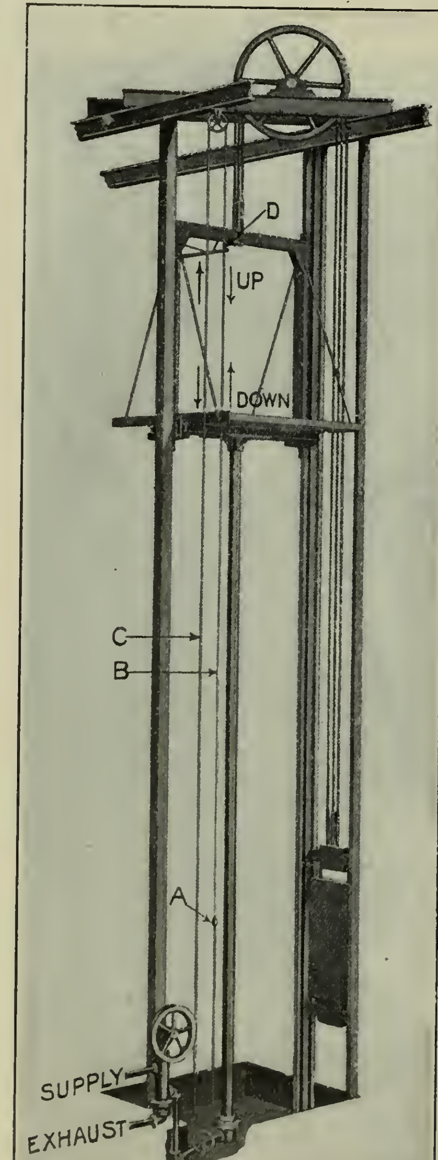


FIG. 309

up far enough to open the valve and then hold it until the stop on the rope strikes the stationary stop. To make a stop at any floor going upward the operator grasps the stretch *B* and holds it until the car stops. On a down trip the operation is reversed, that is, in starting, the stretch *C* is pulled down slightly and held until the desired speed is obtained, and to make a stop the stretch *B* is grasped and held, just as in stopping on the upward trip. The stationary stops that limit the movement of the rope when the stretch *C* is held are set apart a distance equal to the combined distances through which the stop balls on the rope *B* move at the top and bottom of the well to stop the car. Thus if the top ball moves 15 feet and the bottom ball 10 feet, the stationary stops that limit the movement of the stretch *C* will be set 25 feet apart, and the stop ball on *C* will be 15 feet below the upper stationary stop when the car is standing at any floor.

"Safe Lifters"

In all large buildings one of the elevators has to be designed to lift extra heavy loads, ranging from about 6000 to 10,000 or 12,000 pounds, according to the size of the building or the character of the business done by the occupants. This elevator is generally called a safe lifter, as the heaviest loads it carries are usually safes. If it were intended to carry such loads all the time it would be arranged precisely the same as the other elevators in the building except that the cylinder and the main valve would be made as much larger as might be necessary to lift the heavier load. But this elevator is only called upon occasionally to lift extra-heavy loads and it is therefore made of the same normal lifting capacity as the other elevators, but with parts sufficiently larger than normal to give it the proper strength to carry the extra load; the increased lifting power is obtained by increasing the pressure of the water that operates it, when used to lift heavy loads. The common practice with all types of hydraulic elevator used for safe lifters is to provide a small high-pressure pump that is capable of developing the pressure required to lift the load, and this is connected directly with the lifting cylinder, so that when a heavy load is handled, all the parts of the elevator excepting the lifting cylinder and the pipes directly connecting with it are cut out of service, and are not subjected to the high pressure. The way in which the Standard plunger elevators are arranged when used as safe lifters is illustrated in Fig. 310, which shows an elevation and a plan view. In the elevation the high-pressure pump, used to lift the heavy load, is moved some distance to the right, so as to bring it out from behind the main valve and the automatic stop valves. The true position of the pump and the pipe connections between it and the lifting cylinder is shown in the plan view. The high-pressure suction pipe taps into the main discharge at the bend *D*, and the delivery pipe from the high-pressure pump connects with the pipe *A* at the upper end. At the places marked V^1, V^2, V^3 and V^4 are located hand valves for the purpose of disconnecting the main valves from the cylinder and from the tanks. The valves V^5, V^6, V^7 and V^8 are located in the piping of the high-pressure pump, and are for the purpose of operating the elevator when used to lift extra-heavy loads. When such a load is to be lifted the valves V^2, V^3 and V^4 are closed to prevent high-pressure water

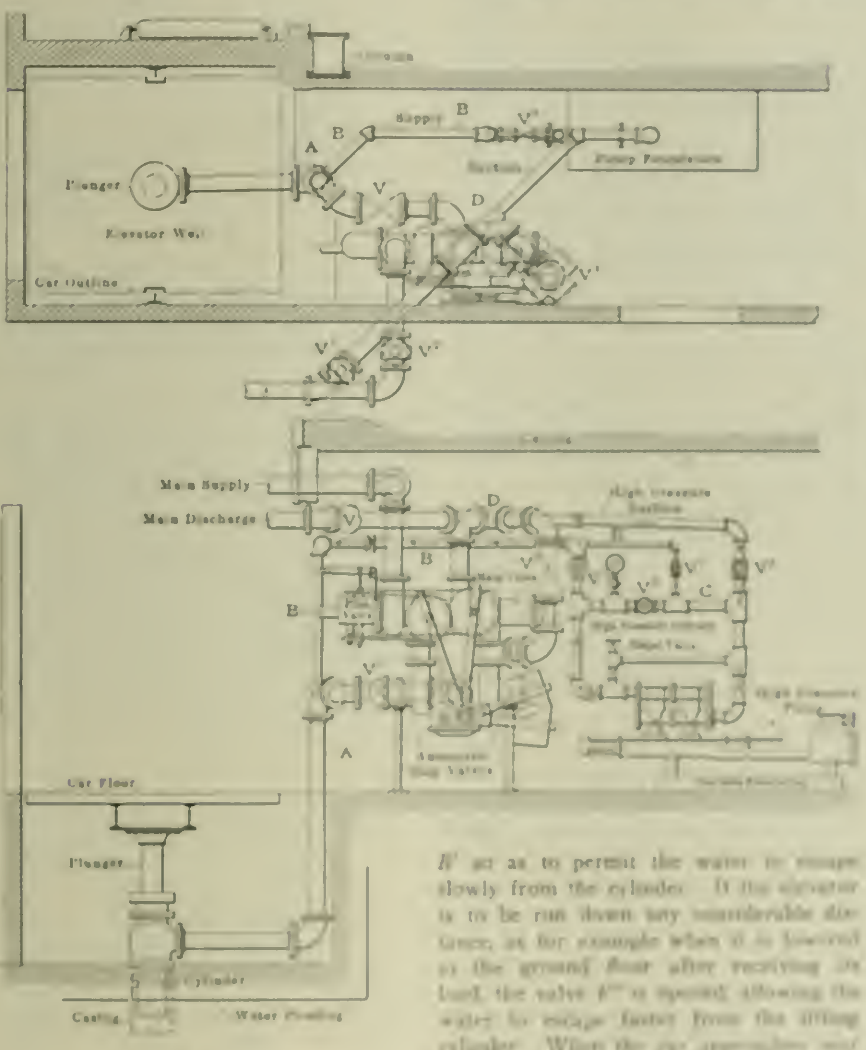


FIG. 310

from reaching the main operating valves. The high-pressure pump is started when the load is to be raised, and the valves V^9 and V^8 are opened; then water is drawn into the high-pressure pump through the high-pressure suction from the main discharge pipe, and from the high-pressure delivery pipe it passes through the valve V^6, and thence into the pipe *B* through the pipe *A* to the lifting cylinder, forcing the plunger and car upward.

As long as the pump is kept running the elevator will rise, and when the stopping place is reached, the pump is stopped. As the movement of the car is controlled entirely by the running of the pump and the manipulation of the valves V^5, V^6, V^7 and V^8, communication of some sort must be established between the car operator and the man at the pump. This is generally done by means of electric bells or a telephone. With this method of operating the car, accurate stops at the floors of the building cannot be made at the first trial, so that the general practice is to stop the car a short distance above the floor, and then to lower it slowly to the proper position by opening the valve V^{10} in the pipe *B'* so as to permit the water to escape slowly from the cylinder. If the elevator is to be run down any considerable distance, as for example when it is lowered to the ground floor after receiving its load, the valve V^{11} is opened, allowing the water to escape faster from the lifting cylinder. When the car approaches near enough to the lower floor, the valve V^{11} is closed and the car descends the remaining distance at a greatly reduced speed, as the water can escape only through the small pipe *B'* and the valve V^{10}. By properly manipulating this latter valve the descent of the car can be made as slow as desired. When the car is being lowered the high-pressure pump is not operated.

When an elevator is used to raise or lower a heavy load that requires some time to place upon the car, it is not advisable to depend upon the lifting cylinder to hold the car in position while the loading is going on, because during this time the car might settle enough to cause some trouble, if not to do actual damage. Owing to this fact it is customary to provide an elevator used as a side lifter with a locking device at each floor that will hold the car immovable while it is being loaded. This device is thrown into action after the car has been run up a short distance above the floor, and then by opening the valve V^{10}, as already explained, the car is permitted to settle gradually upon the locking device. When the load is in position the first thing to do is to run the car up far enough to free the locking device, then this is drawn out of the way and the car is started for its destination.

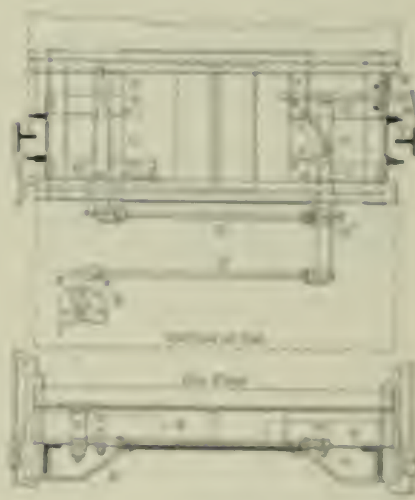


FIG. 313

FIG. 314

LOCKING DEVICE FOR PLUNGER ELEVATORS

The type of locking device used with the Standard plunger elevators is shown in Figs. 313 and 314, the former giving a plan view and a front view of the apparatus and the latter a side view. At each floor of the building strong supports *A*, *A'* are secured in the proper position upon the guide rails *Y*, *Y'* to hold the car level with the floor. Under the car are mounted sliding bars *B*, *B'* which are pushed out over the supports *A*, *A'* by means of levers connected with a vertical shaft *F* located in the car floor at one corner and so arranged that it can be turned by a pocket wrench. The flat lower end of this shaft is [illegible] a crank [illegible] a rod [illegible] links the crank to a lever *C*, which is pivoted at [illegible] and at its end engages with a [illegible] mounted on the back bar *B*. A connecting bar [illegible] is connected with the lever [illegible] by a [illegible] and through this connection any movement of [illegible] imparts motion to the lever C which is pivoted at H and moves the lock bar B' through the stud connection H'. If the shaft F is turned counter clockwise, the lock bars B, B' will be moved outward over the stationary supports A, A'. In Fig. 311 the lock bars B, B' are shown very close to the supporting pieces A, A', but when they are in their normal position they are drawn in far enough to prevent accidental striking of the stationary supports. The position of the levers C, C' is such that the shaft F can be rotated clockwise as well as in the opposite direction, and then the bars B, B' will be drawn in toward the center of the car.

When a plunger elevator is used to lift safes the compression stress on the plunger is greatly increased, as no additional counterbalance is provided to offset the weight. This extra stress is not serious in elevators of moderate rise, but when

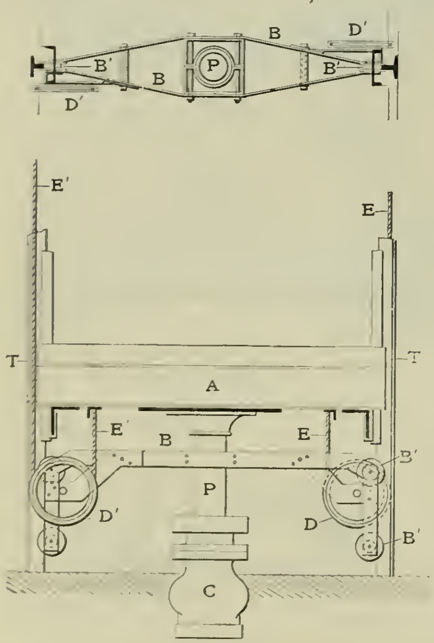


FIG. 313

the rise is fairly great, say between 200 and 300 feet, it is necessary to provide a stiffener to reinforce the plunger and avoid liability of buckling it. The stiffener used with the Standard plunger elevators is shown in Fig. 313, which gives a side elevation and a plan view. It consists of a frame B carrying at the center a guide through which the plunger P slides and at its ends guide wheels B', B' that run on the elevator guides T, T. The frame also carries two sheaves D, D' under which pass two ropes E, E', fastened at one end to the under side of the car and at the other end to the beams at the top of the elevator well. As the elevator runs upward, the rope ends attached to it are drawn upward, of course, and pulling the frame B upward just one-half as fast as the car moves, so that at all times the frame will be at a point midway between the bottom of the well and the car, and will brace the plunger at the central point of its exposed length.

The plungers of these elevators are made as nearly water-tight as practicable, but they are liable to be leaky sometimes. If a plunger leaks, the effect will be that the load to be raised will be increased by whatever the water in the plunger may weigh. In extreme cases, in very high buildings, the accumulation of water in the plunger may be sufficient to prevent the elevator from lifting its maximum load. If the plunger leaks, it is not an easy matter to make it tight, but it is a very simple thing to remove the water, and this should be done. The best way to do it is to drill a hole about ¼ inch in diameter in the lower section of pipe, just above the end casting, say 2 feet above the lower end of the pipe, and draining the water out. After the water is out the hole must be plugged up. This is easily done by tapping the hole and screwing in a brass plug, which should be filed off flush with the plunger surface and smooth.

Operating Direct Current Generators and Rotary Converters

By Norman G. Meade

When a generator or rotary converter is put into operation, the attendant should always be sure that the connections are tight, the brushes in the proper position and the oil wells properly filled. When first starting, rub the commutator of a direct-current generator or a rotary converter with a cloth having a few drops of oil on it, until the commutator obtains a dark gloss. If sparking occurs, the brushes should be shifted backward and forward until a point is found where there is no sparking under normal load. When a machine is first started it is advisable to change the oil in the bearings two or three times in the first few days; after that the oil may be left in about three months, adding enough occasionally to make up for loss. The machine should be watched closely at first, say for two or three days, to see that the brushes do not grind and that the oil rings revolve freely.

Any machine should be kept clean and dry, and no bolts, nuts, screws, etc., should be left around, as these may be drawn into the revolving part when the field magnet is excited and the machine running.

The armature of a belted machine should oscillate endwise in its bearings while running under load, as this will lengthen the life of the commutator and the bearings. Precautions should be taken never to break a field circuit suddenly, as the voltage of the inductive discharge is always many times higher than the operating voltage, and may puncture the field insulation; care should also be exercised not to open a switch in a circuit carrying a large current; trip the circuit-breaker first, then open the switch. The operator should make sure that all switches, circuit-breakers, etc., are open when the machine is not in operation, and always close the circuit-breaker first, then close the main switch.

The ends of brushes should be fitted to the commutator so that their whole end surfaces make contact; this can be done by putting each brush in its holder and grinding it with a piece of sandpaper slipped between the brush and commu-

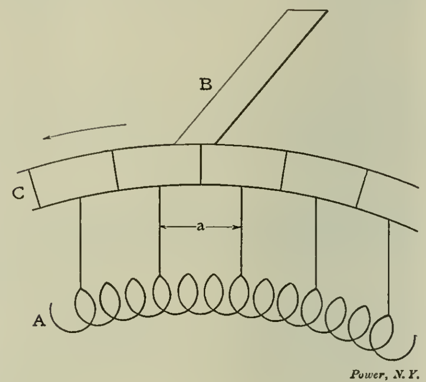


FIG. 1

tator until it fits the curvature of the commutator surface. If the brushes are copper-plated their edges should be slightly beveled, so that the copper does not come in contact with the commutator.

Care of the Commutator

To keep a commutator clean will ordinarily require only a daily wiping off with a piece of canvas; if this is done regularly so as to keep the commutator surface and end free from dirt and oil, in the majority of cases the commutator will require no other attention. In service the ideal appearance of a commutator is a polished, dark-brown surface. Sandpaper or other abrasive should never be used

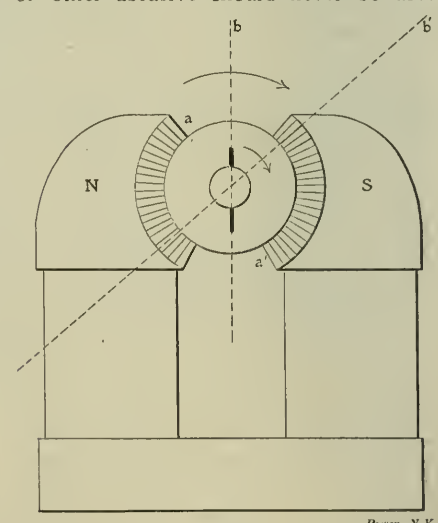


FIG. 2

on a commutator which is taking on a polish and shows no signs of roughness. Commutators which do not take on a polish, but show signs of roughness, should be smoothed off with a piece of sandpaper, and if quite rough a piece of sandstone may be used. Flat spots on commutators are usually caused by excessive wear, or a soft bar, or too much end play, by a loose commutator, a bad belt splice, or a flash produced by a short-circuit on the line. When a commutator becomes out of true from uneven wear it should be turned down. If the machine is of small size it is better to put the armature in a lathe, but if of large size a turning gear should be attached directly to the machine. Special care must be

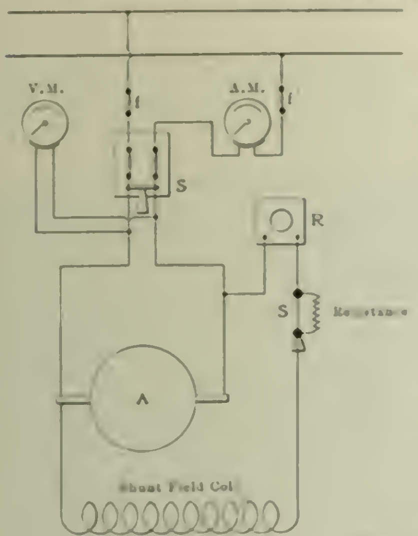


FIG. 3

taken that the cutting tool does not gouge into the commutator, as when an engine is running very slowly, which is necessary when turning off a commutator, its speed is liable to vary considerably during each revolution.

A small amount of lubricant may be applied to a commutator while in service. A lump of paraffin rubbed across the surface once a day is sufficient. Lubricant should always be applied sparingly and never in sufficient quantities to collect on the surface and about the brushes and

FIG. 4

leave them in a gummy condition. Excessive noise from the brushes may frequently be remedied by the application of a small amount of lubricant.

A commutator bar which projects above the others may be detected by a jumping motion of the brush-holder arms, by a pencil point held on the commutator surface and, in some cases, by a short intermittent spark at the brushes. If the commutator is found to have a high bar the fault should be corrected at once.

Too much tension on the brush springs will cause heating and excessive wear of the commutator; about one pound tension will be found generally satisfactory. The tension can be determined by a small spring scale. Place the hook under the lever or spring-end resting on the brush and pull on the scale until the finger is just raised from the brush; the scale reading will indicate the spring tension.

If on starting a generator it fails to generate, all connections should be examined carefully. It will generally be found that a poor joint is the cause of the trouble.

Sparking

Sparking will occur if the brushes are not set in the proper position. Each time a brush touches two commutator segments the coil connected to them is short-circuited, as represented in Fig. 1, where *A* represents the armature winding, *B* a brush and *C* the commutator. At the particular instant in the revolution of the armature the coil *a* is short-circuited. To maintain sparkless commutation the short-circuited coil must be under the influence of a field so that there will be generated in it during the instant of short-circuit an electromotive force that is in the same direction that the current will flow when it leaves the brush. In order to obtain this result a slight forward lead of the brushes is generally necessary as the load increases, because the armature reaction shifts the flux of the magnetic field, causing it to crowd at the trailing pole tips *a* and *a'*, Fig. 2, and to thin out at the leading pole tips. In the sketch the line *b* represents the theoretical position of the brushes during light load, and the line *b'* the position under heavy load.

Sparking at the commutator of a rotary converter may be caused by hunting, although this is practically eliminated in modern machines by the use of copper grids imbedded in the face of the pole shoes. Hunting is caused by an oscillation set up by changes in frequency in speed and in some generators or between a rotary converter and the supply circuit. The converter operates as [illegible] [illegible], and if the frequency of the supply circuit suddenly increases, the speed of the converter will increase, and in the sudden effort to gain synchronism will pass that point, owing to the momentum of the armature, and will oscillate backward and forward from synchronous speed until the right point is reached. During this oscillation above and below synchronous speed, excessive currents will flow backward and forward between the rotary and supply circuits, causing the neutral point of the commutator to shift, with resultant sparking.

To Start and Stop a Shunt- or Compound-wound Generator

Throw resistance in the field rheostat *R*, Fig. 3, and bring the generator *A* up to speed; then adjust the voltage to normal by means of the rheostat. Close the circuit-breakers and throw in the main switch *S*. If for any reason it is imperatively necessary to stop a machine suddenly from generating, open the field switch *S*. To stop a single machine, first trip the circuit-breakers, then open the main switch and increase the resistance in the shunt-field circuit by means of the

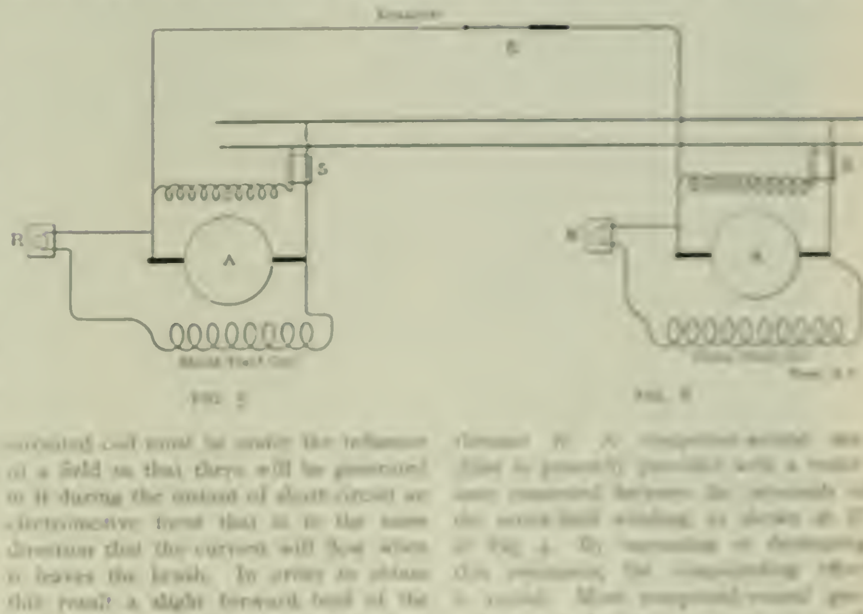


FIG. 5 FIG. 6

rheostat *R*. A compound-wound machine is generally provided with a resistance connected between the terminals of the series-field winding, as shown at *R*, Fig. 4. By increasing or decreasing this resistance, the compounding effect is varied. Most compound-wound generators are designed to over-compound, that is, give a higher voltage at full load than at no load, this is to compensate for the increased drop in potential in the line which occurs at heavy loads.

To operate two or more generators in parallel requires some skill in connecting the machines together. Suppose, for example, the generator *A* in Fig. 5 is in operation, and it is desired to start the generator *B*, Fig. 6. Before starting the latter the equalizer switch *E* would be open as well as the circuit-breakers on the machine and the main switch *S*. Bring the machine *B* up to speed and adjust the voltage as usual; then close the equalizer switch, then the circuit-breakers and finally the main switch *S*. The two machines will then operate in parallel, each taking its share of the load.

Supernatural Visitation of James Watt

The "Shade" of the Old-time Inventor Attempts to Throw Light upon Several Matters which Have Interested a Great Many of Us

BY WARREN O. ROGERS

Since relating my experience concerning a supernatural visitation of James Watt, a few weeks ago, grave misgivings at first beset me as to the wisdom of continuing the narration of similar manifestations. Naturally, there have been those who have not hesitated to deny that such happenings could have occurred; others have declared that it must have been the production of a fanciful brain, whatever that is, while still others attribute it to an attack of acute indigestion. I might have concluded that the visitation in question was purely visionary had it not been for the two empty glasses and numerous cigar stubs found on the table the next morning by the maid who cleaned up the room. Not only this, but a number of similar experiences of more recent date have left no doubt in my mind as to their genuineness. In fact, I am so firmly convinced of their reality that I have decided to publish an account of the various visitations I have received from my distinguished friend, and others, be the consequences what they may.

I did not feel in the mood for a second visitation for some days, preferring, as may be easily understood, to dwell on what I had already seen and heard. In fact, it was more than a week before I experienced a desire to engage in another chat with Watt, and should not have cared to then had it not been for a peculiar influence which I could hardly withstand; for, to tell the truth, wonderful though the first experience was, it was almost too uncanny for mortal enjoyment.

The second visitation of Watt was almost identical with his first, as far as the manner of accomplishment is concerned, except that I did not experience any uncomfortable sensations. I sat before the fireplace, idly musing and watching the flames as they shot upward trying to see which could reach the highest. The evenings were cold, and the warmth and soft, mellow light of the blazing wood gave one a sense of comfort and contentment. Thus, in the semidarkness I experienced a desire for another visit from my former midnight companion.

Concentrating all my energy to accomplish that end, I awaited his coming. The first indication was a faint body shadow, which rapidly developed into the form of James Watt. We shook hands and, passing the cigars, I invited him to be seated and make himself comfortable.

"Well, James," said I, as he accepted a chair, and extended his transparent hands toward the blazing fire, stating at the same time that he was cold, a fact I had noticed as we shook hands, "how have things been going with you since your last visit?"

"Oh, in a circle; you know that is all we have to do, just prance around in a particular circle until we obtain perfection for the requirements of that circle, when we are promoted to another, but easier one, which gives us more liberties. As soon as I get to the next circle, I can come to you whenever I like, day or night, rain or shine, and then we will hit the 'pike'," and James gave me a poke in the ribs, after a manner that indicated that he would not be at all "slow" when it came to seeing the town.

When James had warmed his hands and feet, he lit his cigar, and settled back in solid contentment. After permitting him to enjoy the "perfecto" for a reasonable time, I said:

"James, tell me how you happened to stumble onto the idea of your condensing engine."

"Well," replied James, as he closed his eyes in ghostly fashion and wrinkled his snow-white forehead as if to recollect memories of the dim past were a difficult operation, "while I was monkeying around the college, I got interested in old Newcomen's engine, and I will give him the credit of having the best and most advanced type of engine on the market at that time, but I decided that it could be made considerably more efficient.

"It was an awful steam eater, and was only used for pumping out mines. I'll never forget the first one I saw. Newcomen was a blacksmith by trade, you know, so what could you expect? I have always maintained that he did a better job than most blacksmiths could under the circumstances.

"You see he didn't have the machine shops to do the work that the present generation have, and, when an engine cylinder was put in a lathe no one knew what the exact shape would be after it was bored out. He not only had poor machines to work with, but the workmen were not skilled, seeing none of them had ever made a decent engine before. In fact, they were hostile to the notion, declaring that they had something better to do than to throw away their time on an idiotic idea."

"But tell me, James—you have been in the spirit world and have had a chance to find out—was Newcomen the inventor of his engine or did he steal it, as so many ideas have been stolen since?"

"No," replied James, as he leisurely puffed at his cigar, "Newcomen did not steal the idea. The engine that bore his name was the result of his own effort. I know that Savery got out his patents in 1705, or two years before Newcomen, but that was because he had a pull with the government; and by the way, his was the first patent issued by the government. I met Savery the other day, and when I put the question to him point blank, he admitted that Newcomen had his idea first. Savery still is in the outer circle, and from the way he cuts up I don't believe he will ever get into another." James gave a little grunt of satisfaction as he said this, which indicated that, although he was a spirit, and a progressive one, he still had one characteristic of mortals. James seemed to think he had been a little indiscreet in giving way to his spiritual animosities, and hastened to change the subject by adding, "I meet plenty who are worse than he is, though."

"How about Savery's and Newcomen's difficulties, did they have a lawsuit or was it settled out of court?"

"Oh, it was settled out of court," replied James, with greatly increased huskiness in his tones, I thought. Wishing to prevent any interruption of his interesting conversation, I rang for a little "Scotch" and soda to act as a lubricant, the which, by the way, was a decided success, as the huskiness immediately disappeared, and when James left me at daylight he rounded out two or three verses of "Auld Lang Syne" in a rather hilarious manner.

"Newcomen's invention was altogether different from Savery's," went on James, after he had creakingly crooked his elbow, and smacked his transparent lips. "Savery, you know, thought he had tumbled onto something new when he found out that the sudden condensation of steam made a vacuum, and he used the idea to draw up water; but this pump was never any good. It was so crude he had to place it in a mine out of sight. You see," said James, as he gave a hacking cough, "old 'Newk's' (Newcomen's too long to bother with in this age of progress) engine had a cylinder that stood on end in a vertical position under one end of a beam, but was open at the top.

The steam pressure in his time was only a little higher than the atmosphere, and it was admitted to the cylinder at the bottom."

"Well, I don't see how even a blacksmith could expect to get work out of such a contrivance as that," I remarked, just to draw James' attention from the decanter which seemed to have a fascination for him.

"Well, it wasn't so bad for an old codger like 'Newk.' In fact, the other night I took a little trip around New York just as the river steamers were putting fresh one. "The idea is the same, only there has been a slight improvement in the general construction of the engine which, by the way, is the outgrowth of my idea.

"In 'Newk's' engine, when the steam was admitted to the bottom of the cylinder, it allowed the piston to be pulled up by an equal weight or a counterpoise at the other end of the beam. The pump plunger was attached to the weighted end of the beam, and as the beam worked up and down the pump was operated. The power of the steam in the cylinder was idea, but didn't know how to use it. [illegible]"

"How did Newcomen happen to use the idea of condensing the steam?" I interrupted.

"Why, 'Newk' used Papin's cylinder and piston and Savery's principle of condensing the steam. I saw Papin the other day and he was still fussing about 'Newk' using his idea. He was so mad he would have gnashed his teeth if they hadn't all fallen out long ago. He had fussed so much about the matter that he is nothing but a walking skeleton.

HE ACCEPTED A CHAIR AND EXTENDED HIS TRANSPARENT HANDS TOWARD THE BLAZING FIRE

out and I noticed that they are still using the same idea of transferring the power in the steam to the shaft of the engine."

"Oh, you will be the death of me," I said, as James looked at me to see how I was receiving his argument. "Why, 'Newk' never had the ghost of an idea as to the power and magnitude of these river steamer engines. I'll—"

"Now you just shut your throttle," interrupted James, as he threw the butt of his cigar into the fireplace, and lit a transmitted to the pump by means of the beam, just as today it is transferred to the shaft of the beam [illegible]. The engineers of today are not such [illegible] as you think."

It will be observed that James had a tendency to be sarcastic at times, which is a [illegible]

"Why, you see 'Newk' had the [illegible]

[illegible]

the steam and then condensing it, and so transferred the heat into mechanical motion.

"'Newk' finally rigged up a cylinder having what you today term a water jacket," resumed James after wetting his whistle, "and I supposed he always would have used it if he had not found out by accident that there was a better way. One day the engine started up two or three revolutions faster than usual and 'Newk,' getting scared, shut it down and didn't know whether it was best to run it again or not. After fussing round awhile he got some 'lumpers' to take off the cylinder head, when he found that a small hole had appeared in the cylinder from the water jacket, allowing a stream of water to run in on top of the piston. This condensed some of the steam and also made the piston steam-tight. After that he abolished the water jacket and injected the water for condensing purposes through a pipe in the bottom of the cylinder."

"Very interesting," I remarked, as James ceased speaking and relit his cigar.

"Interesting nothing," replied James, in a disgruntled voice; "that is the kind of an engine they make so much noise about and say I got hold of, and that I got all my ideas from 'Newk' and other old fossils, and all that. I did get an old model of 'Newk's' engine to monkey with, but I can tell you it was a total failure. It had a sort of valve gear for operating the valves. It is said that a boy by the name of Humphrey Potter got up this idea, and from what I know of 'Newk' I would as soon think 'Hump' worked out the idea as that 'Newk' did."

"Well, how about your condenser?" I asked. "We started to discuss that question at the start and I don't know any more about it now than I did before."

"Well," replied James, as he arose and rattled his bones in his attempt to stand steadily, for truth demands the confession that he had begun to show signs of a state not altogether supernatural, and at times sang softly a few verses of the latest catchy songs, although where he got them I don't know. "Well," repeated James in a thickening voice (I determined then and there to have the mixture weaker for his next visit), "I take it that we had better let matters stand for a time. It is about sun-up and this staying up all night ain't what it is cracked up to be. I will tell you about my condensers next time. So long."

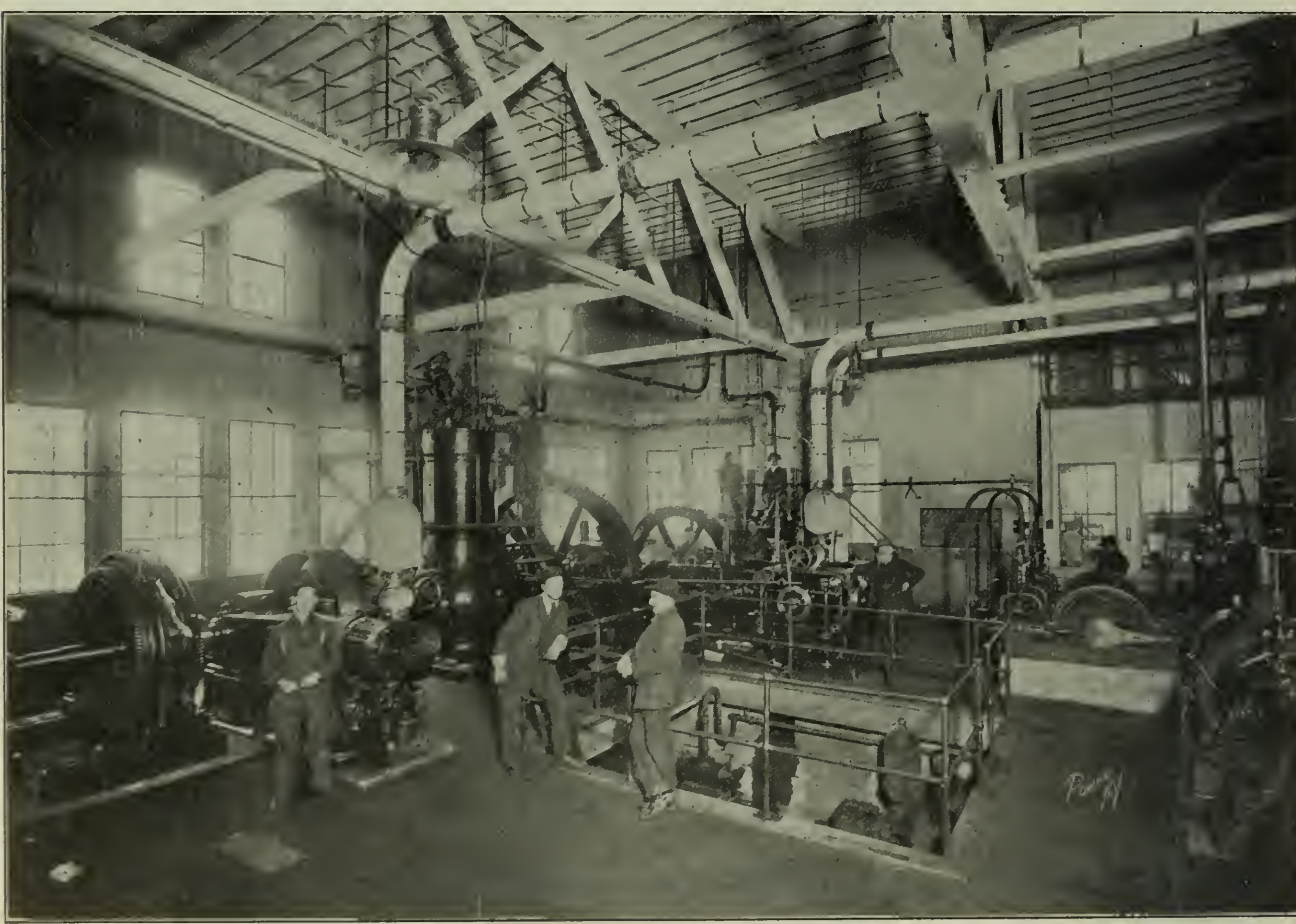
He reached out his cold, bony hand to shake goodby, and as I extended my own the morning sunlight streamed in through the window and in the twinkling of an eye the phantom vanished.

Power Plant of Miller & Lux

By Nelson Dean

Some years ago I chanced to be in southeastern Oregon, when I made up my mind to take a trip to Texas on the hurricane deck of a bronco. One of my friends suggested that I make the trip by way of the Miller ranches. I secured a map and, with his aid, marked out a route that was to take me to the heart of the cattle plains of Texas. During a trip of six months I traveled over several thousand miles and only once slept on anyone else's property.

At one of the ranches I met and made a friend of an engineer, Mack Lyon, whom I chanced to meet a short time ago on Market street, in San Francisco. He invited me to visit the plant at "Butcher Town," which is located south of the city by San Francisco bay. I found the place so interesting that I went to the trouble



INTERIOR OF POWER PLANT OF MILLER AND LUX of securing the accompanying photo showing the plan of the main machinery.

The engine room comprises 3166 square feet. The view taken shows to the left a 135-kilowatt two-phase 60-cycle Fort Wayne generator, operated at a speed of 275 revolutions per minute, and direct-connected to a 14x14 inch "Ideal" engine. Naturally, the chief electrician tried to hide the engine by getting in front of it. Next to the right is the central point of interest in the form of a Larsen-Baker ice machine of 100 tons capacity, with an 18x36-inch steam cylinder and a 15x25-inch ammonia cylinder, driven at 60 revolutions per minute and direct-connected to a Bates-Corliss engine.

Next may be seen the 30-ton ice machine, with a 12x32-inch steam cylinder and a 10x20-inch ammonia cylinder. The ice machines are packed with Garlock ammonia packings. Next come two 7½ and 8 by 9-inch duplex air pumps fitted with special regulating governor. The work of these pumps is to bring water from three 14-inch wells, 150 feet deep, located half a mile from the plant. To the extreme right are two electrical exciters. The larger is a 25-kilowatt 200-ampere 125-volt generator direct-connected to an American blower engine, with a 6x6½-inch cylinder, running at 370 revolutions per minute. The small exciter is a 7.5-kilowatt 52-ampere 145-volt machine, direct-connected to another American blower engine, with a 5x5-inch steam cylinder, driven at 375 revolutions per minute.

It will be noticed that all the steam mains head toward the right-hand side of the print, showing the location of the boiler room, which has 2070 square feet of floor space. Here are three 300-horsepower Atlas water-tube boilers and one 10-horsepower vertical boiler carrying 175 pounds superheated steam pressure. In this room there are also two 7½ and 4½ by 10-inch boiler feed pumps, one 400-horsepower Cochrane heater and purifier, and one 12 and 7½ by 18-inch salt-water fire pump connected with a modern sprinkler system. The foremost figure in the picture (my friend, Mack Lyell) acted as installing engineer and is now chief engineer. He is facing the imperturbable Mr. O'Brien, superintendent of the packing house.

The pit in the foreground contains two large water pumps used in connection with the air compressors. The cooler is equipped with 33,000 feet of 2-inch direct-expansion pipe and 10,000 feet of ammonia pipe. There is 650 feet of live-steam pipe and 600 feet of exhaust-steam pipe, used for heating purposes; also 2000 feet of water pipe used about the buildings. Oil is used as fuel, being stored in two 15,000-gallon tanks, 275 barrels being used daily.

The cost of the power plant stands at about $300,000, there being $100,000 to be used in installing new machinery in the near future. The total cost of the packing house is about $1,750,000. This particular plant is one of several that handle the output of the Miller ranches. All of its products go to supply our navy department on the Pacific coast and everything is rigidly inspected by United States inspectors.

An Instructive Experience with the Tirrill Regulator

By W. Nelson

In an hydroelectric plant of 20,000-kilowatts capacity, where there are two 200-ampere 125-volt exciter units, the exciters are sometimes operated in parallel on account of heavy overload, as this gives better voltage regulation. There is in use there the Type TA Form F4 Tirrill regulator, which has three secondary contacts shunted across each exciter-field rheostat. Under normal load with one exciter the instrument gives excellent regulation, but with about 25 per cent. overload on the station there is excessive sparking at the contacts, when the power factor is low.

ELEMENTARY DIAGRAM OF EXCITERS AND SECONDARY CONTACTS OF REGULATOR

To avoid this wear on the contacts and for better regulation the exciters are run in parallel during the peak-load period. There are no equalizing rheostats in the circuits; the exciters are [illegible] and although of the same type and size, with the field rheostats in the normal running positions and the commutator brushes on the neutral points, exciter No. [illegible] it would take about 40 per cent. more load than No. 1.

At first the load was equalized by cutting resistance out of No. 1 exciter field rheostat. This caused excessive sparking at one of the three contacts on No. 1 side of the Tirrill regulator, as the rheostat was out of its normal running position.

Method of Equalizing the Loads

After several trials a method was devised to equalize the loads and still keep the exciter field rheostats in their normal running positions, and without the expense of installing equalizing rheostats. As the exciters, when in parallel, carry only 50 to 60 per cent. load at most, the brushes could be shifted a little about the commutator without sparking. The brushes of No. 1 exciter were set as far back and those of No. 2 as far ahead as possible. The load was not then evenly divided, but the division was improved.

Now the normal secondary contact spacing of the Tirrill regulator is given as 1/32 inch, but as the exciters were being run at little more than half load this spacing could be varied slightly without affecting the action of the regulator. It was found that by setting the contacts of No. 2 side of the regulator at a little more and those of No. 1 side at a little less than 1/32 inch, the excitation of No. 1 exciter was increased enough to make it keep its share of load with the exciter field rheostats in their normal running positions.

The explanation of this is that although the contacts all operate at the same instant due to the action of a common magnet, they open (break) by individual coil springs and the contacts on the No. 1 side of the regulator closed an instant before those of the No. 2 side because they had less travel; the resistance of the rheostat of the No. 1 exciter was therefore shunted longer than that of No. 2.

It has been proved after running this type of regulator for some time that 1/32 inch is the best spacing for the secondary contacts. Wider spacing will cause excessive sparking at the contacts and cause variation in the voltage, while with closer spacing there is little or no sparking but the contacts, which are of platinum-silver alloy, will weld rapidly and have to be cleaned about once a day. With 1/32-inch spacing there seems to be just enough spark to keep the contacts clean of oxide and with frequent [illegible] of the contacts through the [illegible] by means of the [illegible] the contacts will work in excellent condition and give no trouble. It was only on account of running the exciters on light load that any variation in spacing could be made. The regulator is a delicate instrument and should not be [illegible] with [illegible] the [illegible] [illegible] to get best results.

Proper Treatment of Boiler Feed Water

Data from Plant Which Reduced Maintenance Charges $160 per Month by Analyzing Feed Water and Treating with Soda Ash and Lime

BY A. J. BOARDMAN

Owing to the widespread interest that is being shown as to the proper treatment of boiler feed water it might be of interest to relate the experiences of a plant that has managed to place its treatment on a substantial, scientific basis. Previous to January, 1907, this plant had a great deal of trouble from boiler scale owing to the large quantity of scale-forming matter in the river water. The plant is located at Indianapolis, on White river, which flows through a limestone country. The analysis shows a total of 25.30 grains of scale-forming and suspended matter per U. S. gallon.

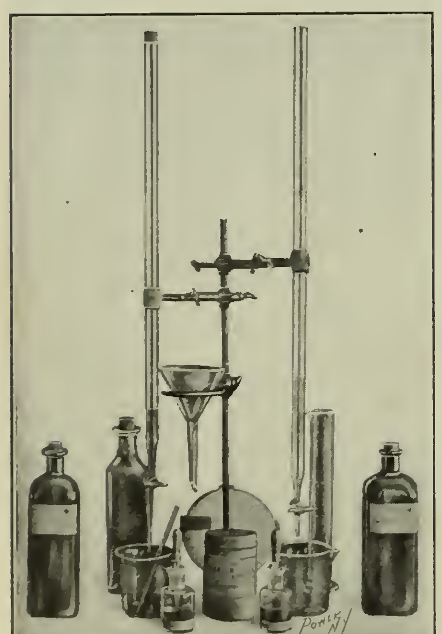


FIG. 1. TESTING OUTFIT

TABLE I.

	Grains U. S. Gallon.
Calcium carbonate	4.30
Magnesium carbonate	1.01
Magnesium sulphate	0.96
Sodium sulphate	0.71
Sodium chloride	0.88
Iron and alumina	0.19
Carbonic acid	0.78
Silica	1.21
Alkalinity	5.85
Suspended matter	8.02
Incrusting solids	15.69
Nonincrusting solids	1.59
	25.30

Pounds of incrusting solids in 1000 gallons, 2.24

Before the first of the year several different boiler compounds had been used with very little decrease in the amount of scale. Boiler tubes were still being purchased by the hundred, and the cost of boiler compound averaged $270 a month, or 3.21 cents per 1000 boiler horsepower monthly.

It was then decided to treat the water by using soda ash and lime to throw down the scale-forming matter, and to follow up and check this treatment with feed-water analysis. The basis of the treatment was to analyze the river water for permanent and temporary hardness and treat it accordingly. The feed-water analysis is the more accurate of the two, and by using it to check up the treatment very satisfactory results were obtained. At the same time the boiler-room records, which are of a permanent value in any plant, were started.

Testing Outfit

The expenditure for a testing outfit was not over $10, and the operations required for the complete analysis are extremely simple. In fact there are automatic feed-water analyzers on the market today. The apparatus consisted of two 50-cubic centimeter burettes, one square pint bottle with rubber cork, one pint standard N/50 HCl solution, one pint standard soap solution, three 500-cubic centimeter beakers, one funnel, 100 filter papers No. 2, one 100-cubic centimeter phenol-thalein indicator, one 100-cubic centimeter methyl orange indicator, one 100-cubic centimeter graduated test tube, 10 ounces barium chloride, stirring rod, burette support, stand, etc. It is necessary to have HCl exactly correct. Normal HCl is 98.7 parts hydrochloric acid, and can be obtained from any chemist. Phenol-thalein and methyl orange are chosen owing to the distinct color effects when the reactions take place.

The burettes mentioned above are graduated test tubes with a glass stop cock in the bottom. The soap or hydrochloric-acid solution is poured in and the hight of the liquid is read on the glass. Suppose the initial reading to be 18.5 cubic centimeters. Then after the operation is completed, shut the stop cock and make the last reading, say 25.7 cubic centimeters. The difference between 25.7 and 18.5, or 7.2 cubic centimeters, is the amount which has been used.

River-water Analysis

The directions for river-water analysis for permanent and temporary hardness are as follows: Hard water may be defined as water containing in solution mineral compounds that curdle or precipitate soap; generally the salts of lime, magnesia, iron, etc. In the United States hardness is generally stated as parts of calcium carbonate per million, i.e., the number of parts by weight of calcium carbonate that would have to be added to a million parts by weight of water to produce the specified degree of hardness. To convert grains per gallon to parts per million multiply by 17.18. The standard soap solution is obtained by dissolving pure castile soap in alcohol. It can also be obtained from any analytical chemist.

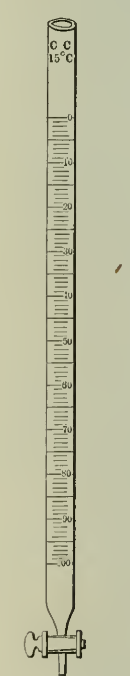


FIG. 2. TYPE OF BURETTE USED

Total Hardness—In testing for total hardness in river water, 25 cubic centimeters of the water to be tested is diluted with 75 cubic centimeters of distilled water. This is to be titrated with the standard soap solution in a square pint bottle provided with a rubber stopper. One cubic centimeter of soap solution is added at a time until there is some evidence of a permanent lather. Then add one-half cubic centimeter and decrease to one-fourth at a time until the lather is permanent, when the bottle can be laid on its side for three minutes with no decrease in the lather. The bottle must be well shaken after each addition of soap solution. In Clark's Table of Hardness* opposite the number of cubic centimeters of soap solution used will be found the degree of hardness in parts per million.

Permanent Hardness.—This is obtained by subtracting the degree of temporary hardness, that due to the bicarbonates and lessened by boiling, from the total hardness. The result is expressed as before in parts of calcium carbonate per million parts of water.

Temporary Hardness.—Each cubic centimeter of the acid solution used indicates [illegible] of a grain of calcium carbonate per million. In testing proceed as follows: Twenty-five cubic centimeters of raw water is diluted with 75 cubic centimeters of distilled water and two drops of methyl orange indicator added, which will turn the solution a yellowish tinge. Now add the acid solution until the color of the solution turns from a yellowish to a faint pink. Care should be taken to add the acid solution drop by drop. When the color turns it indicates the end of the reaction. Set the result down and multiply by 4. The product will be the temporary hardness expressed as calcium carbonate in parts per million.

*Gill's "Engine Room Chemistry," page 105.

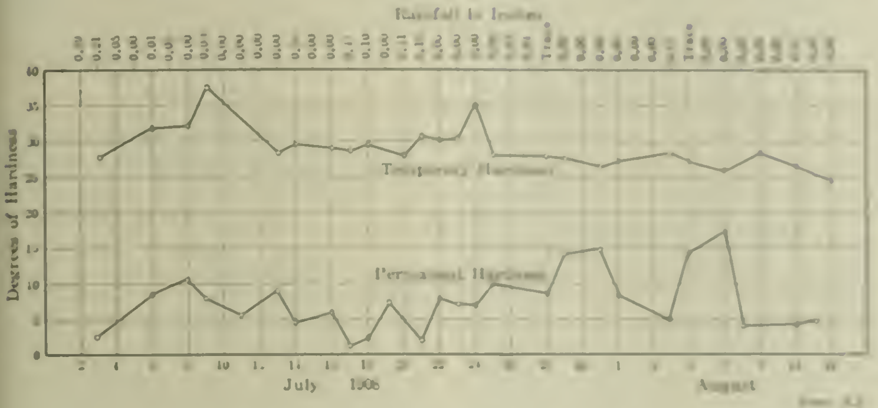


FIG. 3. WATER FROM WHITE RIVER AT INDIANAPOLIS, IND.

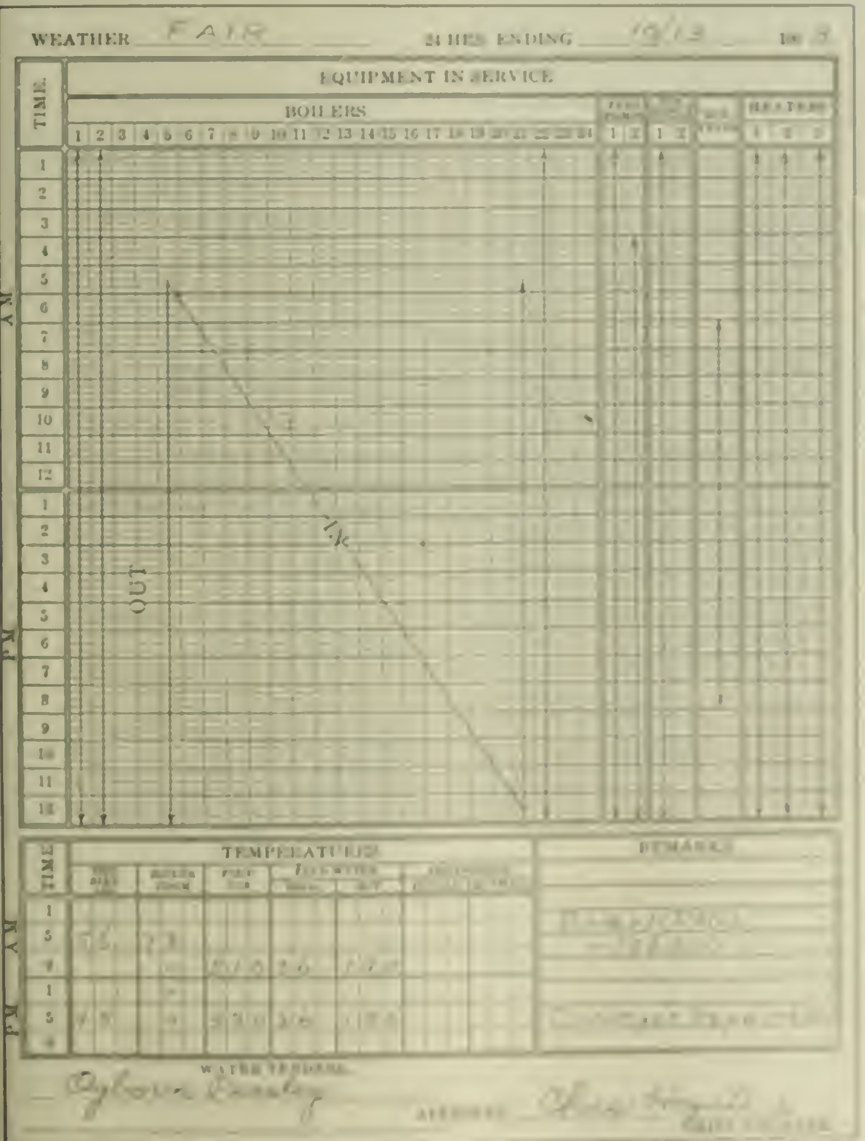


FIG. 4. DAILY BOILER-ROOM REPORT

Analysis of Softened Water

Measure out 100 cubic centimeters of the purified water, put it into a beaker and add a few crystals of barium chloride. The addition of four drops of phenolphthalein indicator will turn the solution purple if there is plenty of lime present. Now add standard acid solution drop by drop to obtain a clear solution. This is analysis for lime. The number of cubic centimeters of acid solution added indicates the amount of lime present, as explained above, and may be read off directly from the graduation on the burette. Measure out another 100 cubic centimeters of the softened water, add four drops of the phenolphthalein solution and titrate with the standard acid solution to obtain a clear solution as before. Call the result in the first operation *B* and the result of the second operation *A*. Then *A* minus *B* in cubic centimeters multiplied by [illegible] equals the number of pounds of soda ash per 1000 gallons; *B* multiplied by [illegible] equals the number of pounds of lime per 1000 gallons.

Use for standard purification [illegible] of a pound of lime and [illegible] of a pound of soda ash per 1000 gallons of raw water. As the results *A* or *B* just differ in value as determined by the standards, to determine the proper correction due to the variations in the reagents, add or subtract the difference in pounds per 1000 gallons.

The soda ash** or sodium carbonate acts on the sulphates of lime or magnesia forming sulphates of soda which are discharged by the blowing-off of the boiler [illegible]. It changes the sulphate into carbonate, transforming what would be a hard crystalline scale into a powdery calcium carbonate which is easily removed from the boiler although it hardens after exposure to the air. The [illegible]

**[illegible] "Engine Room Chemistry," page [illegible]

$$\text{Calcium Bicarbonate } CaH_2(CO_3)_2 + \text{Sodium Carbonate } Na_2CO_3 = \text{Sodium Bicarbonate } 2\,NaHCO_3 + \text{Calcium Carbonate } CaCO_3$$

When injected into boiling water the above gives:

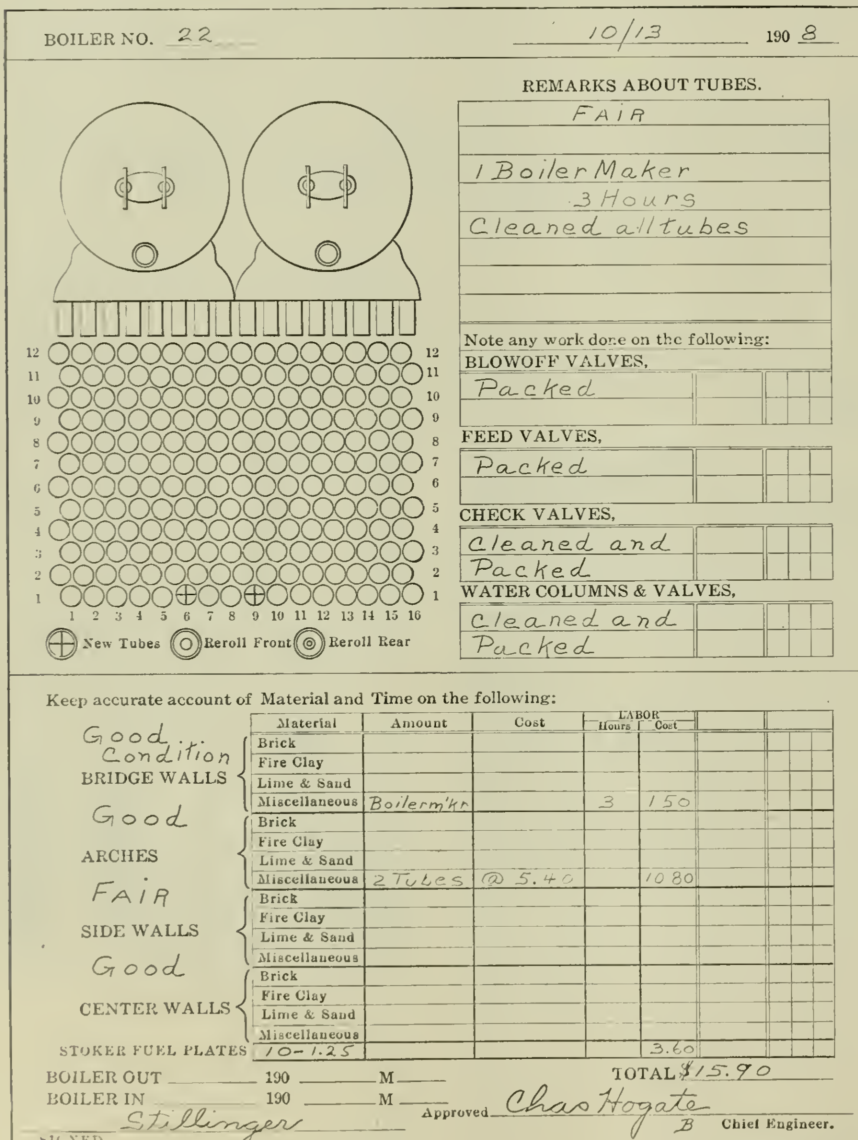
$$\text{Sodium Bicarbonate } 2\,NaHCO_3 = \text{Sodium Carbonate } Na_2CO_3 + \text{Water } H_2O + \text{Carbon Dioxide } CO_2$$

The effect of sodium carbonate on sulphates is shown by the following reaction:

$$\text{Calcium Sulphate } CaSO_4 + \text{Sodium Carbonate } Na_2CO_3 = \text{Calcium Carbonate } CaCO_3 + \text{Sodium Sulphate } Na_2SO_4$$

The precipitation of the above carbonates has a tendency to clarify the water if it is very turbid, carrying mud or clay. In extreme cases a small quantity of iron sulphate can be used.

With the open feed-water heaters in use at the present time the precipitation of the bicarbonates is not complete, as with atmospheric pressure the highest attainable temperature in a heater of this sort would be 212 degrees. The temperatures actually reached are from 190 to 200 degrees Fahrenheit, and the result is that there is precipitation in the feed-water pipe line. In order completely to precipitate the bicarbonates in a closed heater, a temperature of 290 degrees is necessary, which corresponds to a pressure of about 45 pounds gage. The lime is held in suspension by the presence of the carbon-dioxide gas, and no matter how alluring are the promises of the feed-water-heater salesman, no precipitation will take place until this carbon dioxide is removed. The best way to do this is to put the steam connection for one of the auxiliary pumps into the heater above the water level and draw the gas off with the steam. Table 2 shows the percentages of lime thrown down at various temperatures.



BOILER NO. 22 — 10/13 190 8

REMARKS ABOUT TUBES.
FAIR
1 Boiler Maker
3 Hours
Cleaned all tubes

Note any work done on the following:
BLOWOFF VALVES, Packed
FEED VALVES, Packed
CHECK VALVES, Cleaned and Packed
WATER COLUMNS & VALVES, Cleaned and Packed

New Tubes — Reroll Front — Reroll Rear

Keep accurate account of Material and Time on the following:

	Material	Amount	Cost	Labor Hours	Labor Cost
BRIDGE WALLS (Good Condition)	Brick				
	Fire Clay				
	Lime & Sand				
	Miscellaneous	Boilerm'kr		3	1 50
ARCHES (Good)	Brick				
	Fire Clay				
	Lime & Sand				
	Miscellaneous	2 Tubes	@ 5.40		10 80
SIDE WALLS (Fair)	Brick				
	Fire Clay				
	Lime & Sand				
	Miscellaneous				
CENTER WALLS (Good)	Brick				
	Fire Clay				
	Lime & Sand				
	Miscellaneous				
STOKER FUEL PLATES	10 - 1.25				3.60

TOTAL $15.90
BOILER OUT 190 M
BOILER IN 190 M
SIGNED Stillinger — Approved Chas Hogate B Chief Engineer.

Power, N.Y.

FIG. 5. REPAIRS ON BOILERS AND BOILER-ROOM EQUIPMENT

TABLE 2.

°F.	Per Cent. Lime Thrown Down.	°F.	Per Cent. Lime Thrown Down.
217	50.0	245	77.4
219	52.3	250	81.7
221	56.8	255	86.0
227	60.5	261	90.3
232	64.5	266	94.0
236	69.0	271	97.7
240	73.0	290	100.0

Sample Analysis of River Water

Soap Test.

28.2 c.c. Final reading.
18.8 c.c. Initial reading.

9.4 c.c. Difference.
0.5

8.9 × 4 = 35.6 Total hardness.

Acid.

39.6 c.c. Final.
32.8 c.c. Initial.

6.8 c.c. Difference.
4

27.2 = Temporary hardness.

Permanent hardness = 35.6 − 27.2 = 8.4

Soda Ash—For each degree of permanent hardness, 0.091 pound of soda ash should be used for each 1000 gallons of raw water,

$$0.091 \times 8.4 = 0.7644$$

of a pound per 1000 gallons.

Lime—For each degree of temporary hardness, 0.048 pound of lime should be used per 1000 gallons of raw water,

$$0.048 \times 27.2 = 1.3$$

pounds of lime per 1000 gallons.

The accompanying curves, Fig. 3, show the varying degrees of hardness, both temporary and permanent, for the month of July. It is evident that the permanent hardness will vary with the rainfall, and that the amount of lime and soda ash should also be varied.

Sample Analysis of Softened Water

Soda Ash (Result *A*).	Lime (Result *B*).
29.4 c.c.	25.2 c.c.
25.2 c.c.	24.0 c.c.
4.2 c.c.	1.2 c.c.

Result A — Result B = 4.2 — 1.2 = 3.0 cubic centimeters.

Then, 3 × 0.091 = 0.27 pound of soda ash per 1000 gallons.

By means of Table 3, which was calculated for the 70,000-gallon tanks that were used, it was possible to tell at a glance how to vary the treatment.

TABLE 3.

(Result *A*) Soda Ash. c.c.	Lb.	(Result *B*) Lime. c.c.	Lb.
0.0	+ 5.95	0.0	+ 11.90
0.4	+ 3.92	0.6	+ 9.89
0.8	+ 0.91	1.0	+ 8.54
1.0	— 0.35	2.0	+ 5.17
2.0	— 0.65	3.0	+ 1.82
3.0	—12.95	3.4	+ 0.48
4.0	—19.25	3.6	— 0.19
		4.0	— 1.54
		5.0	— 4.88
		6.0	— 8.25

From the result of the above analysis of softened water, result A = 4.2 cubic centimeters. By looking at the table for

Result *A* at 4.2 cubic centimeters it means to cut the treatment down by about 20 pounds. Therefore,

$$53.5 - 20 = 33.5$$

pounds of soda ash, which is correct. The other result, 1.2 cubic centimeters for *B*, by the table indicates that eight pounds more lime are necessary for the completion of the treatment. Therefore,

$$91 + 8 = 99$$

pounds of lime. New treatment, 33.5 pounds of soda ash, 100 pounds of lime. The analysis the next day checked this up and it was found to be correct.

Cost of Treatment

For September, 1908, this was $103.80 against $270 for boiler compound. The cost of treatment for 1000 gallons at the present market prices for high calcium lime and 58 test soda ash is 66.5 cents. The lime used should be high in calcium oxide, of approximately the following analysis: Calcium oxide, 98.5 per cent.; magnesium, 1 per cent.; iron, alumina, silica, 0.5 per cent.

When properly hydrated it should contain 15 to 25 degrees moisture, as this lime is liable to air slack during the summer months unless the hydration is complete. The ordinary Dolomite lime contains from 20 to 30 per cent. magnesium, which is useless as far as the treatment is concerned and it is best to buy on test and still farther check up the lime by an occasional analysis.

Reducing Boiler Repairs

It should be borne in mind that this analysis is not absolutely correct and that other factors will enter into the treatment. The river water analysis will generally give an overdose of lime and soda ash. This will cause liming and foaming of the boilers, so it is necessary to keep

TABLE 4

Month	Maintenance	B.H.P. Hours	Cost Per B.H.P. Hour, Cents	New Tubes
January	$182.80			31
February	180.12	4,077,180	0.0044	15
March	414.07	7,400,000	0.0056	44
April	208.37	4,976,000	0.0042	16
May	448.96	4,880,000	0.0092	12
June	150.17	4,013,200	0.0037	12
July	64.90	3,200,000	0.0020	6
August	108.08	3,340,000	0.0032	[illegible]
September	103.80	3,487,800	0.0030	[illegible]
October	60.90	3,877,000	0.0016	[illegible]

posted on the conditions of the boilers and the river, etc., for successful results.

Table 4 shows the results of ten months' treatment. The number of boiler tubes replaced has been reduced to a minimum and the expense of maintenance is mostly repairs to brickwork. Take September, for instance; the boiler records show that of the total expense for maintenance, $93.80 was for brick arches, side walls, etc., and the remainder, $10.00, for stoker fuel plates. With the form of boiler records shown in Figs. 4 and 5 it is possible to follow closely the performance, depreciation and repairs to any boiler, and also keep a close check on the renewals of tubes and boiler parts.

The boiler equipment consists of eighteen 400-horsepower and four 250-horsepower Babcock & Wilcox boilers. Total, 8400 boiler horsepower.

It may be noted that during the early months of the year there was only a slight improvement in the condition of the boilers and the number of tube renewals. This was due to the fact that while the importance of the treatment was recognized, there was no one in the office who could systematically follow the treatment from day to day or at least check up the treatment twice a week, owing to other interruptions. The last of June, however, the writer took charge, and the above would indicate that some sort of system is necessary for the best results.

By Table 4 the average cost of maintenance for material was $247.81 for the first six months; the average cost for the last four months was $82.87, a saving of $160 a month for the plant.

The writer is indebted to Charles Hosgate, chief engineer of the power station, for courtesies extended.

Hydroelectric Development at Grand Falls, N. B.

The contract for the construction work involved in the hydroelectric development of the Grand Falls Power Company, on the St. John river at Grand Falls, N. B., has been awarded to the Frank B. Gilbreth organization of New York. The plant is to develop natural horsepower to electric current to be distributed to various cities in New Brunswick and Maine. The falls at this point are the largest in eastern Canada, with a head of 125 feet. They are on the Canadian Pacific railroad about 200 miles north of St. John, N. B., and about 1 mile east of the Maine border. It is expected that the development will cost [illegible]. John B. McRae, of Ottawa, is chief engineer, and Ralph Mershon, of New York City, electrical engineer.

The International Congress of Applied Chemistry, which meets in London, England, May 27 to June 2, will be invited to hold its 1912 meeting in New York City. The cooperation of educational institutions, scientific societies, manufacturing corporations and others interested is being sought in order to render the invitation more effective. The matter is in the hands of a temporary committee, of which the secretary is B. [illegible], [illegible] street, New York.

Polytechnic Mechanical Society Meeting

Members of the Brooklyn Polytechnic Institute student section of the American Society of Mechanical Engineers listened on Saturday evening, March 6, to two excellent addresses. The first speaker, George A. Orrok, mechanical engineer of the New York Edison Company, and secretary of the Gas Power section of the American Society of Mechanical Engineers, discussed the development of the large gas engine in connection with blast-furnace operation, showing slides of interesting lantern slides and explaining the operation of various types of engine running up to 4000 horsepower capacity. The speaker called attention to the fact that among the largest gas-engine builders in the world there should be included the Standard Oil Company, or rather its subsidiary, the National Transit Company. It does not, however, build engines to sell.

Following Mr. Orrok's address, which was frequently interrupted by questions from the audience, evidencing the keen interest taken in gas-power developments, Ernest Bournonville, of the Davis-Bournonville Company, gave a demonstration of the oxyacetylene blowpipe for welding and cutting metals. By mixing oxygen and acetylene the temperature of 6300 degrees Fahrenheit is reached, permitting of the direct welding of metals together with the use of solder or brazing. Mr. Bournonville made several welds of steel and cast iron, and also welded cast iron to steel and steel to copper. By the use of an additional oxygen jet various metals were cut by the flame. A piece of [illegible] steel plate about 7 inches wide was cut in two in less than one minute. A piece of burglar-proof steel, about 3 inches square and 1 inch thick, was severed in an [illegible]. Mr. Bournonville also described welding and cutting operations on a larger scale. The experiments [illegible] [illegible] interest and were continued until a late hour, after which the usual collation was served to the [illegible].

The [illegible] mill of [illegible], near Manchester, England, is driven by a [illegible] [illegible]. [illegible] [illegible] with the [illegible] from the [illegible] generator. [illegible] the [illegible] of the [illegible] [illegible] [illegible] for [illegible] purposes. After passing through the [illegible] it is delivered at a temperature of about 100 degrees Fahrenheit [illegible] [illegible] [illegible] [illegible] [illegible] and returned [illegible] to the mill, where it is distributed in the [illegible]. The [illegible] would otherwise have been [illegible] [illegible] and a [illegible] effected, as the [illegible] [illegible] by the [illegible].

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Renewing a Valve Seat

Some time ago the valve-chest face of a high-pressure cylinder became so badly worn and scored that a new valve and valve face were necessary. The new valve was finished complete from measurements taken from the old valve and the valve chest. The new seat was machined the exact width, and approximately the proper thickness, allowance being made for some fitting; the ports were also finished to size. This meant that after the old valve seat was removed it would only be necessary to make a templet from the old holes, drill and counterbore the new seat and bed it in position; then the screws being put in, the job would be completed. It sounds quite simple and easy.

For various reasons it was considered expedient to carry the job through on a Friday night, and have the engine ready for work at 6 a.m. the following morning. Accordingly, when steam was shut off at 5:30, operations were begun. The casing door was removed and the valve spindle and valve taken out. After some preliminary cleaning out of the slots in the holding-on screws, the serious part of the work was begun. The holding-on screws were of brass, ½ inch in diameter, with slotted heads. After removing the screws holding the valve seat in place an attempt was made to remove it with steel wedges, but without success; it seemed to be rusted on solid. It was then decided to split it off in pieces. A line of holes was drilled down the center of the valve face and nearly through; the remaining metal was then cut out with a cape chisel. Wedges were inserted in this space and the face wedged off in pieces.

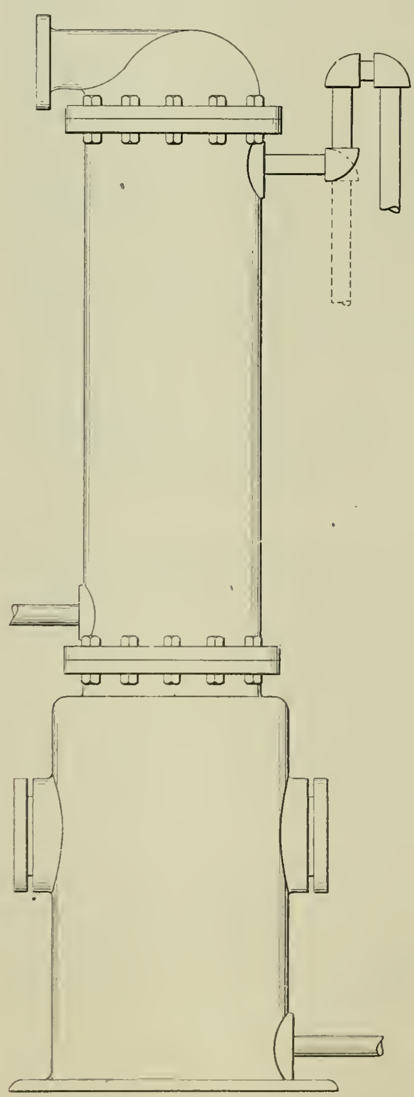
After tapping out the holes for the pins, stout drawing paper was procured and a templet made from the valve chest, ports and holes. The holes were then marked and drilled on the new valve seat, which was then bedded into position. The rust had left the chest face somewhat uneven, but with a judicious use of the chisel and file it was soon pronounced "good enough." A thin coating of red lead was placed between the face and the chest and the screws put in tightly. The new valve and spindle were then placed in position, the door put on and the engine was ready for steam.

W. Burns.

Glasgow, Scotland.

A Gasket Difficulty

A troublesome gasket in a vertical surface condenser recently came under my observation. It was located between the vapor dome and the barrel. The con-



CAUSE OF A GASKET DIFFICULTY

denser is used to condense the hot vapors from a drying oven. Numerous failures of the gasket necessitated the frequent removal of the dome.

It was noted that when the circulating water had been run through under higher pressure than usual for several weeks, the gasket lasted much longer. This led us to the solution. The outlet pipe at the top of the barrel turned downward, as shown by the dotted lines in the accompanying sketch, and prevented the maintenance of a head of water sufficient to come into contact with the tube plate. The loop in the pipe keeps the troublesome surface flushed with water, and obviates a great deal of bothersome work.

J. J. O'Brien.

Buffalo, N. Y.

Technical Education

Through the engineering journals, at frequent intervals, we see the young technical graduate heated up in the furnace of public inspection and then placed under the steam hammer to be knocked and pounded into shape, or ridiculed by a few prejudiced unbelievers.

Notwithstanding all that has been said to the contrary, there is no person in the world who realizes how little he knows as does the graduate during his first year out of college. He begins to see that he has just got a few principles or foundations by which he may use his brains for useful thinking. For this reason, contrary to Mr. Johnston's assumption that the "ordinary grad" considers himself 100 per cent. efficiency, he joins the ranks of the toilers, and is willing and anxious to pick up the tricks and kinks as they present themselves; and the man who takes the pains to help the poor "tech" on his way finds a warm place in the heart of the latter.

It is admitted that a great many boys have the conceited and bloated feeling, but that does not come after graduation, it is in the fellow when he comes to college, and in the most of our schools it is the purpose to kill this evil by means of that essential to all condensing apparatus, cold water.

A large percentage of the fellows who come from our State universities and other institutions worked their way through by sacrificing a good many things, and they appreciate the value of technical education. Do not condemn the college graduate because he is not expert in some particular thing; he has got only the fundamentals, while you may have worked on this very job for five, ten or twenty years.

Caleb H. Johnson.

Orono, Me.

Do Crank Pins Always Wear Flat?

W. O. Platt, in his article on "Do Crank Pins Always Wear Flat?" in the February 9 number, brings up that question in a direct manner. He has had personal experience with bearings on crank pins where the pin did not wear flat. Some pins wear flat and others do not, depending on several conditions. The first and most important of these is the fitting of the bearing around the pin. If the bearing fits snugly the pin cannot wear flat, while if it does not the pin will surely wear flat, especially in a single-acting engine. This may be illustrated in the following manner.

Take a flat surface bearing on a pin along a single element of its surface and, with the impulse all in one direction, the side of the pin toward the impulse will always wear flat, the flatness depending on the magnitude of the impulse. This will be seen to be the condition when a loose box is placed around a pin, the box only bearing along a very narrow surface.

However, in a well fitted bearing it is impossible for the pin to wear very flat, for to make it wear flat the box must bear harder at one place than at another. As the box fits the pin it must bear hard around one whole half instead of merely on a line. Further, the impulse usually lasts for almost a half revolution of the pin, so that the portion of the pin on which the bearing is forced by an impulse extends almost all the way around the pin. The very slight flatness which may be induced by the resiliencies of the material in the box and pin, and by the small clearance which the box must have in order to run freely, are taken off by the general frictional action removing the high parts first, and also by the force exerted on the "nonwearing" side of the pin by the resistance of the piston moving back to its original position. This last force is also augmented in the gas engine by the compression pressure.

James T. Barrows.

Los Angeles, Cal.

Scaled Pipe Connection

Fig. 1 is a sketch of the piping connected with the feed pumps and hot-water heater in the Criminal Court building, Chicago, Ill. The pumps refused to run at their rated speed, although they did so when installed, their speed gradually reducing until it was evident that something must be done to provide sufficient water for the boilers, tanks, etc. The steam for the pumps was taken from an auxiliary steam main. The exhaust from each pump entered a 4-inch auxiliary exhaust main, thence blowing to the main exhaust and feed-water heater, not shown.

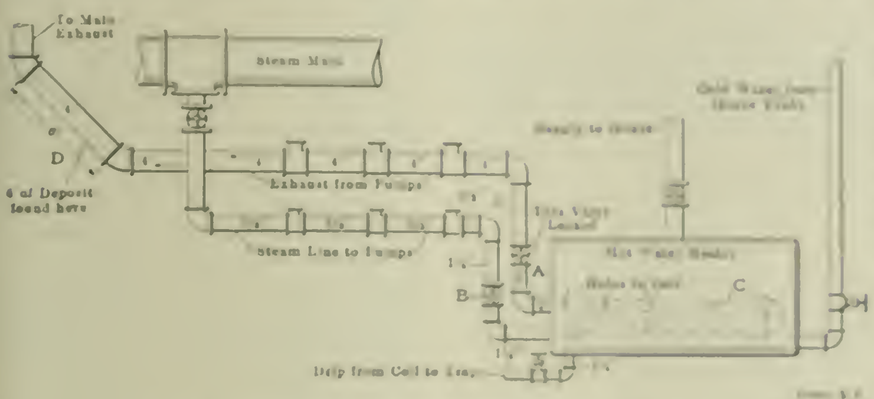


FIG. 1. CONNECTIONS OF FEED PUMPS AND HOT-WATER HEATER

It will be noted that the hot-water house-supply tank is provided with a valve A to heat by exhaust steam, and a valve B, to heat by live steam.

FIG. 2. SECTION OF 4-INCH EXHAUST PIPE SHOWING DEPOSIT

The cause of the trouble was due to the 4-inch coil C in the hot-water tank becoming perforated and the water from the cold-water house tank being forced into the exhaust pipe through the body valve A.

This leak [illegible] was supplemented by a second one, as the water was found to come in contact with the exhaust steam and mingled with some of the [illegible] the pump cylinders, causing the solid matter in the water to precipitate in the interior of the 4-inch exhaust pipe. As this composition was being exhausted toward the main exhaust, it is plain that if any restriction were to be offered to its passage it would occur between the two 45-degree ells. Consequently, I ordered the exhaust main taken apart between these points.

No flange unions being near, we used a large 4-inch pipe cutter, placing it at the point D and cut out a piece about 8 inches long. The condition of the interior of the pipe is shown in Fig. 2; the formation of the different layers of scale is shown by the numerous circles. It was found that this scale, which was as hard as a piece of limestone, reached the entire distance, 6 feet, between the two 45-degree ells.

J. W. Graham.

Chicago, Ill.

Extraneous Supervision of Power Plants

I should like to ask the following questions of the Engineering Supervision Company, of New York City.

To whom do they furnish absolute proof of their ability to decrease the cost of power and maintain or increase the efficiency of the plant without any further outlay or expenditure on the part of the user?

Can they afford to hire a well-trained engineer to operate and keep in repair each individual plant, involving a knowledge of the most economical methods of conducting such work; or do they mean to say that [illegible] a few superficial examinations they can accomplish what some very able and experienced men have often found it difficult to do by working every day and some nights?

Upon whom does the responsibility rest for the safety of the mill property in a plant so conducted? [illegible]

[illegible]

[illegible]

book is to be taken as documentary evidence that all inside the covers may be taken literally by the man who foots the bills?

HORACE L. BRADBURY.

West Everett, Mass.

Removing Broken Studs or Set Screws

There are two methods in general use for extracting a broken stud or a set screw. One is to drill it out with a drill of about the same diameter as the bottom of the threads, and remove the remaining small pieces from the hole with a chisel or other suitable tool; the other method is to take a round-nose or diamond-point chisel and drive the stud around, thus screwing it out, sometimes.

The first method has many drawbacks, as the threads in the hole are often damaged, either by the drill running to one side or during the subsequent operation of extracting the threads; it is also next to impossible to drill out the commercial set screws that are case-hardened all over.

The second method is not always successful and very often does more harm than good, but sometimes very stubborn pieces may be started by employing two chisels, one on each side, and having each man strike in unison.

Fig. 1 illustrates a job I had to do some time ago. The casting weighed several tons, and the only shop within miles was a blacksmith shop, where I borrowed

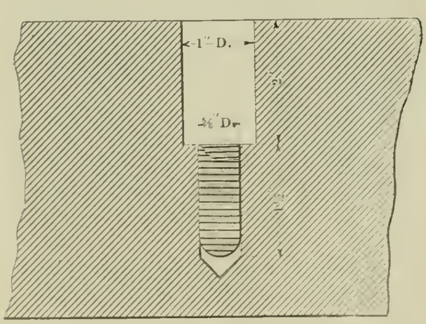


FIG. 1

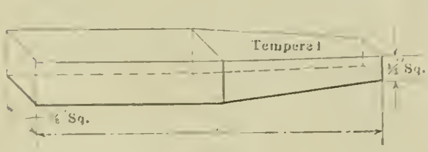


FIG. 2

a breast drill with a 3/8-inch drill and forged a punch similar to Fig. 2. I then drilled a hole 1/2 inch deep in the end of the broken stud, drove in the punch, applied a wrench to the projecting end of the tool and screwed out the troublesome piece.

This method has since proved extremely useful on many occasions, especially when extracting small set screws, as the center of these is generally soft enough to enable a small hole to be drilled with comparative ease. I have also removed taps by the same method, after softening with a torch.

A. J. TAYLOR.

Nanaimo, B. C.

Pressure Vibration in a Steam Main

The accompanying indicator diagrams were taken at one of the power plants of which I had supervision. They are a good illustration of the influence which can be

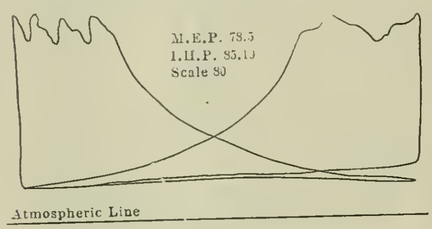


FIG. 1

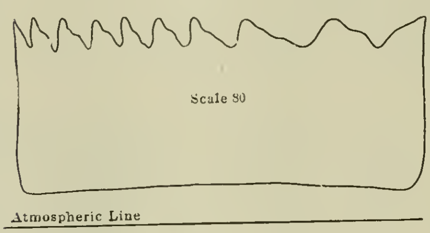


FIG. 2

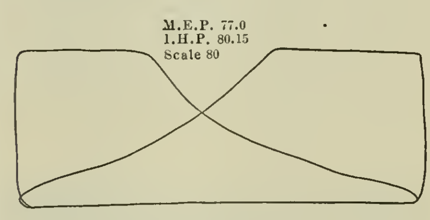


FIG. 3

exerted upon one engine by another fed from the same steam main and standing nearer the boilers.

A 6-inch steam main from a battery of Heine boilers feeds, by means of a branch pipe, a 30 and 52 by 48-inch cross-compound noncondensing direct-connected engine. The pipe then diminishes in cross section and supplies an Ingersoll-Sergeant 16 and 32 by 36-inch cross-compound noncondensing air-compressor engine with Corliss valves.

When the dynamo engine is running, the intake line of the second engine shows considerable vibration; when the dynamo engine is not running, the intake line of the compressor engine becomes straight.

In Fig. 1 is shown a diagram of the high-pressure cylinder taken from the compressor engine when the dynamo engine was running under usual conditions. Fig. 2 shows a diagram taken under the same conditions, but with a 100 per cent. cutoff to show distinctly the characteristic vibration of the intake line on the compressor. Fig. 3 shows a normal diagram of the same cylinder, the compressor working under the same load, all the conditions being the same as in the first case, except that the dynamo engine is not running.

During these trials the dynamo engine made 103.5 revolutions per minute, developing 156 horsepower. The compressor engine made 23 revolutions per minute, compressing 750 cubic feet of free air per minute to an average pressure of 87 pounds.

The second diagram shows nine vibrations. Multiplied by 23, the number of revolutions per minute, gives 207 double vibrations per minute, which exactly corresponds to the number of strokes of the direct-coupled dynamo engine.

A comparison of the energies used in the compressor in the cases of Figs. 1 and 3 gives the following difference in favor of Fig. 3: Fig. 1, high-pressure cylinder, 86.193 horsepower; low-pressure cylinder, 75.33 horsepower. Fig. 3, high-pressure cylinder, 80.154 horsepower; low-pressure cylinder, 74.25 horsepower.

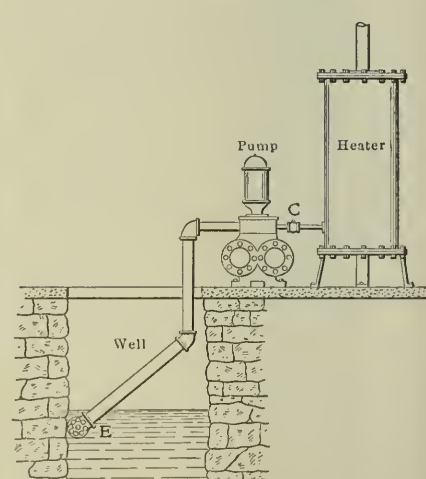
The vibration of the steam pressure in the main in this case causes a loss of about 4.4 per cent. in the efficiency of the compressor engine.

W. N. POLAKOV.

New York City.

Faulty Pump Connections

The arrangement of a new boiler-feed pump that caused trouble is shown in the



FAULTY PUMP CONNECTIONS

sketch. The pump had a lift of 20 feet and was placed quite close to the feed-water heater. When the pump was first started no trouble was experienced, but after stopping and then restarting the pump the failure occurred.

The trouble was caused by the pump being placed too close to the feed-water heater, as the heat from the heater coils prevented the pump from producing a vacuum, consequently the water would fail to rise to the plungers. A check valve *C* was placed in the discharge line from the pump to the heater and no further trouble was experienced. This little failure called an outside engineer from a distance of over 100 miles.

In erecting the pump carelessness had been displayed in placing the suction line, foot valve and strainer as shown, consequently the foot valve failed to work. It was tested by trying to prime the suction pipe, but it could not be filled, indicating that the foot valve was not tight. An examination of the valve disclosed its faulty position.

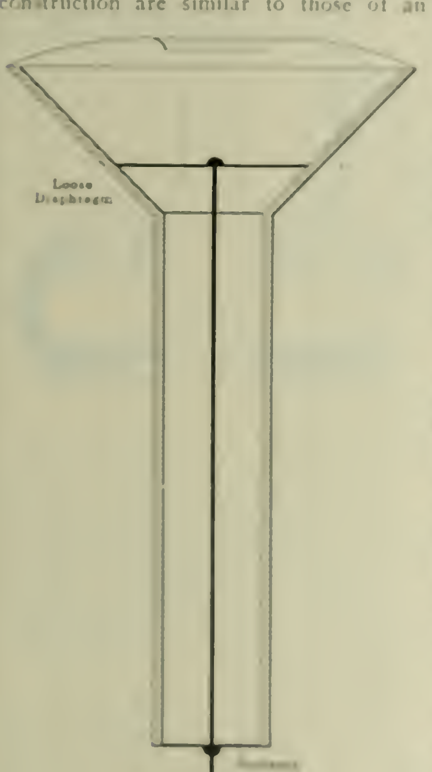
C. R. McGahey.

Lynchburg, Va.

Engineers' Knock Detector

The instrument shown in the accompanying cut is an engineers' homemade detector, invaluable for determining the location of knocks, pounds, drips and leaks. A great many of these detectors are used by municipal water inspectors in their "waste and leak" inspections.

The principle of operation and mode of construction are similar to those of an



KNOCK DETECTOR

elementary telephone receiver. A transmitter rod communicates the vibrations to a diaphragm, which produces the proper vibratory effect on the ear. The requisites for construction are some scraps of tin, soldering tools and 6 inches of brass wire about 1/16 inch in diameter. The [illegible] the wire the better.

The cut shows the construction clearly enough to need little description. Make the tube about 5 inches long and 1 inch in diameter. Close the end with a disk punched to allow the rod to project through about ½ inch, and solder the rod to this disk. Make the greatest diameter of the funnel 3 or 4 inches, and leave a ½-inch hole in the cover for the ear. Cut the diaphragm 2 inches in diameter and let it fit loosely under the curved head of the rod.

To use the instrument, place the rod end on the object to be investigated and the funnel end to the ear. Such trouble as loose piston rings, chattering slide valves, water in cylinders, etc., can readily be located. To locate leaks in piping, shut off all valves and then listen for running water in the pipes.

J. J. O'Hagan.

Buffalo, N. Y.

An Engineer Who Is also a Doctor

One of the best engineers on the Boston & Albany railroad leads a dual life, as after his daily run the engineer becomes a doctor. He is a graduate of Brown University and has a medical diploma. His name is H. F. Brackett, and he drives a locomotive because he loves the "iron steed." At certain times during the day he wends his way through the streets of Brighton with an air of dignified reserve and with medicine case in hand. His calls upon patients being over, his silk hat is placed in its bandbox, off comes his white necktie, fancy vest and other stylish clothing, and an hour later Dr. Brackett is speeding over the rails, eyes to front, and his hand firmly clutching the throttle. The clever physician has become the skilled engineer.

For twenty-seven years, and up to the present year, Dr. Brackett ran the big record-breaker "No. 22," which pulled the New York express from Boston to Springfield. In his thirty-eight years of unbroken service as an engineer he has the [illegible] record of never having been [illegible]. He has never killed a person nor destroyed a cent's worth of property through carelessness or inefficiency. With "No. 22" he [illegible] records, but made a name by [illegible] and his daily [illegible] in two [illegible].

As a physician, Dr. Brackett is a member of [illegible] medical societies. As [illegible] he is known to every [illegible] in Boston. He is examining physician for the Brotherhood of Locomotive Engineers and for the New England Order of Protection. He is the physician of the men of the Boston & Albany, and when Dr. Brackett is [illegible] the [illegible] of that road he is [illegible] by the [illegible] and the [illegible]. In his [illegible] [illegible] [illegible].

W. S. [illegible]

[illegible], Mass.

An Engine Revolution Gage

In our plant there are two [illegible] [illegible], [illegible] [illegible] [illegible]. It is [illegible] necessary to adjust the speed of the engines from time to time according to the requirements of

ENGINE REVOLUTION GAGE

their loads, we used to have to "feel around" with the governor and then count the revolutions with watch in hand, sometimes [illegible] [illegible] times a day. This made it very inconvenient, so we made the arrangement shown in the sketch.

We screwed a graduated [illegible] made out of a piece of sheet [illegible] on the side of the governor stand, and attached a [illegible] [illegible] [illegible] [illegible] [illegible] through the vertical slot in the stand. The [illegible] was [illegible] down, and we [illegible] that the [illegible] was pointed to the lowest mark on the scale at [illegible] when the engine was stopped. When the engine runs at its highest speed the pointer is at the highest mark on the scale, which is [illegible]. We run at different speeds, [illegible] [illegible] revolutions per minute, and in that way we graduated our scale. We graduated the scale [illegible] [illegible] revolutions by [illegible] the [illegible] [illegible]. All we have to do now is to look at the scale to know at what speed the engine is running.

[illegible]

[illegible], Mass.

Boiler Settings

When called upon to design a new boiler setting the engineer usually recalls the defects in his present settings and endeavors to eliminate them in the new.

Probably the weakest point in the brickwork of a return-tubular boiler setting is the back connection, which is sometimes so small that the tubes can only be reached with difficulty, and often the top row of tubes is so close to the arch that they will not admit an expander. There is no reason why this part of the combustion chamber should not be roomy.

Back arches made up of firebrick will be found to be unsatisfactory and expensive, considering the frequency with which they must be renewed. A slight shrinkage in each of the numerous joints will soon cause the brick to loosen and a bursting tube or an accidental blow when cleaning will bring it down. There are several forms of arches composed of molded blocks of refractory material, which will hold their place and are independent of iron bars or forms for support.

A space of ¾ inch should be left between the head and the back arch to allow free movement of the shell, otherwise the back wall will bulge out and crack. This space should be packed with asbestos after the boiler has been fired up. Usually some of the rivets of the braces will come into this space and if the heads are formed up as they should be will interfere with the free movement of the boiler. This can be overcome by chipping out a recess in the arch opposite each rivet head.

The combustion chamber should be paved with firebrick, starting at a point near the top of the bridgewall, sloping until directly under the end of the boiler and then continue level to the back wall. The clean-out door in the back wall should be set so as to be on a level with the paved floor, which will render it easy to remove the soot. The clean-out door should be of a heavy pattern and fit the frame closely. The frame should be firmly anchored and made tight. More air will usually leak in between the frame and the brickwork or around a warped clean-out door than anywhere else in a setting.

The blowoff pipe should be protected by a firebrick shield, open on the back for inspection. A pier of red brick should be built from the foundation up to near the floor of the combustion chamber to form a firm and independent support for the blowoff shield. The blowoff pipe should be extra heavy and extend from the boiler to an elbow under the paving of the combustion chamber, and then through the back wall. A thimble of 4-inch pipe should be built in the back wall for the pipe to pass through so that it can be easily renewed. The opening between the pipe and thimble can be filled with asbestos fiber.

Care must be taken to see that the brackets have an even bearing on the wall plates. If this is not the case it will cause a serious strain upon the shell. It is customary to specify that the bottom of the brackets be machine finished, and it is just as important that the wall plates be finished on their top surface. Care should also be taken that the rear brackets are properly placed on their rollers and that a space is left around them when bricking in, so as to allow free movement.

It is customary to carry the outside walls considerably above the top of the boiler and to finish with a stone or concrete coping. There should be a space left in the center of the back wall about 2 feet wide, with the bottom on a level with the top of the arch so that soot on the top of the setting can be swept out and collected here. Usually the top of the arch is the bottom of a deep pit which is hard to keep clean. Such an opening will facilitate repairs to the arch.

It will be found very convenient when making tests to have an opening into the combustion chamber back of the bridgewall, also in the back wall opposite the tubes, to insert a pyrometer or to connect a draft gage or gas sampler. This can be accomplished by inserting a 1¼-inch pipe in the wall flush with each side and screwing a cap on the outside. The inner end can be packed with asbestos fiber. A ¾-inch hole drilled in the delivery pipe between the valve and the nozzle will save drilling one by hand when it is desired to insert a calorimeter.

The ashpit should be deep and have a waterproof cement bottom. It should slope back from the ashpit door to a point under the back edge of the dead plate and the cement should be carried up the sides and bridgewall at least 6 inches, to prevent wetting the brick when water is carried in the ashpit. It will also eliminate the corners which cannot be kept clean. Care should be taken that the fire-door arches extend back far enough to protect the front row of rivets and the space between the arch and shell packed with plastic asbestos.

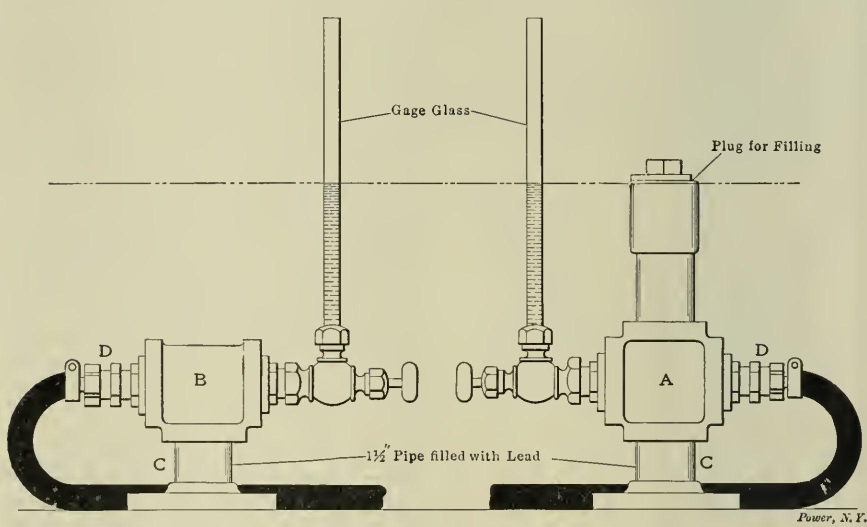
Many of these small details which the operating engineer sees do not come to the notice of the designer, as he does not have the opportunity to see the weak points in his plans; however, it is usually these very things which cause the annoyance and extra labor in operating and maintaining the plant.

Lewis C. Reynolds.

Willard, N. Y.

A Useful Leveling Instrument

The accompanying sketch shows how a leveling instrument I have used for some time is made. The two gage-glass standards are made of ordinary pipe and fittings, except that at *C C* the pipes are filled with lead and calked. A ¾-inch hose nipple is used at *D D* to connect to an ordinary 50-foot garden hose, although a small rubber gas tube would do as well.



A USEFUL LEVELING INSTRUMENT

In filling, place the standards side by side on the bench and allow the hose to trail out on the floor; then fill with water to the top of the coupling and screw the plug in tight. See that there are no air pockets in the hose, as the air might cause an inaccuracy in the level by bubbling up through the water.

One person must tend each gage, and at a signal each must mark the hight of the water level on the wall; then after closing the valves A transports his gage and holds the water level at the mark made by B while B makes a new mark; thus relays may be established for any practical distance.

This device will be found very convenient where it would be inconvenient to use a transit, even if one were at hand, because of darkness and intervening walls. It will also be found useful in grading long lines of steam pipe, etc.

Philip Parker.

Woburn, Mass.

Throwing Coal Away by the Ton

I was recently in an engine room that showed how coal could be thrown away by the ton. There were two 1000-horsepower vertical engines of the high-speed, cross-compound type running condensing. There was also another smaller engine of similar type to carry the lighting load nights. The real trouble was in this small engine and in one of the larger units. Their exhaust connections are arranged as in the accompanying sketch, and to make matters worse, the pistons are of the oval type with dished heads, so that the bottom one is like a cup in which condensation may collect.

The exhaust connections shown in the sketch may work all right if the engine is loaded all the time, and there is sufficient volume of steam to keep it swept clear of water. When the engine is not fully loaded the steam will cut across corners and allow all the condensation to run back into the cylinder, as it is a difficult matter any way to carry the water around the curve *A*, up the vertical portion and turn a right angle into the exhaust pipe.

EXHAUST CONNECTIONS OF LOW-PRESSURE CYLINDER

All the water from the top of the cylinder is also blown down to the bottom. When it accumulates in large quantities a portion of it will be blown out, but there will always be some left in the bottom of the cylinder, which will leak through the packing and make it almost impossible to keep the piston or valve rods tight, and frequently flange joints leak, too. There is not sufficient water to cause a wreck, but there is enough for the piston to give light blows and distress the weakest part, which, after a time, will give way.

It is wholly inexcusable to make an exhaust like this, as on a vertical engine the exhaust should go out straight from the bottom so as to thoroughly drain all condensation. I had a low-pressure cylinder like this at one time, and I put in a 2½-inch drain pipe, as shown by the dotted lines, and led this pipe down into the condenser.

At this engine room the trouble is [illegible] credited to the boilers giving wet steam, notwithstanding thousands of boilers of the same make are giving good service, and show no tendency to prime.

To remedy the trouble they have taken the trap off every drain pipe and opened them wide, some five or six 1- to 1½-inch pipes and 130-pound steam pressure. Then all of the cylinder cocks are run wide open. Just think how much coal can blow to waste under these conditions. Also the chance the boilers have to give dry steam with such a drain and the first run so hard that the breeching to the chimney is badly blistered.

They have decided to get some new boilers, also some new engines of some kind. Getting the new engines is all right, but there is nothing wrong with the boilers if they only had a chance.

W. E. CRANE.

Broadalbin, N. Y.

Transformer Connections

When reading Mr. Carroll's letter, I noticed that he does not quite understand that his two transformers being connected in open delta take current from the three phases, as he states they take current only from phases one and two. One transformer is connected between leads one and two, and the other transformer is connected between leads two and three, and the resultant of the phase displacement between the two transformers, which is taken care of by the leads one and three, is a third phase supplied to the transformers, so with the motor connected to the circuit all three leads supply the same amount of power.

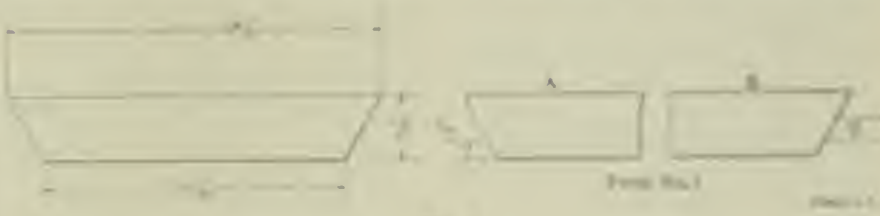
The transformer which supplies current to the lamps, connected to one phase, should not cause any serious effect on the regulation of the system, as [illegible] the three-phase circuit which supplies the power side. If the lighting load is heavily [illegible] under unbalancing of the [illegible], it would be advisable to add another transformer and balance it with the other so each delta [illegible] lines, and then evenly divide the load on the secondary side. This will eliminate unbalancing. The regulation of circuit mentioned should not necessarily give any trouble.

JAMES E. KELLY.

Lincoln Place, Penn.

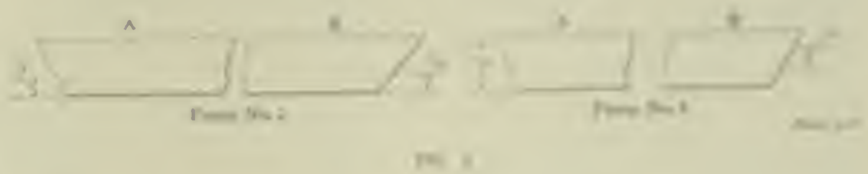
Pressure Required to Raise a Valve

In recent numbers there have been letters discussing this subject. I have made several tests on three 2x3-inch double-cylinder (crank between cylinders), single-acting oil pumps which worked against a common pressure of 200 pounds and entirely independent of each other, with pipe connections. The illustrations and table explain the results obtained. Taking pump No. 1, the bearing surface of valve *A* is 3/32 inch and the tank pressure 190 pounds. The cylinder pressure, or that necessary to raise the valve is 195 pounds. With the valve having a bearing, as shown at *B*, Fig. 1, the tank pressure was 180 pounds and the cylinder pressure 190 pounds. The tank pressure was raised by the same gage, through a simple arrangement of piping, before and after any test. There was no special arrangement of the [illegible] except that the springs were so [illegible]



Pump No. 1

FIG. 1



Pump No. 2

Pump No. 3

FIG. 2

TABLE OF TESTS [illegible]

		[illegible]	[illegible]
No. 1	[illegible]	[illegible]	[illegible]
No. 2	[illegible]	[illegible]	[illegible]
No. 3	[illegible]	[illegible]	[illegible]

[illegible] In the tests the pressure raised to the highest point, in starting, and then dropped back to about 5 pounds above tank pressure.

[illegible]

[illegible], Wash.

Wear of Bearings on High Speed Engines

Many engineers say they do not like high-speed engines, because of their wearing so fast. I have a 150-horsepower high-speed engine and I find its performance remarkable in this respect.

The engine has been in service over five years and the tool marks are quite visible on every wearing journal. I have taken up on the two main bearings once since the engine was erected, and by disconnecting the eccentric rod at the bail joint and working the valve by hand, after steam is turned on, no shaft lunge can be noticed, and it will probably be another year before the bearing caps will have to be removed. The crank-pin brasses ran for thirteen months without adjustment, and all I took up then was the thickness of a piece of very thin paper. Not the slightest wear on the crosshead pin can be detected with a pair of calipers, although the engine has done a twelve-hour "stunt" every day since it was first started. The valve has a large wearing surface and seems to be as tight as at first. I use metallic packing on the piston rod.

I also have a 20x42-inch Corliss engine that has been in service over five years. I have never had to take down a single rod or bearing. I had one of the dashpots out once, and also centered the piston rod in the cylinder. We also do the ordinary adjusting all around every so often.

OAKS KYGER.

Danville, Ill.

Pump Valves

The writer was recently called to a plant to locate the trouble with a boiler-feed pump. The engineer said he had just taken out the brass valves and replaced them with hard-rubber valves.

I found that he had placed the rubber valve on a seat which did not have any bearing next to the stud, the stud being cast solid on the seat and required a valve with a hollow stem which works over the stud.

It was evident the water would be forced up through the hole in the valve, around the stud and then forced back again by the pressure from the boiler, the water churning back and forth through the valves. I had him get a new set of valve seats, having a screw stud and a bearing around the same.

I have found that a good rubber valve is the best for a boiler-feed pump, no matter how hot the water is, but I think it a good idea always to place the old brass disk on top of the rubber, as it distributes the pressure all over the valve and keeps it from cutting down or sinking through the seat.

Some engineers argue that they must have springs on top of the valve on a boiler-feed pump. I cannot see why this should be, because the pressure from the boiler always holds them down, and again the area of the top is a great deal more than the bottom, the spring only making it harder to lift.

H. T. FRYANT.

Jackson, Miss.

An Engine Accident

Not long ago I was running a 16 and 30 by 42-inch cross-compound Corliss engine. It had only been installed about three months when the high-pressure piston rod broke off in one of the three threads remaining outside of the jam nut of the crosshead, with the result that the cylinder head was pushed off, pulling the stud bolts out, breaking out the holes and cracking the walls for a distance of from 1 to 6 inches.

We had to get a new rod, piston and cylinder, and as the engine was guaranteed for a year the company naturally expected the builders to pay the damage. The agent was in town and had been in looking the plant over the day before and, as he said, had noticed that we were carrying 5 pounds receiver pressure with an average load of about 300 horsepower. The agent took the short piece of broken rod which showed about one-third of its area as a new break. The other two-thirds had been pounded smooth, showing that the crack had been opening and closing a great number of times, perhaps, since the rod was put in.

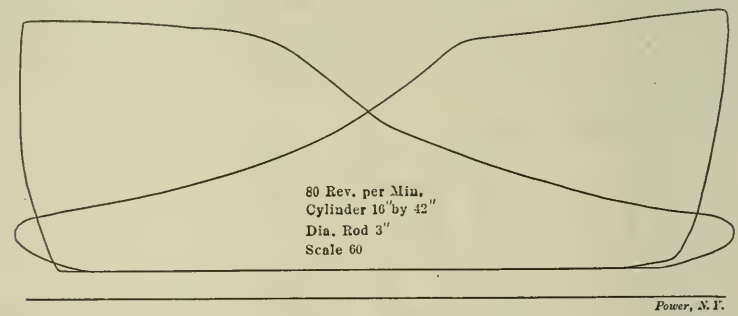
In a week he came back with data from experts showing that there was enough good metal in the rod to pull the load, provided the load were balanced. I was called to the office to explain why I did not run the engine as it should be run. I stated that the engine was balanced as well as it could be without taking diagrams every time the load changed; but the agent pointed out that I was only carrying 5 pounds receiver pressure, and that the gage was tested and found to be all right. My argument did not "go," for I could not talk as well as the agent.

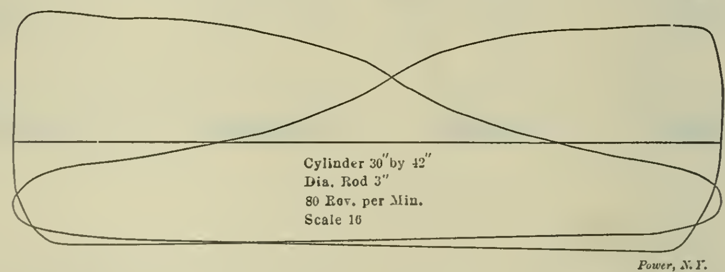
I told him that the specifications called for a square thread on the rod, not a V-shaped thread, neither did they call for a cracked rod.

The accompanying diagrams were taken under the same conditions as when the rod broke, and I should like some of the readers to point out the defects of each and figure the horsepower.

THOMAS SHEEHAN.

Pittsfield, Mass.





DIAGRAMS FROM A 16 AND 30 BY 42-INCH CROSS-COMPOUND CORLISS ENGINE

Use of Coal Oil on Commutators

I can recommend the use of coal oil on commutators for low-voltage machines. After shutting the machine down I take a little coal oil on a rag and wash the commutator with it. This removes the foreign matter and will generally keep it in good condition, providing the machine is free from grounds, short-circuits, etc.

For machines much above 110 volts I have found it unsatisfactory. I first tried it on a 550-volt rotary converter. It sparked so badly that I had to take it off the line and give it a good cleaning, using paraffin for my brushes. I have used coal oil on other machines of about that voltage with the same result.

I obtain good results with paraffin on the higher voltages. It not only lubricates the commutator, but stops all chattering. I heat the paraffin quite hot and dip the brushes into it.

J. J. McINTOSH.

Phoenix, Ariz.

A Cause of Engine Wreck

The following conversation took place between a license examiner and an engineer:

Examiner—What would be the result of lengthening the long rod and shortening the short rod on the governor of a Corliss engine?

Engineer—It would make the cutoff longer.

Examiner—But would it?

Engineer—Certainly it would.

Examiner—If the load and steam pressure remained the same, would it?

Engineer—The governor would assume a higher plane.

Examiner—That's it, the governor assumes a higher plane.

If the engineer had been allowed to continue he would have said "And to assume this higher plane the engine must run faster, and to run faster the cutoff must be longer." There is another question that comes in here and that is: Will it bring the governor to a point where, with no load, the cutoff is too long and the engine will run away?

There have been many flywheel wrecks from this cause. When the engine is erected these rods are left so that the governor at its highest point will not allow the valves to open to admit any steam and care should be taken that the governor is always in that condition.

Poppet valves are usually opened by one cam sliding around on the small side of another. To set the valves the governor is raised to its highest point, and in that position the governor is turned to bring the highest point of the cam opposite one of the valves. The valve should be set so that the cam will pass and just touch but not open it. The other valve is then set the same way. The governor is then lowered and brought up to one of the valves so that the cam will open it the amount of lead that is necessary. The engine should be on the same center.

Poppet valves are driven by gears. The gear should now be put on the stud and put in mesh with the gear on the engine shaft. If it will not mesh upon the first trial, turn it around until it does. The valves are now set to give the full range of cutoff, and the engine will not run away, as it cannot get steam to run above a certain speed. There are no belts to break and nothing can happen to the governor.

The same thing should be looked after in all engines. An engine that will admit steam after the governor is at its highest position is unsafe to run, for with a vacuum and no load a runaway is almost assured. To change the length of the rods on the governor without investigating this point is to invite trouble. This is one of the most important [illegible] about any kind of an engine, but in how many cases does it receive a thought?

With governor belts there is always danger and a safety stop is necessary. If gears and a positive drive could be substituted it would reduce the danger.

W. E. Crane.

Broadalbin, N. Y.

Some Condenser Troubles

A certain steam plant was equipped with a barometric condenser which discharged into a hotwell, overflow of which led to the river some distance away. Upon starting the engine a vacuum of from 26 to 27 inches was obtained, but in about ten minutes the vacuum would drop to 18 or 20 inches and remain there. No air leaks could be found and the supply of water was ample. An investigation of the hotwell showed an overflow pipe but little larger than the condenser-discharge pipe, and about 2½ feet below the top of the well, which was fitted with an air-tight cover. When the water rose above the overflow, the vapor from the condenser accumulated in the top of the well and raised the pressure in the well above that of the atmosphere. This reduced the effective weight of the column of water in the discharge pipe and decreased the velocity of the discharge, consequently causing a loss of vacuum. A larger overflow pipe was put in and the trouble disappeared. A vapor pipe in the well cover, to prevent the accumulation of vapor, would probably have answered as well.

A combined air and circulating pump in another plant discharged into a small sewer. As time went on many connections were made to the sewer, and the condenser began to give trouble. With the engine under a heavy load the pump would become suddenly flooded in several instances [illegible] the pump. As there was no automatic atmospheric valve the exhaust had to pass through the pump until a gate valve was opened by the engineer. A separate sewer for the condenser was built at considerable expense, but the writer believes that a vapor pipe on the condenser discharge with an automatic atmospheric valve in the exhaust pipe would have overcome the trouble which was doubtless due to an accumulation of vapor in the sewer.

In another steam plant a barometric condenser gave considerable trouble due to air leakage. A vacuum could be obtained and held when the engine was not running, but when running the vacuum would fall off and break with a heavy load. It was at first thought that the water supply was insufficient, or that the [illegible] leaking enough to cause the trouble.

[illegible] showed that the [illegible] of the [illegible] leaked considerably, causing them to [illegible] a mixture of air and water in the [illegible]. The air came over with the water to the [illegible] and then to the condenser, accumulating in the top of the condenser until it finally broke the siphon. A new [illegible] pump solved the trouble.

One plant apparently had no difficulty in the condenser line. The gage on the board showed 30 inches, and the engineer claimed that it was correct, as it had been tested. A test gage placed directly upon the exhaust pipe showed about 26 inches. The engineer said that when the plant was first started the gage showed 26 inches, but this had gradually increased until it reached 30 inches. He had supposed that the condenser was becoming more efficient with use. Upon loosening the union nut beneath the gage the needle dropped back to 26 inches, where it remained when the nut was tightened.

This engine operated part of the time exhausting to the atmosphere, and when so working the condensation was forced up into the gage pipe, nearly filling it. When running condensing the gage showed the vacuum, plus the weight of the water in the pipe. Loosening the nut on the union had allowed the water to flow back to the exhaust pipe.

W. D. [illegible]

[illegible], N. J.

Improper Boiler Blowoff Connection

Our boiler blowoff pipe was [illegible] inches in diameter and was screwed into the back head about 2 inches above the bottom of the shell, so that it was impossible to blow out the mud and sediment which in time accumulated in the boiler to a considerable extent. It was impossible to wash it out with a hose, so the only way to clean the boiler was with a [illegible], which was not satisfactory. A hole the same size as the blowoff pipe had been tapped in the bottom of the shell about [illegible] from the back end, but plugged. To put the blowoff pipe in the proper place could not be done until a reinforcing ring had been placed around the hole. A local [illegible] was asked [illegible] boiler-repair work was [illegible] of putting [illegible] reinforcing ring.

The boiler had no manhole in the back head, while one had to the front [illegible] smaller than the average, and it was difficult to get the rivet [illegible] inside the boiler. The [illegible] was made the shape of a [illegible] plate, [illegible], and had to go in [illegible] so it could be pushed back toward the back head. We [illegible] succeeded in getting it in place, allowing [illegible] to [illegible] the holding and hammering. Since [illegible] was pulled out through the [illegible] blowoff hole.

[illegible]

[illegible], Canada.

Safety Valves*

A Posthumous Contribution to the Recent A. S. M. E. Discussion; How Safety Valves Should Be Rated; An Argument against "High Lift"

BY A. B. CARHART

Certainly there is one way in which safety valves should *not* be rated, and that is by the *area* of the disk or of the inlet connection; for in every case the outlet-discharge capacity is proportional to the circumference of the valve seat and the circumference will, of course, increase in proportion to the diameter, while the inlet and disk areas will increase in proportion to the square of the radius. If the lift of the disk is the same for all the ordinary sizes of valve, the discharge areas and capacities of the valves are directly proportional to the diameters, and the inlet diameter becomes a direct measure of the relative size or capacity of the valve. There seems to be no good reason to depart from this method of denoting valve sizes, which has been the uniform custom in the past, and it will be found to be more accurate and satisfactory than any other method. The lift may properly be assumed to be uniform in all the sizes of valve such as we are considering, for this is the actual performance in practice. If there is any measurable difference in special cases, it will generally be found that the larger valves lift less vertically than the smaller ones. This is as it should be in proper designing, from the practical point of view of prompt and quiet action, durability of the valve and safety to the boiler. The smaller valves have less weight of moving parts, less momentum, less load, springs of more tractable proportions and may safely lift higher.

Valves should not be rated in discharge area alone. The discharge rating of a valve would be different for every pressure and would be dependent upon the care in maintaining the uniformity of commercial springs; and it would be in any case a theoretical amount arrived at by a formula which might be amended by any designer or salesman to suit the exigencies of every contract price or specification of capacity. This would introduce in the first place a hopeless confusion in odd sizes, and leave the engineer wholly at the mercy of the representations or the misrepresentations of selling arguments. The standard sizes, familiar in practice to all engineers, now denote the size of the inlet-pipe connection which must be provided in the boiler; if different designs of valve have different apparent or claimed efficiencies, allowance can be made for this in the judgment of the engineer. We do not rate iron pipe in discharge capacity or area, but by commercial-diameter sizes; and this universal custom has never been overturned at anyone's suggestion merely because the inside diameter of hydraulic or extra-heavy or brass pipe differs from that of ordinary pipe, or because bends and elbows may reduce the flow; engineers exercise their judgment in specification. The actual lifts or discharge areas of valves should be determined and reported upon after impartial tests conducted by competent and disinterested engineers, under conditions of scientific accuracy and fair precautions, where each valve is intelligently regulated to work under its intended normal limits, and not from any reports of tests conducted by any one manufacturer without the knowledge of the other makers whose valves were thus treated, and where the one measurement noted was in many cases purposely limited.

My judgment is that the valves should be so designed and proportioned to the boiler capacity that the valve disk should not be required to lift too far from its seat. The effects of hammering the seat and unduly distorting the loaded helical spring are to cause leaky valves, which require frequent regrinding, and the sticking of the valves in opening and closing. All such trouble or danger can be avoided by limiting the rise of the disk in valves for stationary boilers so as to give an effective free opening through the valve seat equal to 0.05 inch vertical measurement as the maximum; and I believe there is no argument, except unreasoning demand for cheapness of boiler equipment, that would increase this limit; in most cases the considerations of stability and safety would suggest to conservative engineers reducing the amount of lift instead of increasing it. The increased discharge capacity of the larger valves is measured by the enlarging circumference of the valve seat, the discharge area increasing in direct proportion to the diameter size rating without increasing the lift.

At 200 pounds pressure the total spring load upon a 4-inch disk is over 2500 pounds, and as the valve lifts the farther compression may increase this 1000 pounds more; and this force acting upon a large disk, through any considerable distance, develops a tremendous energy, which is redoubled as the time or suddenness of movement is lessened, and rapidly multiplies in proportion to the square of the distance for every increment of higher lift. The destructive effect of such augmented force in actual experience is beyond anything that the mere figures of a formula for acceleration and energy would convey to the mind. The loads and reaction and the unwieldy proportions of such large springs will, of course, be reduced to about three-fourths as much in the flat-seated valve. I do not refer now to the mere pounding of the seat, causing leaks and chatterings, and requiring frequent repair and regrinding, but the destructive and dangerous effects upon the boiler. The circumstances of opening up the seams in testing boilers when models were tried out, the condemning of boilers on account of leaks developing soon after being fitted with new valves of the so-called improved design, are well known, not to one manufacturer, but to everyone who has undertaken any original work in this field, and not this year only, but a dozen and twenty years ago, within the knowledge of those who were leaders in the business at the time. For, after all, this is a practical question, about which the best manufacturers know more from the records of past experience than all the discussions of a year could suggest for possible trial. Tests of lifts and capacities of safety valves are reported in textbooks, such as Peabody and Miller's "Steam Boilers," printed a dozen years ago.

For locomotive valves, where the steaming capacity of the boiler is relatively large, and the steam is freely discharged into the open air in all directions, and the valves are subjected to thorough monthly inspection and repair, sometimes by requirement of law and always by skilled and experienced repairmen, the lift of the disk has been commonly equal to about 0.075 or 0.08 inch of effective vertical measurement, but it should not be more. In valves of the 45-degree bevel-seated type, the effective opening is only about 0.7 of the actual vertical lift, less also any overlap of the regulating lip or ring which controls or throttles the steam after it passes the valve seat, so the actual spring compression should be about 1½ times the measurements given. Freedom and directness of flow of the escaping steam are essential points to con-

*Discussion submitted since the A. S. M. E. February meeting, which was devoted to "Safety Valves" and was reported in our issues of March 9 and 16, 1909.

sider, and measurements of dimensions and time of discharge are subordinate to and to be interpreted in the light of actual performance in long-continued service.

In this matter of proper opening for a valve, "it is a condition which confronts us and not a theory." The present practice of some manufacturers is deliberately what it is, because, in their judgment, it is the wise and the proper one. Customers have not in recent years inquired so much about the lift and dimensions of safety valves, but manufacturers themselves have studied and considered them from all sides.

A high lift is not in itself a desirable thing nor a direct measure of the discharge. It would be ideal if, when the critical pressure were reached, some by-pass valve or outside linkage would operate the lever and lift the disk, freely to permit the steam to escape directly to the open air over a rounded edge. But the too common practice is exactly contrary to this, and the steam which theoretically has been released at the seat of the valve finds itself imprisoned in an outer chamber where it must be delayed and harnessed, in a sort of low-pressure cylinder, until by its impact in a tortuous passage and its expansion against the enormous spring load, it forces the disk up in the "pop" lift. Not an ounce nor breath of all the steam (supposedly necessary to be released at a critical moment of danger, and freed only to relieve the boiler) can escape to atmospheric pressure until it has thus given up its measure of work to lift the disk, and the larger the disk area and corresponding spring load, the greater will this work be; and the higher the lift desired, the longer and more completely will the steam be confined and throttled to extract the utmost of work from the escaping flow. The expansion chamber is sometimes cunningly constructed with a regulating ring (patented by Richardson in 1866 and 1869) so devised that the edge overlaps the edge of the lip of the disk to prevent all free passage to the air whatever until the disk has lifted at least the amount of the overlap, so the first few hundredths of an inch of lift are practically ineffective and the remainder of the lift gives the equivalent of only 0.7 of the actual vertical movement. Richardson himself described the essential feature of his invention, in thus limiting the outlet flow: "Consisting in forming the valve with a surface outside of the ground joint for the escaping steam to act against; the said surface being surrounded by a projecting or overlapping lip, rim or flanch, leaving a narrow space for the escape of the steam when the valve is opened, but which, although of greater diameter than the valve seat, by reason of the said lap, presents a less area of opening for the escape of steam than is produced at the valve seat."

Although traditionally accepted by the various boards and approved under the admiralty rules, I cannot help looking upon this as a wrong engineering principle and design, deliberately to throttle or constrict the outlet during the first part of the lift, and strangle the escape discharge, for the sole purpose of getting extra work out of the steam, instead of discharging it freely and immediately. The steam may appear to get out over the valve seat with the large lift, but it is not yet safely out into free air to give the boiler relief. If the steam can be made to get away freely in proper quantity, without any delay, restraint or expansion chamber, why should it be thus hindered simply to produce a spectacular lift of the disk?

The lifting of the valve disk against the increasing pressure of the shortening spring should be performed by an auxiliary stream, separate from the main discharge. If we could discharge sufficient steam with even less lift, any valve would be the more efficient and desirable. With large lift the strain and torsional deformation of the spring are unnecessarily great, with resultant cocking and side thrust on the guide-wing bearings, which have been known to show a reduction in diameter of 1/4 inch in a few weeks of service; the strain upon the boiler itself is dangerous when such a valve opens and closes, and water is drawn out of the boiler with the steam when the opening is too great and sudden. The throttled-lip action can be likened to the mule that stops to kick over the whiffletree: it is spectacular, but there is not a pound of useful pull on the traces and no progress made until it is over. We do not buy mules by measuring the height they can kick, but by the load they will actually haul in a steady pull, and sudden jumps and jerks that break the harness but do not really start the loaded wagon are not useful work. In Africa the savages buy old muskets by their kick or recoil, that gun is considered the most powerful which has the worst kick; but we know that all the kick of a gun is subtracted from its effective work of discharge upon the bullet, and we do not buy guns on that basis.

For stationary boilers, which are used generally at the lower pressures, 4 inches diameter of the valve seat is the limit which should be attempted, and valves larger than 5 inches in diameter cannot be recommended. A 5-inch valve is the largest size permitted by law so far used in Massachusetts, and the board in this State was not influenced by any [illegible] from manufacturers on this point. [illegible]

[illegible] larger than 5 inches is a fair indication that such practice is reasonable and within good judgment.

My opinion, based upon experience and the records of the performance of many thousands of valves in use, of the several styles of different manufacturers, is that pop safety valves for locomotives should not be larger than [illegible] inches diameter at the seat. At 200 pounds pressure the total load upon the valve disk in the bevel-seated type of valve is [illegible] pounds, increased perhaps [illegible] pounds more to maintain the lift when the valve opens, or more than [illegible] pounds as the maximum. For the flat-seated annular valve the initial load is [illegible] pounds, increased to about [illegible] pounds when the valve lifts, but the possible maximum is under all conditions less than the initial or maximum load upon the bevel-seated valve; and the effective discharge area in the [illegible]-inch size amounts to a little more than 1 square inch at only [illegible] inch lift of the disk, or something over [illegible] pounds of steam per second, according to a common formula. [illegible]

[illegible]

ness, as endless experiments in mechanics are designed to demonstrate. Much better practice is that recommended and more commonly followed for locomotives, using three valves of comparatively smaller size, set to open 2 pounds or 4 pounds apart, one or more of the valves being called into operation in succession as the steaming conditions may require; the successive sudden shocks not being dangerous or destructive. This prevents any serious rise in boiler pressure before relief is afforded.

We know that in actual service two 3½-inch valves or three 3-inch valves have been ample to take care of the largest locomotive boilers under the most severe requirements of heavy steaming and freight service on mountain railroads, and that under such circumstances the third one of a series of three 3-inch valves has never been known to blow; while records made of locomotives under special observation on this point prove that on many locomotives not more than one of the 3-inch valves has been known to blow and the pressure has never increased sufficiently to reach the second one set at 2 pounds or 4 pounds above the first. The effective discharge area of a 3-inch flat-seated valve with a lift of 0.075 inch is a little more than 0.8 of a square inch, actually discharging 2.5 pounds of steam per second, so that the combined capacity of the three 3-inch valves would be 7.5 pounds of steam per second. This confirms my opinion that Mr. Whyte is correct in saying that safety valves need not have a discharge capacity equal to the steam-generating capacity of the locomotive boiler under forced draft. I believe that experience has been sufficient to demonstrate that a total valve capacity theoretically equal to 2 square inches of discharge area for ordinary locomotives, and 3 square inches for the largest ones, has been safe and efficient, and has never been called upon for more than two-thirds of even this provision. To provide greater capacity than required means either a multiplication of valves unnecessarily or a provision of larger valve capacity in each unit, not only needlessly, but recklessly regardless of other conditions of certainty of operation and freedom from repairs in the more vital daily operation of a locomotive. What purpose will it serve for a designer to point with pride to a locomotive and boast that its valve capacity is a certain large and heretofore unrequired amount, if those valves are of short life, cause dangerous strains and costly deterioration in the boiler and constantly leak so that ordinary working pressure cannot be maintained in the daily runs? The last state into which we are led by theoretical discussion may easily be much worse than anything that conceivably could happen to us, but has never yet happened, when empirical rules of the past have been sensibly and reasonably applied.

Our own honored past president, F. R. Hutton, wrote not long ago upon the subject of steam boilers: "There are supposed to be, in some circumstances, sudden evolutions of steam in such quantities that no relief is possible through safety valves. In regard to such cases it can easily be shown that by reason of the high specific heat of water, as compared with iron, it is very difficult for any large quantity of steam to be made even from overheated plates, so that disasters perhaps rightly attributed to low water are the result not of excessive internal pressure but of strain from contraction when such overheated plates are suddenly cooled by contact with water."

I believe that the most sensible solution of this whole question will be found in equipping a locomotive with three valves each of 3-inch or 3.5-inch diameter size, as may be indicated in proportion to the capacity of the boiler. The first one of such valves would be a muffled valve set at 200 pounds, to permit only 2 pounds drop in steam pressure when it opens, to be a working valve to take care of all ordinary running conditions, leaving the locomotive with proper pressure to continue its work after the blowing of the valve. The second would be a reserve valve of the same type, set at 202 pounds or 204 pounds, to take care of unusual conditions under which the steam pressure might possibly continue to rise in spite of the first valve, and set to permit a drop of 5 pounds or 6 pounds and yet not let the pressure go much below the normal 200 pounds. The third valve of the series would be an emergency valve, of the same general type as the others, but of different proportion of disk and an extremely resilient spring, with an adjustment set to insure an exaggerated lift and large discharge, which should cause the boiler pressure to drop 15 pounds or 20 pounds, thus practically putting the locomotive out of service temporarily until this drop in pressure could be regained; and this would be its true function, for the blowing of such a valve on rare occasions would indicate an extreme condition which would need immediate remedying and would compel attention not only from the engineer and fireman, but from the conductor of the train as well. Such a valve would not be practical as an economical or satisfactory working valve for the ordinary purposes in running a locomotive such as is desirable in the first and second valves of the series recommended, to be true safety valves of economical range, designed simply to limit the working pressure to 200 pounds and to blow and relieve the boilers under ordinary conditions, but not to stall the train, and not intended as the only or ultimate protection against boiler explosion, which function the third valve would undertake. To distinguish these valves in service, some sort of difference in design or marking might be established by the manufacturer; or the working valves might be muffled and the emergency valves be of the ordinary open type or fitted with a lever.

Large discharge capacity and high lift are not necessarily synonymous, but a valve of small capacity can have its discharge increased by making the disk lift higher. Any manufacturer can make any disk lift higher, and every manufacturer can make a valve of high lift if desired, for there is no secret or invention involved; but this is not the same as saying that every manufacturer can and will supply what may be possible in this direction. Some manufacturers have been through the experience of experimenting with freak valves, going to extremes in size dimensions and lift, and have discovered the rational objections to their use; and if called upon to furnish valves of such specifications would advise customers why their use could not be recommended. It is conceivable that some manufacturers might, for their own reputation, refuse to put out under their trade mark or guarantee valves to meet peculiar specifications which they could not approve and which they knew would cause dissatisfaction to the user and damage to the maker.

The ordinary practice in making valves for locomotives has been to design and regulate the valves so that they would cause the steam pressure to drop 5 pounds before closing, and the regulating ring or device would be set at the time of testing to accomplish this. The greatest difficulty valve makers meet today is not in the simple problem of mechanical design to build safety valves with large discharges or lifts, but in educating and persuading operating engineers actually to utilize the valves to their intended normal capacity instead of resetting the regulating adjustment so as to throttle the valve beyond reasonable limits, to prevent what they regard as waste of steam when the valve does open in performance of its proper function. It is not reasonable to expect a valve designed and regulated to lose 5 pounds in boiler pressure to perform equally well when the regulating device is readjusted so that the pressure is allowed to drop only 1 or 2 pounds, as is the actual condition on many railroads today. Engineers should not complain of lack of valve capacity as much as of their own blindness in throttling the valves they already have. That locomotive valves designed for 5 pounds loss do actually work so well and give such satisfaction without chattering or singing, when regulated to lose only 1 or 2 pounds pressure, without change of spring or dimensions, is remarkable. But locomotive valves would operate much more satisfactorily and give much more effective relief in volume with only 2 pounds drop of steam pressure if they were originally designed and regulated to accomplish this, instead of the 5 pounds drop nominally specified and desired; and therefore the proposed emergency valve, to lose 15 pounds or 20 pounds with extremely large volume of discharge, should have proportions of valve disk and springs different from the closely regulated working valves intended to lose only 2 pounds. Anything of this sort can be provided by any manufacturer who understands the principles of design, but complaint should not be made because the manufacturer has designed a thing which serves its purpose admirably when properly used according to instructions, but may develop unsatisfactory actions when working conditions are deliberately and unreasonably altered.

However, the number and diameter sizes of safety valves have always been specified by the locomotive builders without consulting the valve makers in any way; and their practice has become arbitrary, confident that they were well within safe limits. The locomotive builders also limit the over-all hight and diameter of the valves, so that valve makers have had little choice or responsibility in the whole matter. Apparently the safety valve has always been regarded as a minor detail of the equipment, whether for the boiler plant or locomotive, and hardly worth much consideration; they must go on as an afterthought, wherever they can be crowded in, in the limited space in the steam dome of the locomotive as already laid out, and to clear all overhead obstructions, or in the cramped room that may be left by chance above stationary boilers when set in place.

If a valve of given size does not discharge sufficient steam, in the judgment of engineers, to relieve the boiler of a certain design and rating, a larger valve should be applied, or two or more valves should be used instead of one. But if low initial cost is to be attained by using only one valve or valves of proportions which involve much attention or regrinding or renewal to keep them in proper serviceable condition, or require the boilers to be shut down for frequent attention, the advantages of low first cost are more than counterbalanced and the valves become a source of danger and annoyance instead of a feature of security and protection.

The term "simmering" valve might more accurately convey to some the idea of one which opens at a variable pressure, sometimes a little higher or lower, and is not held positively to its seat, so that it may allow a constant small leak or wisp of steam to escape. Such valves are an unalloyed nuisance and disappointment: the steam clouds the vision ahead, the constant small leak robs the steam pressure at critical times and cuts the seat, no matter of what material, and the slow condensation deposits lime salts from bad water over the threads and inner parts of the valve so that the testing and adjustment make the repairman's life a burden. A slight "warning" like the blowing of a moderate [illegible] of sound than of louder noise, is a desirable feature and will generally be noticed in valves properly set; except where the adjustment has been changed to reduce the pressure drop and make the valve lose too little. The throttling of the adjustment is therefore generally the cause of howling or singing sometimes complained of, and can be instantly cured by putting the adjustment back to allow the 4 or 5 pounds drop in boiler pressure intended by the valve maker; the same cure could be effected by making the valve with slightly different disk proportions, if this close adjustment had been thought proper or specified.

The inlet or throat diameter of all valves is many times greater than the effective discharge area, so that point is not important to discuss. The valves should in all cases be connected directly to the boiler, without intervening bends or piping; otherwise, relief of the boiler is not immediate and uniform, but an irregular destructive hammer to the boiler will result. The essential characteristics of any proper muffling device is to afford ample volume for the increasing expansion of the escaping steam, with rapidly enlarging outlet passages, thus effectually muffling the noise without any appreciable back pressure, such as would be caused by series of baffle plates or deflectors.

Dry Niagara

By James L. [illegible]

The third week of February brought a most unusual experience to the power interests at Niagara Falls, while the scenic interests gained from the customary [illegible]

[illegible]

ness prevailed, but careful comparison of photographs taken in 1903, 1905 and this year indicates that there was little difference in the conditions of the American channel in 1903 and 1909. This year the ice was heavier; there was seemingly more of it. Snowfalls assisted to cover up the rocky bed of the stream, leaving more of a plain-like whiteness, bleak in its appearance and impressions.

Crossings were made from Prospect park to Luna island a short distance back from the brink of the American fall, and others crossed the channel above Goat-island bridge. Still other bold adventurers made their way from the head of Goat island over the ice to Port Day, where the Niagara Falls Hydraulic Power and Manufacturing Company receives its water supply. These were most unusual trips, and their possibility should indicate the remarkable conditions that existed in the Niagara river in front of the intakes of all the power companies on both sides of the river, for the effects were felt by all.

Under normal conditions the inlet canal of the Niagara Falls Power Company carried 12 feet of water, but during the "low period" this was reduced from 4½ to 5 feet, it is understood. The full load of current was not kept up, and some of the plants on the power company's land were shut down for a brief period. The water in the surface canal of the Niagara Falls Hydraulic Power and Manufacturing Company was lowered about 8 feet in the forebay. This result made clear the advisability of placing the mouthpiece of penstocks well down toward the bottom if they are not to draw air at such times. The new forebay over station No. 3 was designed by Chief Engineer John L. Harper with this possibility in view, and its penstocks were well supplied with water. The Cliff paper mill and the Pettibone paper mill, both on the canal basin, had a day or two of idleness.

All of the power companies on the Canadian side experienced more or less difficulty, and yet it is reported that one day during the second week in February the water on that side was lower than during the period of greatest trouble on the New York side. After the American channel was closed as an outlet for the water of the upper river, the flow of the stream was diverted to the Canadian channel, but this did not give the Canadian companies all the water wanted. Dynamite was used on both sides, and after the river started to resume business route channels were opened to assure a full flow of water.

During the night of Tuesday, February 16, the wind changed and early on Wednesday morning it was evident that Lake Erie had resumed its effort to provide a suitable overflow to redeem the reputation of the Niagara cataracts. Throughout Wednesday, Thursday and Friday the recuperative effort continued, but normal conditions had not been attained as the week closed.

The severity of the experience has been very instructive to engineers, and it may be of benefit to the Niagara as well as other power installations. Above all, however, credit must be given for the manner in which the great power companies met the conditions that practically settled down on them in a night. It will be recognized as a stupendous task to continue the development of power in such quantities as at Niagara, when so much of the available water as that represented by the normal flow of the American channel is diverted to other routes.

"DRY NIAGARA," IN FEBRUARY, 1909

For busbars and back connections in switchboards, aluminum is frequently advantageous, the saving in weight allowing of lighter supports and framework. For the front of switchboards aluminum is also suitable for bolts, lampholders, instrument cases, etc. There are several methods of jointing aluminum conductors. For small-diameter wires, as used for making into cable, the usual butt-welded joint is made either in the flame of a blowlamp or by means of the electric welders as used for copper. For bare stranded cables the two ends are welded together by pouring molten aluminum into a cigar-shaped mold previously clamped round the joint, but where high tensile strength is required a mechanical joint may be used, so designed as to give a wedging action when pulling tight in order to insure good electrical contact.

Some Useful Lessons of Limewater

What Would Happen if Nitrogen Were Removed from the Air; How to Prepare Pure Oxygen; Things to Remember; Making Iron Wire Burn

BY CHARLES S. PALMER

We have seen that there are two principal things in the air, as far as burning is concerned. One, oxygen, which helps ordinary burning—and which makes up about one fifth by volume of the air—and the other, nitrogen, which does not help common burning, although it makes up nearly all of the other four fifths of the air and, as far as combustion is concerned, is only "so many chips in the porridge."

The two-sided question has been proposed: What would happen if the nitrogen were to be taken out of the air, leaving only the oxygen, or what would happen if the nitrogen were to be taken out of the air and its place supplied by oxygen? In the first case, where the nitrogen is simply taken out, there would be no difference, as far as common burning is concerned, but there would be a great difference in the atmospheric pressure. One would see burning go on about the same as it does at present, because although the air pressure would be only about one-fifth of what it is now, all of that pressure would be in terms of oxygen, which would then make it practically all of the air, so that a flame would get the same quantity of oxygen that it does now. But a man would be under much less air pressure than he is now and would be, physically, in the same condition that he would experience if he were to ascend many thousands of feet above the sea level. He would suffer from bleeding at the nose, at the same time that his lungs would be taking in the same quantity of oxygen as at present. There would be no difference, practically, in the oxygen, but the loss of the four-fifths pressure now supplied by the nitrogen would make a great physical difference.

You want to think this all over, and you will see that each gas exerts its own pressure independently of any other gas; and if the nitrogen were taken away without any other gas taking its place, the difference would be simply a difference of pressure of the air as a whole, and so that air would practically be made up of oxygen, the supporting of burning by the only thing in the air that helps burning, oxygen, would be changed very little if at all. We cannot easily construct such conditions, because it would require a set of large and powerful apparatus to sustain the greatly diminished air pressure; but we can easily imitate the conditions of the other side of the question, namely, the case where the nitrogen is removed and its place taken by oxygen; and you will find that you will have an air which is practically made up of oxygen at the same total pressure as that supplied by both the oxygen and the nitrogen which make up common air. This experiment we will proceed to prepare, by making a few jars of practically pure oxygen, and as we will collect it in a jar which is closed under the pressure balance of the air acting on water, we will have the conditions of the second part of the question.

FIG. 1

FIG. 2

The Preliminary Work

As we get ready for this experiment, we will study some of the new conditions of your wash-dish pneumatic trough. You will take your fruit jar and fill it with water; also have the wash dish about half full of water, as shown in Fig. 1. Take a piece of common cardboard about 4 inches square and, holding it over the mouth of the jar, slide it on so that no bubbles of air get below the cardboard into the jar. It will take one or two attempts to do this, but you will soon learn the trick. One good way is to have water over the full jar as you are sliding the cardboard cover over the mouth of the jar. As soon as you have secured this "seal," hold the cover tightly on the mouth of the jar, and with the other hand grasping the jar at the side or end turn it upside down—all the time holding the cardboard cover on tightly so that no air bubbles can get into the jar—and place the jar, mouth downward, in the wash dish, as shown in Fig. 2. This will take several trials, but you will soon learn to do it successfully. What is wanted is to fill the jar with water, cover it with the pasteboard and invert it in the wash dish, mouth downward, without letting any bubbles of air get into the inverted jar. Of course, if one or two little bubbles of air get in the jar while turning it, it will make no serious difference; but do not let more than a little air get into the jar, because you are going to fill this jar with oxygen, and if there is very much air left in the jar it will dilute the oxygen just so much.

Just to practice "displacing" the water in the jar by a gas, take a tube of glass or rubber and blow through it, placing the farther end of the tube in the water in the wash dish and under the mouth of the jar. You will note that as the air from your lungs rises into the jar, which is at first full of water, the jar catches the air blown in and at the same time releases the same volume of water, and now you will begin to respect this old but ingenious device of the pneumatic trough. You will see the elegance and simplicity of this scheme for isolating a separate part of any desired gas by the simple trick of leading a gas below the mouth of a full and inverted jar.

In the case of the water pneumatic trough, of course, there is some absorption of the gas in question by the water, and that itself will suggest to you that it would be a refinement and an improvement if we could get some liquid like mercury which absorbs gases very little. It is too expensive to use such expensive and [illegible] liquids as mercury for some simple experiments such as we are trying in our homemade water home-made apparatus, although it is a satisfaction to know that there are other and more exact methods and to know what they are. But we will stick to water, and we will find that it will give us results [illegible] to be desired.

So now we will blow bubbles of air from the lungs into the full and inverted jar until the jar is full of air and some of the bubbles "underflow" from the mouth of the jar, which is kept locked by the water seal, from the air outside. In this way you will soon get hold of some of the possibilities of this pneumatic trough in its power to receive, to hold and to isolate or separate a quantity of any desired gas, as the air from the lungs or the oxygen which you will now get ready to make. Be sure to try this filling and inverting of the full jar in the wash dish, and the blowing of air into it, until you become perfectly familiar with the principles and purposes of this simple but useful apparatus; for we shall find that much of the foundation of chemistry has to do with gases, and it is a trick not to be despised to know how to take a portion of a slippery thing like air, or any gas, and handle it as though it were a solid which can be taken hold of and locked up temporarily. But this pneumatic trough is only the receptacle or storehouse of the gas, pure oxygen, which we want to get; and the next thing to attempt is the planning of a simple piece of apparatus for preparing some of this oxygen.

Preparing the Oxygen

The first thing to do now is to take one of the 4-ounce flasks which came with your outfit and fit it with a perforated cork, with a glass-tube outlet, or leader, a rubber conducting tube and a glass delivery tube, as shown in Fig. 3. Get a good cork which fits the flask snugly, roll it under your foot on a clean floor until the cork is soft and springy, and try it again in the neck of the 4-ounce flask. Next, bore a hole through the cork, lengthwise, a little smaller than the glass tube which came with your outfit. You can cut this hole in the cork with the small blade of your jackknife, which leaves the hole rough; then carefully trim out the hole with the round or "rat-tail" file. With a little care you can trim this hole through the cork so that it will exactly take in the glass tube, the edges of which should be rounded in a hot flame, or it may be filed off. Be sure and do this, for if you do not get a smooth and tight fit for the glass tube through the cork your apparatus will leak, and you won't think that chemistry is worth your while, a disappointment which can be avoided by exercising a little care.

The piece of glass tubing, or leader, which passes through the cork must reach only just through the cork, extending not very far into the inside of the body of the flask, and this tube should be bent at right angles, with the two arms each 2 or 3 inches long from the bend. In case you have to bend the glass tube yourself, don't try to bend it in a round gas flame, but in a wide, *flat* gas flame, as shown in Fig. 4; then the tube will bend with a good even curve, without buckling. The old-fashioned "fish-tail" burner will be just the thing for your purpose. Also, as you heat the glass tubing preparatory to bending, turn the tube around in the flame, giving it time to get well heated before trying to bend it. As soon as it is hot enough, a gentle pressure will bend it at the heated portion so that you can easily get the two arms turned at right angles to each other as shown in the cut. Before cooling, let the heated part become covered with soot in the flame, to anneal it by slow cooling. The tube can be cleaned when cool.

The delivery tube also has to be bent, not at right angles, but at an angle of about 120 degrees ("finger bend"), as shown in Fig. 3. The short arm needs to be only some 2 or 3 inches long, leaving most of the tube as a "poking" tube, to be thrust down into the water. You will, of course, connect the leader tube and the delivery tube with a bit of rubber tubing.

You have just tried the trick of filling the inverted jar in the pneumatic trough with air from the lungs, and before you make oxygen drive some air from the flask over into the jar, by heating the dry, clean, empty flask over the flame of an alcohol or gas lamp. As you heat the empty flask, considerable air will pass through the leader tube, the rubber connector and the delivery tube, down under the water and up into the jar in the pneumatic trough; and in this way you can see how the oxygen, which you will soon make in the flask, will pass over to the water-filled jar in the pneumatic trough. But you cannot get very much air over in this way, only enough to show that heated air expands, and that this air can be put into the jar in the pneumatic trough by displacing the water from the water-filled jar; for just the same volume of water will escape from the jar for each bubble of air driven over from the dry and heated flask.

Some Things to Remember

Remember this: *You must always remove the delivery tube from the water before you take the heat away from the flask, or before you take the flask away from the lamp.* The reason is that the closed and heated flask is really a very sensitive air thermometer, and as soon as the heated air in the inside of the dry flask has been cooled the water in the trough will rush up back through the delivery tube into the hot flask and crack and break it. Remember, then, not to allow any water to be sucked back into your dry flask, by cooling it, unless you have first taken the delivery tube out of the water before you cool off the dry and partly empty flask.

All this will set you to thinking about some of the laws of heat which you know perfectly well, but which you may never have had put up to you before in just this way. You will see that heat expands all substances, and gases more than liquids or solids. If you get a considerable expansion of the air in the oxygen-making flask when it is empty, naturally you will get this same expansion when the flask contains some of the "oxygen mixture" which you will put into it in this lesson or the next. You can see that all this preliminary explanation is to show you how to throw away the first air that will come over, before the real oxygen comes; for the air is much more sensitive to heat than is the "oxygen mixture," and you do not need to save

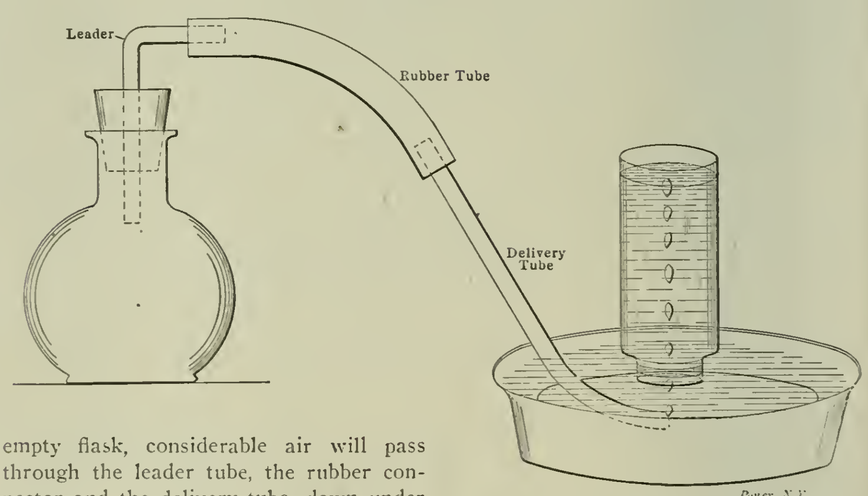


FIG. 3

the first bubbles which come over when you make oxygen, because that is only common air from expansion and will only dilute your oxygen just so much.

Now, if you will look over the outfit which you procured, as recommended in the first lesson, you will note the potassium chlorate and the black oxide of manganese. The white salt, potassium chlorate, is the stuff which is going to give you pure oxygen; and yet it is best to mix it with some of the black oxide of manganese, because if you heat the white potassium chlorate alone the oxygen will come off rather too rapidly for perfect safety; while if mixed with some of the black oxide of manganese, the oxygen will come off quickly enough, and much more evenly and quietly. The reason for all this is not entirely understood, and the explanation therefor would take us too far away from the point; but the fact is that a mixture of one part of black oxide of manganese with three or four parts of potassium chlorate will give up oxygen in a clean and satisfactory manner. By the way, the black oxide of manganese will itself give off some oxygen, if heated to a red heat, but you will not get that probably in this experiment, and as that side of it does not immediately concern us, because you will not heat your flask nearly as hot as to a bright red heat.

There is another matter to which you want to give a moment's attention, and that is the advisability of testing the mixture of the potassium chlorate and black oxide of manganese—with all due apologies to the excellent and reliable agents from whom you may have bought your supplies. The point is this: There are many black things in the world, and even if there is no desire to adulterate your goods, "accidents will happen in the best of families." So just take a "knifepointful" or two of the white potassium chlorate and another knifepointful of the black oxide of manganese, both well powdered and well mixed, and heat them hot in a common iron spoon, watching carefully to see what happens. If there

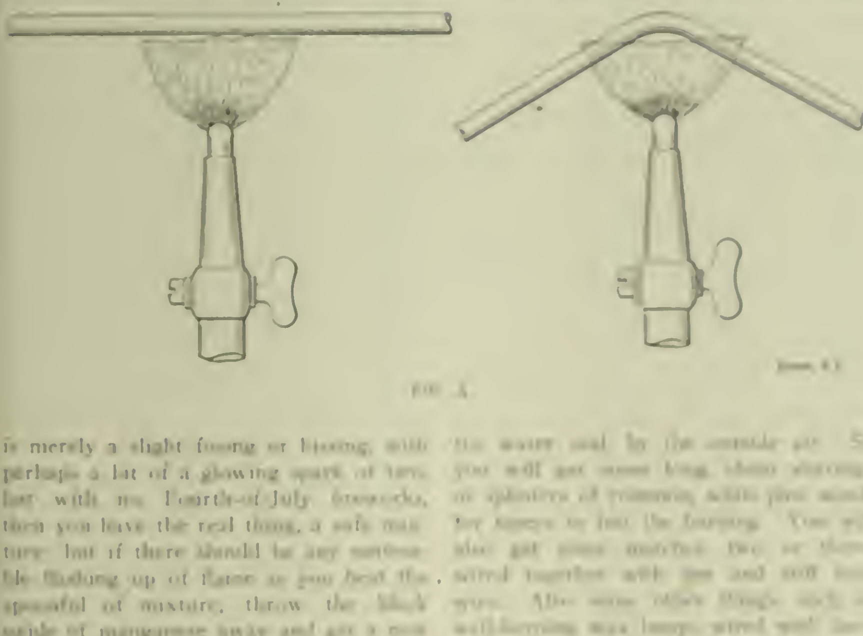


FIG. 3.

is merely a slight fusing or hissing, with perhaps a bit of a glowing spark or two, but with no Fourth-of-July fireworks, then you have the real thing, a safe mixture; but if there should be any noticeable flashing up of flame as you heat the spoonful of mixture, throw the black oxide of manganese away and get a new supply—your dealer will cheerfully make good; although there is not one chance in a thousand that you will find anything wrong with the black oxide. The reason for all this caution is that such things as carbon, soot, coal dust and the like are common, and once or twice I have found that no time was wasted in taking pains to be sure that one has a safe mixture.

Before you put the mixture in the flask, be sure that the flask is clean and dry. Wash it out with good soapsuds, with a few bits of scrubbing paper, as described in the first lesson. Then rinse it out well, waving it violently in a wide swing, mouth away from you, to throw the few clinging drops out by "centrifugal force." Then set the nearly dry bottle up in some safe and warm place, and when the flask is dry and hot, if you put the glass tube into the flask and suck the air out three or four times, you can be sure that your flask is clean and dry, but you will soon learn to taste the characteristic "dry test" of the last air sucked through the well-cleaned flask. All this trouble is worth while, because you will soon learn that it is just as easy to make things go right the first time as later; and it pays in experimenting to take pains.

MAKING THIS WORK BURN IN OXYGEN

Another matter: You are going to make some pure oxygen, and it will illustrate what would happen if the nitrogen of the air were removed and its place were taken by oxygen. You can see that if one-fifth of the air, at 30 inches pressure of the barometer, helps common burning, this new kind of air, which is also at 30 inches pressure of the barometer, will do something in the way of burning which will be worth watching; and you know that the oxygen to be collected in the jar is at 30 inches of barometric pressure (instead of one-fifth of this) because it is balanced through the water seal by the outside air. So you will get some long, clean shavings or splinters of common white pine wood, for tapers to test the burning. You will also get some matches. Two or three, wired together with fine and stiff iron wire. Also some other things, such as well-burning wax tapers, wired with [illegible] 8 or 10 inches long. Also [illegible] [illegible] of piano wire [illegible] [illegible] and prepare it as follows: Heat the end red hot for a moment, and plunge it into some powdered sulphur, or flowers of sulphur. Then, when the [illegible] a little [illegible]. You see, you are going to light [illegible] that will light the sulphur [illegible] will light the fine wire [illegible] the match [illegible] and the fine steel [illegible] will burn in the oxygen so well [illegible] you will be surprised to see how [illegible] [illegible] will burn [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible] But it will be a good thing to try [illegible] and don't be disappointed if it doesn't work so long.

Remember what we said about [illegible] and that Mother Nature is [illegible] [illegible] the same [illegible] [illegible] [illegible]. If you can think of any other things that will burn, [illegible] [illegible] [illegible] [illegible] or two of the oxygen; but if you do this carefully, you will get results that you will remember as long as you live, results that will put new ideas into your head and new dollars into your pocket.

There is one other thing to do, and that is to read all this [illegible] right over again and again, until you see just what you want to do and how you are going to do it. In this really good experiment of making oxygen, an experiment that will put you in shape to begin reading the marvelous history of chemistry. As you learn the names of Scheele (pronounced "Shaile"), Priestley and Lavoisier (pronounced "Lav-wah-see-ay"), you will find that you have jumped right up and [illegible] that good sense under your hat into some of the [illegible] that ever [illegible] scientific discovery. You will [illegible] that you are doing all this as the [illegible] of [illegible] [illegible], right down in your boiler room.

Catechism of Electricity

[illegible]

(57). [illegible]?

[illegible]

(58). [illegible]?

[illegible]

[illegible]

[illegible]

very noticeable vibrations, where is the trouble likely to be?

If the vibrations are generally distributed over the entire machine and increase in intensity with the speed of the armature, the noise is likely to be caused by a poorly balanced pulley or armature.

976. *How should a pulley or armature be tested and remedied for an unbalanced condition?*

Remove the pulley and armature from the machine and test them separately. The armature can best be tested by placing it so that its shaft is supported at the ends upon two knife edges *a* and *c*, Fig. 284, placed flat and parallel to each other. Then, if the armature is poorly balanced, the heavy side will cause rotation except when this side happens to be downward. By setting the armature at rest on the knife edges with different points around its periphery placed upward the weighty side may be easily ascertained. The trouble may be remedied either by firmly fastening some lead on the lighter side, or by filing or boring holes in the heavy side.

A shaft should then be provided temporarily for the pulley in order that it, too, may be tested; if necessary, it may be balanced in the same manner as described for the armature.

977. *State how noise produced by the pulley, belt or shaft collar striking against the bearings of the machine can be easily detected.*

By pushing the shaft or belt away from the one or other of the bearings while the motor is running and noting if the noise ceases.

978. *How may noise produced as mentioned in 977 be stopped?*

The trouble may usually be overcome by changing slightly the direction of travel of the belt. However, if this change does not improve matters, shifting the pulley on the shaft or turning off the shoulder of the bearing, as the case may be, will probably effect the desired result.

979. *What kind of noise is made by the pounding of the jointed portion of a belt against the pulley?*

The loud thump which occurs but once during each revolution of the armature.

980. *Does not the armature when striking against the pole faces make a similar noise?*

Yes, but it is less of a thump and more of a scraping character.

981. *How should a trouble of the nature mentioned in 980 be investigated?*

Usually, an examination of the armature surface will determine if it has been striking the pole faces. Great care should be taken to make this examination thorough, for the danger of damage to the armature when it comes in contact with the pole faces is very great. Another, and perhaps a better, test consists in removing the belt or power connection from the armature shaft, and while slowly turning the armature by hand, observing whether or not it sticks at any point.

982. *How should a trouble of the nature mentioned in 980 be remedied?*

If the trouble is caused by one side of the armature winding projecting abnormally, it may be remedied by binding down the bulging part with a wrapping of iron wire which should extend around the armature body but be well insulated from it at all points. If the armature is out of center, it may be possible to adjust the bearings so there is a uniform clearance between the armature surface and each of the pole faces. Sometimes the trouble lies in one or more of the pole faces projecting abnormally; in this case it will be necessary to file out the projecting portions.

983. *What is indicated by a hissing sound produced at the brushes?*

Either a dry or sticky commutator, or rough contact surfaces on the carbon brushes. By listening near the commutator, it is easy to ascertain if there is trouble from these sources or if the defect lies in the brushes instead of the commutator.

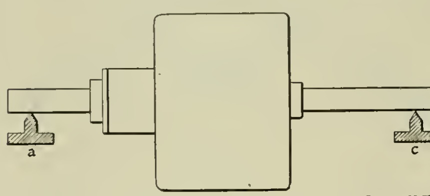


FIG. 284. METHOD OF TESTING AN ARMATURE FOR AN UNBALANCED CONDITION

984. *If the brushes are making the noise, how may the noisy ones be detected?*

By raising one brush at a time while the machine is in operation, and noting if the noise ceases. This test, however, can be applied only to motors having more than one brush on a stud, as otherwise the motor circuit would be opened by the raising of a brush and an arc would be formed that might endanger the experimenter and burn the commutator.

985. *How can brushes usually be made to operate noiselessly?*

Sandpapering their contact surfaces or applying oil to them at this part will generally reduce the noise. Sometimes it is merely necessary to raise or lower the noisy brush a trifle in its brush holder to stop the hissing sound.

986. *How should a noisy commutator be silenced?*

Recourse may be had to filing or sandpapering if the commutator is rough, or to the application of a minute amount of oil or vaseline if it is dry. In the case of a new machine having a noisy commutator, it is advisable to run it awhile unloaded until both the brushes and the commutator become adjusted to each other and smooth.

Estimating the Horsepower of a Gas Engine

By Cecil P. Poole

Knowing the kind of gas to be used, the bore and stroke of the engine and the number of revolutions per minute, it is a simple matter to estimate the probable horsepower at maximum load by assuming a mean effective pressure appropriate to the gas quality and applying the old steam-engine formula, $P\ L\ A\ N \div 33{,}000$. But a less tedious method is to base the estimate on the piston displacement, the quality of the mixture and an assumed heat economy for the engine. This latter assumption is not likely to be as far wrong as the assumption of mean effective pressure in the first method. Natural-gas engines will readily yield a brake horsepower on 10,700 B.t.u., producer-gas engines on 11,500 B.t.u. and illuminating-gas engines on 12,000 B.t.u. per hour. Natural-gas mixtures will average about 50 B.t.u. per cubic foot at the temperature existing when the inlet valve closes; producer-gas mixtures will average about 46 B.t.u., and illuminating-gas mixtures about 60 B.t.u. per cubic foot. Since $178\frac{1}{3}$ B.t.u. per minute ($10{,}700$ per hour $\div$ 60) will yield one brake horsepower with natural gas and each cubic foot of mixture contains 50 B.t.u., a natural-gas engine should yield $50 \div 178\frac{1}{3} = 0.28$ brake horsepower per cubic foot of effective piston displacement per minute (by "effective" displacement is meant the displacement during power strokes only). Similar reasoning will produce the numbers 0.24 for producer gas and 0.3 for illuminating gas.

The effective displacement per minute by a single-acting piston is equal to the displacement per stroke multiplied by one-half the number of revolutions per minute, working on the four-stroke cycle. For a double-acting engine the effective displacement per minute in each cylinder is equal to the displacement per stroke $\times$ revolutions per minute. These statements apply to hit-and-miss engines as well as the throttling type because at maximum load the governor does not cut out any explosions.

Computing piston displacement in cubic feet, however, is tedious, and as the displacement is proportional to the stroke multiplied by the square of the diameter in inches, it is simpler to change the constants 0.28, 0.24 and 0.3 to others which will cover the translation of piston displacement in cubic feet per minute to $d^2 \times s \times r.p.m.$ This gives the constants in Table 1. The proper constant multiplied by the square of the piston diameter, the stroke (both in inches) and the number of revolutions per minute will give a fair estimate of the maximum probable brake horsepower per cylinder.

TABLE 1

Kind of Gas.	Single-Acting	Double-Acting.
Natural	0.000065	0.00013
Producer.........	0.000056	0.000112
Illuminating.....	0.000070	0.00014

In double-acting engines the piston and tail rods considerably reduce the exposed piston area. The space neutralized by the rods ranges from 6 per cent. of the gross piston area in relatively small engines to about 10 per cent. in large engines. The accompanying Table 2 gives values of the product of the constants in Table 1 and the square of the piston diameter for single-acting engines of 5 to 30 inches bore. For double-acting engines the product has been modified by an allowance of 6 per cent. for the piston rods in all sizes. The higher efficiency of larger sizes tends to compensate for the deficiency in piston-rod allowance. This may seem to be a highly academic refinement of a method designed to give only approximate results, but it gives a nearer approach to accuracy than would be obtained if the piston-rod space were ignored, and is therefore considered justifiable. If the reader prefers to disregard it, the constants for single-acting engines, multiplied by 2, will serve for double-acting engines, of course.

EXAMPLES

1—A natural-gas engine having three single-acting cylinders each 25 inches bore and 30 inches stroke developed on test 530 brake horsepower at 150 revolutions per minute. The estimated power would be

0.0406 × 30 × 150 × 3 = 548

brake horsepower, or a trifle under the actual power.

2—A natural gas engine with three single-acting cylinders 13½×16 inches developed 130 brake horsepower at 225 revolutions per minute. The estimated power would be

0.0118 × 16 × 225 × 3 = 127.4

brake horsepower. This engine was rated at 125 horsepower, but tested to 130.

3—A two-cylinder double-acting (tandem) natural-gas engine with cylinders [illegible] inches, rated at [illegible] brake horsepower at 200 revolutions per minute, had to be driven at [illegible] revolutions to obtain the rated output. The estimated power at 200 revolutions per minute would be

[illegible] × [illegible] × 200 × 2 = [illegible]

horsepower; at [illegible] revolutions per minute [illegible] would figure out [illegible] horsepower.

4—A tandem single-acting producer-gas engine, [illegible] inches, developed [illegible] brake horsepower at [illegible] revolutions per minute, [illegible] rated at [illegible] horsepower [illegible] revolutions per minute. The estimated brake horsepower would be

0.0[illegible] × [illegible] × [illegible] × 2 = 315.

5—A twin tandem producer-gas engine with cylinders [illegible] inches is rated at [illegible] brake horsepower (maximum) at [illegible] revolutions per minute. The estimated output would be

0.0[illegible] × [illegible] × [illegible] × 2 = [illegible]

brake horsepower.

6—A single-cylinder single-acting illuminating-gas engine of [illegible] inches bore and [illegible] inches stroke gave [illegible] brake horsepower at [illegible] revolutions per minute. The estimated output is

[illegible] × [illegible] × 0.00[illegible] = [illegible]

brake horsepower.

7—A similar engine of [illegible] inches bore and [illegible] inches stroke gave [illegible] brake horsepower at [illegible] revolutions per minute. The estimated output would be

0.00[illegible] × [illegible] × [illegible] = [illegible]

brake horsepower. This engine was rated at [illegible] revolutions per minute, but developed full power at [illegible] revolutions because of unusually rich gas ([illegible] B.t.u. at [illegible] degrees Fahrenheit). At the rated speed the estimated output would be [illegible] brake horsepower.

Those familiar with the principles of gas-engine operation will recognize that the close agreement between some of the test results here cited and the results estimated are due to the fact that in those cases the engines used happened to be working under a combination of thermal conditions which gave constants very near to those on which the method is based. Thus, the engine cited in example No. 1 actually used over 11,000 B.t.u. per brake horsepower-hour, but the mixture was enough richer than the assumed value of [illegible] B.t.u. per cubic foot to produce almost exactly the constant [illegible] of Table 1. Again, the engine in example No. 2 is rated at [illegible] B.t.u. per brake horsepower-hour, but its piston rods cover about [illegible] per cent. of the piston area and the heat value of the mixture required to give the rated output at the rated speed [illegible] [illegible] B.t.u. The close agreement between the tested and the estimated output was purely accidental and will not [illegible] when the ratio [illegible] the [illegible] of the [illegible]. It is not to be expected that the method will give close results in all cases, but it serves well in determining the "order of magnitude" of probable output, [illegible] in the terms of the particular [illegible], whether high [illegible] or low [illegible] be the [illegible].

TABLE 2 APPROXIMATE HORSEPOWER CONSTANTS

Constant × Stroke × Rev. per Min. = Probable Brake Horsepower per Cylinder.

SINGLE-ACTING ENGINES.				DOUBLE-ACTING ENGINES.			
Cylin Diam.	Natural Gas.	Producer Gas.	Illum'g Gas.	Cylin. Diam.	Natural Gas.	Producer Gas.	Illum'g Gas.
5	0 00162	0 00140	0 00175	10	0 0122	0 0105	0 0132
5¼	0 00179	0 00154	0 00193	10½	0 0135	0 0116	0 0145
5½	0 00197	0 00169	0 00212	11	0 0148	0 0128	0 0160
5¾	0 00215	0 00185	0 00232	11½	0 0161	0 0139	0 0173
6	0 00234	0 00202	0 00252	12	0 0175	0 0151	0 0189
6¼	0 00254	0 00219	0 00274	12½	0 0191	0 0164	0 0206
6½	0 00275	0 00237	0 00296	13	0 0207	0 0178	0 0222
6¾	0 00297	0 00255	0 00319	13½	0 0222	0 0191	0 0239
7	0 00319	0 00274	0 00343	14	0 0239	0 0206	0 0258
7¼	0 00342	0 00294	0 00368	14½	0 0257	0 0222	0 0277
7½	0 00366	0 00315	0 00394	15	0 0274	0 0236	0 0296
7¾	0 00390	0 00336	0 00421	16	0 0313	0 0270	0 0335
8	0 00416	0 00358	0 00448	17	0 0354	0 0305	0 0381
8¼	0 00443	0 00381	0 00476	18	0 0395	0 0340	0 0426
8½	0 00470	0 00405	0 00506	19	0 0441	0 0380	0 0474
8¾	0 00498	0 00429	0 00536	20	0 0489	0 0421	0 0526
9	0 00526	0 00454	0 00567	21	0 0538	0 0464	0 0578
9½	0 00587	0 00505	0 00632	22	0 0587	0 0518	0 0637
10	0 00650	0 00560	0 00700	23	0 0648	0 0552	0 0696
10½	0 00717	0 00617	0 00772	24	0 0703	0 0606	0 0758
11	0 00786	0 00678	0 00847	25	0 0764	0 0657	0 0827
11½	0 00860	0 00741	0 00926	26	0 0826	0 0711	0 0889
12	0 00936	0 00806	0 0101	27	0 0890	0 0767	0 0959
12½	0 0101	0 00875	0 0109	28	0 0956	0 0825	0 103
13	0 0110	0 00946	0 0118	29	0 103	0 0883	0 111
13½	0 0118	0 0102	0 0127	30	0 110	0 0947	0 118
14	0 0127	0 0110	0 0137	31	0 117	0 101	0 126
14½	0 0137	0 0118	0 0147	32	0 125	0 108	0 135
15	0 0146	0 0126	0 0157	33	0 133	0 114	0 143
16	0 0166	0 0143	0 0179	34	0 141	0 122	0 152
17	0 0188	0 0162	0 0202	35	0 149	0 128	0 161
18	0 0210	0 0181	0 0227	36	0 158	0 137	0 171
19	0 0234	0 0202	0 0252	37	0 168	0 144	0 180
20	0 0260	0 0224	0 0280	38	0 177	0 152	0 190
21	0 0287	0 0247	0 0309	39	0 186	0 160	0 201
22	0 0315	0 0271	0 0339	40	0 195	0 168	0 210
23	0 0344	0 0296	0 0370	41	0 205	0 177	0 220
24	0 0374	0 0323	0 0403	42	0 216	0 186	0 232
25	0 0406	0 0350	0 0437	43	0 226	0 195	0 243
26	0 0439	0 0379	0 0473	44	0 236	0 204	0 255
27	0 0474	0 0408	0 0510	45	0 247	0 213	0 266
28	0 0510	0 0439	0 0549	46	0 258	0 222	0 278
29	0 0547	0 0471	0 0589	47	0 270	0 232	0 291
30	0 0585	0 0504	0 0630	48	0 281	0 244	0 303

[illegible] Association No. [illegible], N. A. S. E., will hold its annual outing and games August [illegible] at [illegible]'s park, [illegible], Staten Island, N. Y.

POWER AND THE ENGINEER

DEVOTED TO THE GENERATION AND TRANSMISSION OF POWER

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March 23	37,000

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Contents

Exhaust Steam

Ask ten engineers which is the more economical, a condensing or a noncondensing engine, and nine of them will tell you: "A condensing engine, of course;" and patronize or pity you for having to ask.

And yet in many cases, most cases we had almost said, the condensing engine is the more expensive to use, and money would be saved by replacing the condenser with a back-pressure valve. This is true wherever there is use for the heat rejected. It costs less than four per cent. more in heat units to make a pound of steam at 150 pounds than to make it at atmospheric pressure. If there is use for heat at or about 212 degrees it is much cheaper to make the steam at the higher pressure and expand it in an engine down to that temperature. Of the 1191.2 heat units required to make a pound of steam at 150 pounds, an engine using 30 pounds of steam per hour per horsepower will take out only about 85, and the rest, with the exception of the trifling amount lost by radiation, passes out with the exhaust. If any smaller number of heat units were voided with the steam they would accumulate in the cylinder and melt it down; if the exhaust took out more than the steam brought in (besides radiation and that converted into work), it would make a refrigerator out of the cylinder. Each pound of exhaust from such an engine, therefore, contains some 1100 heat units which are available for heating and manufacturing processes requiring heat around 212 degrees. It would cost just about as much to make low-pressure steam especially for this purpose as it did to make the high-pressure steam, and the power has been had practically for nothing.

There is no more efficient power-generating proposition than a steam engine used as a reducing valve between a high- and a low-pressure system.

This truth escaped general attention for a long while on account of the attempt to use exhaust steam just as dry high-pressure steam is used. It was characterized as "cold" and "sluggish" simply because the water was not taken out of it and sufficient cross-sectional area given to the conducting pipes to conduct the required weight at the large volume due to the low pressure. With the separators now available exhaust steam can be easily purged of all moisture in excess of the percentage allowable in "commercially dry" steam.

Of course the amount of exhaust made must be in accord with the demand. It would not do to run a thousand-horsepower engine noncondensing for the sake of using up one-tenth of its exhaust and letting the rest go to waste. In the New England textile mills, where exhaust steam is used, even in the summer time, for manufacturing processes, engines are often run one-half condensing, the exhaust chest being divided so that one end can be exhausted to the condenser and the other to the back-pressure system. It is a common practice to take steam for such purposes from the receiver of a compound engine, and we know of one instance where the course of the steam through a compound engine was reversed, the larger cylinder being made the high-pressure; so much steam being taken out of the receiver that there was only enough, even in its expanded condition, to run the smaller cylinder. Successive heatings from the different stages of a steam turbine would bring the temperature of the feed nearly to that of the steam, fulfilling the compression condition of Carnot's cycle.

But whether the demand for exhaust steam warrants the running of the main engines noncondensing or not there is usually occasion for the use of all the exhaust which the auxiliaries can make in heating feed water. Where this is the case it is wasteful and extravagant to run the auxiliaries from the main engine, electrically or otherwise, for the main engine, notwithstanding the smaller number of pounds of steam it uses per horsepower-hour, cannot compare in efficiency with the most extravagant steam pump credited with all of its exhaust. When the exhaust is used for heating feed water the water of condensation which it contains makes no difference, but can be mingled with the water being heated, as can also the rest of the exhaust condensed by such mingling. This not only saves the water which by its previous use has been freed from scaling materials, but the heat which would otherwise be carried away by that water.

Centralized Auxiliary Control

In the design of power plants of importance the modern tendency is toward the use of a system of auxiliary control from the switchboard. In addition to the remote control of oil switches in the main circuits, which has long been practised, it is now quite feasible to start and stop motors for all purposes from a central point. The old idea that a controlling switch must be located within a few feet of its motor has been modified by the production of remote-control motor starters, the master switches of which are grouped at a central point. It is only a question of a little more wire and a little more elaborate controller, the extra cost of which in most cases will be a small price to pay for the greater convenience of operating the various motors for pump service, valve operation, coal and ash handling, fan driving, air compression and the like, many of which may be located in places inconvenient of access.

Additional switches on the switchboard

for the control of lighting circuits in the engine and boiler rooms, coal pockets, oil-storage room, pipe tunnels and of the motor circuits for the traveling crane constitute an added improvement which does not interfere in the least with the provisions of parallel switches or controlling apparatus located near the equipment they control, and in the light of the necessity for continuity of service this duplication of control in many instances would be well worth while.

Condenser Speed and Vacuum

In operating a compound condensing engine the condenser should receive the same intelligent attention that is given to the engine. Condensers are installed usually for the purpose of making the engine a more efficient means of converting the heat in the steam into useful work, and logically to fulfil their mission they should not only be efficient machines, but should also be efficiently operated. Pipe joints between the condenser and the engine cylinder should be absolutely airtight and the condenser should be run at the lowest possible speed which will maintain the desired vacuum.

While it is generally true that the higher the vacuum the better, it is not always so. If the engine is lightly loaded it is sometimes better to reduce the vacuum by reducing the speed of the condenser, if independently operated, or, if directly connected to the engine, by reducing the injection, allowing a little longer cutoff in the cylinder and a higher temperature of the exhaust to give up heat to the feed water.

But under most conditions the degree of vacuum should be regulated by the hight of the governor, that vacuum being carried which will cause the governor to revolve in the highest possible plane. Under certain conditions of load and steam pressure the governor will be found to revolve in a higher plane with a vacuum of twenty-six inches than with a greater vacuum. It will be found that the receiver pressure, also, will have much to do with the hight of the governor, and by judicial experiment with both vacuum and receiver pressure, the relation of one to the other and of both to the governor hight, the best vacuum and the proper receiver pressure for each condition of load may be found.

Changing the receiver pressure will alter the distribution of the load between the cylinders. By reducing the receiver pressure more work is thrown on the high-pressure cylinder, while an increase in the vacuum will increase the work of the low-pressure cylinder, and it is probable that with a long cutoff in the low-pressure cylinder the highest possible position of the governor will be maintained with the highest possible vacuum in the condenser.

Gas Equipment for a British Battleship?

According to a brief press cablegram published recently in some of the New York dailies, the British government has made all the necessary arrangements for the construction of a fighting ship of the "Dreadnought" class to be equipped throughout with gas power. Efforts to get at whatever facts may have given rise to the dispatch have thus far produced no results, nor have any supplementary cablegrams appeared to corroborate the first one or amplify the "information" which it purported to present. It is possible that a new series of experiments with larger equipment than that tested recently on the "Rattler" may form the basis of the cabled report. Certainly it does not seem probable that a government as conservative as that of Great Britain would incur the great risk of flat failure involved in an attempt to construct a [illegible]-horsepower producer-gas battleship, with no precedent beyond the 500-horsepower unit tried out in the "Rattler," or the [illegible]-horsepower unit now in process of trial.

When it is considered that the maximum gas-engine output per cylinder thus far secured on land, under the most favorable conditions yet known, is less than 1500 horsepower, schemes as to the equipment of a battleship or other vessel with units which would need to develop at least that much power per cylinder, and probably more, take on the aspect of what the street gamin characterizes as "pipe" dreams. There is no doubt whatever that gas power in large units will be applied to marine work some day; there is, however, doubt amounting to incredulity on our part that it will happen this year. There exists right now a most promising opportunity for someone to produce a satisfactory marine engine of 1000 horsepower for service on the Great Lakes of this country, but no builder has as yet accumulated the necessary nerve to make the attempt, although a perfectly responsible financial concern has signified its readiness to buy and pay for such an engine the moment it is built.

The Art of Economical Steam Production

Among the many factors which enter into the successful or unsuccessful operation of the power plant is not only the man in the chief engineer's place, but also the man in front of the boiler. The plant may be of the latest design, with every sort of [illegible] produced by the best of manufacturing concerns, and [illegible] may be installed, and yet the good results of all the refinements of modern practice may be nullified by a fireman who does not understand economical steam-making.

Economical steam production is an art to which altogether too little attention is given. If an intelligent fireman is wanted, he is paid, as a rule, [illegible] with the [illegible] to which his ability as a [illegible] makes him entitled. Firemen, like poets, are born—not made—and when one is discovered who is intelligent and active, interested in his work and willing to do his best all of the time—one who knows how to get the most out of the coal under the conditions existing in the plant where he is employed, and does it every day—he should be encouraged, the results of his work should be recognized in a substantial way. Such a man is not to be parted with lightly. His work appeals to the owner in a practical way, with the eloquence and logic of dollars and cents saved. The plan that his work makes for him should be recognized and every possible effort put forth to make him feel satisfied with his position, not with words alone, but with a part of what he saves and an improvement of the conditions under which he works.

Firing, at the best, is work for strong men, but strength and intelligence are not incompatible, and in the operation of steam boilers their association in the same man is an absolute necessity if good results are expected from the fuel burned.

It is pleasant to note that from many different parts of the country it is learned that advanced ground is being taken by power-plant designers and owners, and that boiler rooms and the men who work in the plants are receiving more attention than formerly. Sanitary and comfortable, if not always pleasing, conditions obtain. [illegible] the employees are [illegible] that they are regarded as of some importance in the operation of their plants [illegible].

It has been estimated that the total consumption of [illegible] in plants [illegible] tons [illegible] by the railway systems and [illegible] the [illegible] that the consumption of [illegible] power [illegible] of using the coal [illegible] the proper [illegible] gas [illegible] could be [illegible] per [illegible] the value of the [illegible] to the [illegible] should be [illegible].—The [illegible].

Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

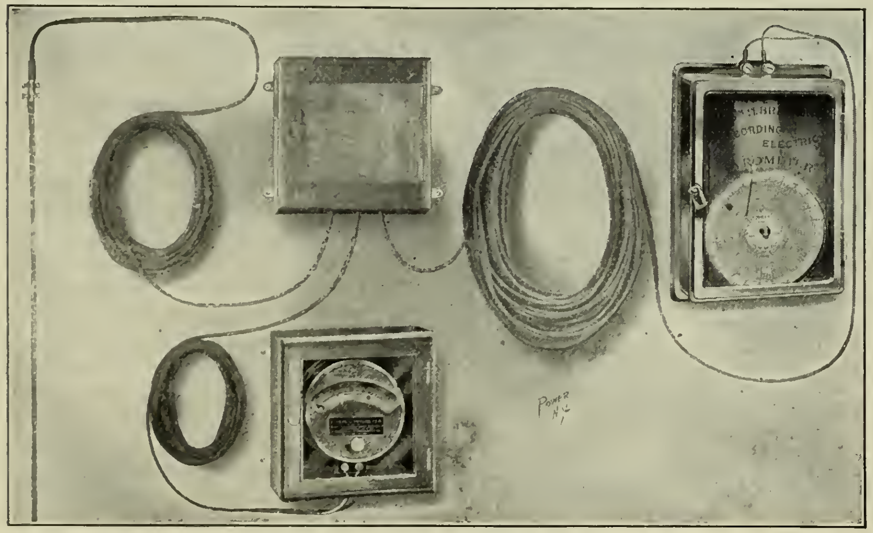
Combination Indicating and Recording Units

The illustration herewith presented shows the complete combination indicating and recording units of the Bristol electric pyrometer, manufactured by the Bristol Company, Waterbury, Conn., as wired up in actual operation.

The recording instruments with the necessary switches and checking system can be mounted in protected cases, either separately or as shown in the illustration. Each combination unit can be made to suit the particular application for which the pyrometer outfit is to be used. By this arrangement the recording instrument can be installed in the superintendent's office, or any convenient place. Their purpose is for all commercial ranges of high temperature, and they are especially recommended for annealing and case-hardening furnaces, water-gas machines, blast furnaces, galvanizing plants, gas producers and open-hearth furnaces.

The indicating instrument of this combination unit is for the use of the operator while at his post of duty. The instrument is in a case so it can be located at the most convenient point for the attendant. The open scale makes it easy for the fireman or operator to read the furnace temperature at a glance.

The recording instrument of the unit is for the benefit of the superintendent or manager in his office. This instrument may be located at a distance, connection being made to the fire end by flexible leads. It makes continuous records automatically of the same temperature shown by the indicating instrument. The record charts are intended to give the superintendent full information and serve as a check on the men.



COMBINATION INDICATING AND RECORDING UNITS

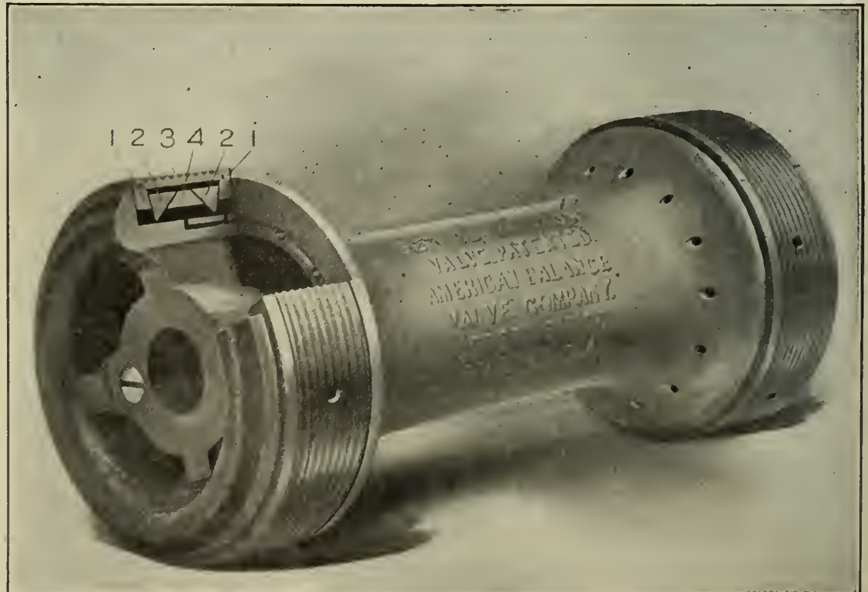
"American" Semi-plug Piston Valve

This valve is called "semi-plug" because while it is without steam it is a snap-ring valve; the packing rings being expansible fit themselves to the valve chamber, but when the throttle is opened the steam is admitted to the chest and enters the space below the rings. The action of this pressure is to lock the snap rings in a fixed diameter, making practically a plug of it during the time the pressure is on. The valve has been designed on the principle of leverage by wedges, the pressure acting upon the wedges. In the valve the wedges take the form of cones, or circular wedges, as shown in the illustration.

The outside walls of the snap rings *1* are straight and fit against the straight wall of the follower and spool. The inner walls of these snap rings are beveled, forming a cone. Next to the snap rings are wall rings *2*, the sides of which are beveled to fit the cones of the snap rings. These wall rings are uncut, nonexpansible steel rings. Between them, in the center, is placed a double-coned expansible wedge ring *4*, which, with the wide ring *3*, interlocked into each snap ring, forms the complete packing.

The wide ring performs two important functions; it carries the snap rings across ports while drifting, and also keeps the snap rings parallel with each other.

The wedge ring is put in under tension and its tendency is to crowd the two solid wall rings laterally against the cone sides of the snap rings *1*. This prevents lateral wear of all rings. The degree of



SECTION OF "AMERICAN" SEMIPORTED PLUG PISTON VALVE angle on the cones is much greater on the double-tapered wedge ring than on the snap rings. These angles are so calculated that, while the pressure is underneath all the rings, the leverage of the double-tapered wedge ring, crowding the solid wall rings against the cones of the snap rings, is just sufficient to prevent the snap rings from farther expansion, but not sufficient to reduce the snap rings in diameter.

When steam is admitted to the steam chest it passes through the small holes around the spool, and finds an outlet, first, under the first snap ring, and second, under the central wedge ring, thus causing the rings to fit the valve chamber, and the wedge ring to lock up the rings.

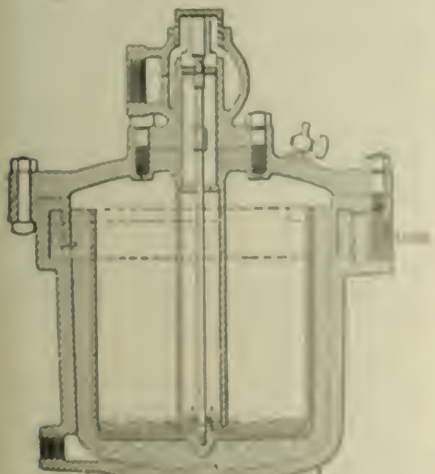
The packing consists of the combination of rings, which are free to move up and down on the spool, that the rings may fit the cage perfectly correctly, regardless of any variation in the position of the spool, which is carried on the valve rod.

This valve is manufactured by the American Balance Valve Company, Jersey Shore, Penn.

Stickle Bucket Trap

The Stickle bucket trap is shown in cross-section in the accompanying illustration. It is designed to be connected to separators used on large steam mains, where boilers prime and there is a large amount of magnesia brought over in the steam. The separating ring around the top is designed to stop the greater part of sediment while the trap is filling. As soon as it opens, it is wide open. The rapid discharge through the ring is intended to clear it from sediment, and it is discharged through the valve when it is wide open. The buckets are very heavy. It is claimed that it never sticks, as the equalizing coupling lets the valve go straight to the seat.

This trap is manufactured by the Open Coil Heater and Purifier Company, Indianapolis, Ind.



STICKLE BUCKET TRAP

Erie City Feed Water Heater

Fig. 1 is an exterior view of the Erie City feed-water heater, the inlet head, trays and deflecting plates of which were

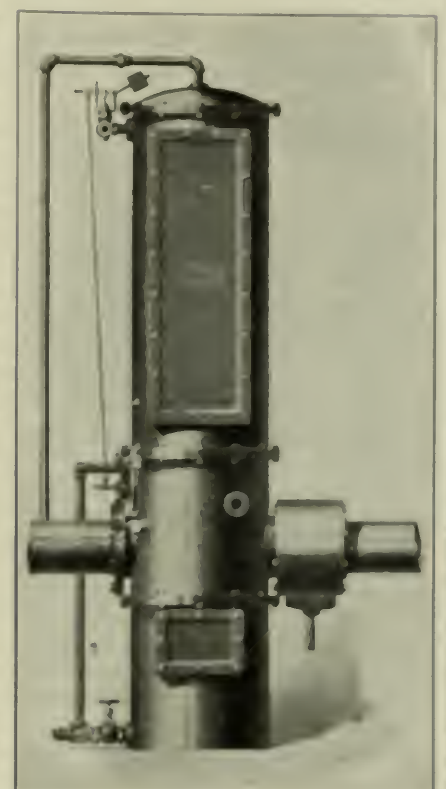


FIG. 1. ERIE CITY FEED-WATER HEATER

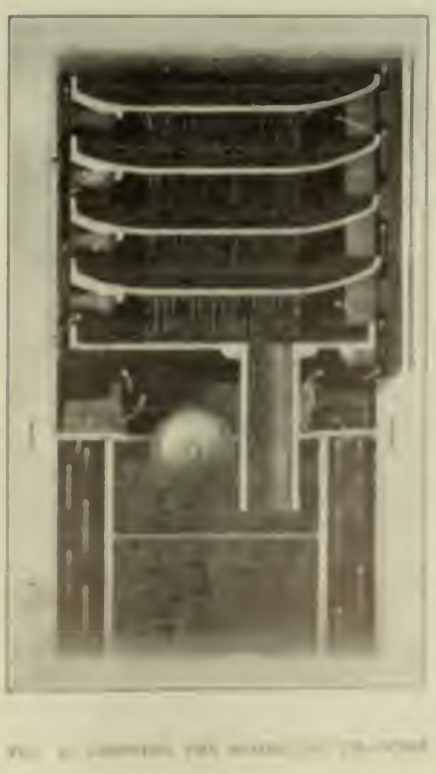


FIG. 2. [illegible]

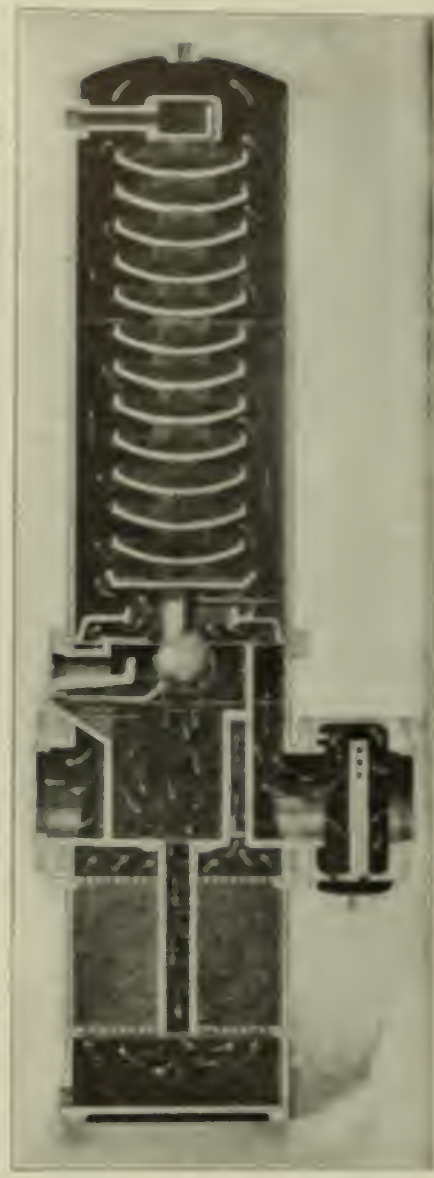


FIG. 3. SECTIONAL VIEW OF ERIE CITY HEATER

specially designed. The illustrations show the construction without going into minute details, but attention is especially called to the [illegible] chamber shown in Fig. 2. The feed water is taken from this chamber, which is directly opposite to and in direct connection with the [illegible] [illegible] [illegible] [illegible] Fig. 3 is a sectional view of the heater, [illegible] The heater is manufactured by the Erie City Iron Works, Erie, Penn.

Book Reviews

The Modern Power Gas Producer. By Horace Allen. Published by D. Van Nostrand Company, New York, 1908. Cloth; 332 pages, 5x7 inches; 136 illustrations; numerous tables. Price, $2.50.

This is not a college textbook. It is a résumé of modern European practice in the construction and application of gas producers for power purposes, to which is added an explanation of the principles involved. The material is valuable and the author's style of exposition is clear and interesting; it is greatly to be regretted that engravings of extraordinarily poor execution have been used to illustrate such worthy text. The diagrams and sectional drawings are so badly reproduced and so excessively reduced in size as to be useless in most instances. The arrangement of the material is not altogether praiseworthy. Much of the technical information which should be given in the chapters devoted to principles is scattered through those which present descriptions of commercial equipment. But the information and data contained in the book are highly useful when once sorted out.

Social Engineering. By William H. Tolman. McGraw Publishing Company, New York. Cloth; 394 pages, 6x9 inches; illustrated. Price, $2.

If it is the function of the engineer to adapt and apply the materials and forces of nature to the use of man, the specification is broad enough to include the "Social Engineer," as Dr. Tolman calls himself. Industrial betterment is something more than a philanthropy. "The betterment of the labor element is a cold business proposition," as Dr. Tolman says in his preface, "and is undertaken commonly to get the best results out of labor."

The damages which a manufacturer pays for loss of life and limb are a part of the operating cost of his business, and included in the selling price of his product, so that it is the consumer who pays them in the last analysis, and it is the consumer who will profit by the betterment of conditions which will not only avoid such loss of life and limb, but increase the efficiency of the producer.

The first chapter of the book treats of the promotion of efficiency through various educational and other methods. Succeeding chapters treat of The Social Secretary; Hygiene; Safety and Security; Mutuality; Thrift; Profit Sharing; Housing; Education; Recreation; Communal or Social Betterment; Does it Pay?

The work will well repay perusal by everybody who is interested in social progress, and especially by those who are engaged in industrial pursuits, either in the office or in the shop.

General Lectures on Electrical Engineering. By Charles P. Steinmetz. Published by Robson & Adee, Schenectady, N. Y., 1908. Cloth; 280 pages, 6x9 inches; 48 illustrations. Price, $2.

The contents of this book comprise seventeen lectures and two appendices, the latter being reprints of papers read before engineering societies. The lectures are extremely simple in treatment, practically no mathematics being employed. The author's manuscript was "edited" by J. LeRoy Hayden, and there are many spots where more careful work by Mr. Hayden would have increased the clarity and smoothness of diction very greatly. The lectures are "popular" in character and their scope embraces the whole field of electric light and power engineering; consequently, many of them are conspicuously inadequate, even for the avowed purpose of the book. There are several obscure statements in the book, and one or two which seem to be erroneous, if the reviewer reads aright the author's meaning. On page 104, for example, varying the number of poles on an induction motor is said to be analogous to varying the number of expansions in a steam turbine, and on page 105 the author says that the mean [effective?] pressure in a gas-engine cylinder "is low"! The reviewer confesses inability to trace the analogy or to imagine what kind of a modern gas engine develops a "low" mean pressure.

The Economy Factor in Steam Plants. By George W. Hawkins. Hill Publishing Company, New York. Cloth; 133 pages, 6x9 inches; illustrated. Price, $3.

This book is intended for the designer of steam-power plants or the student of the subject of steam-plant design. The author has had access, as a member of the engineering staff of C. C. Moore & Co., to a mass of data upon the several efficiencies of the various factors which go to make up such a plant, has analyzed the effect of varying conditions upon such apparatus and devised formula charts or "graphs" and tables which will assist the designer in determining the constituents of the most efficient plant for a given set of conditions, or the probable efficiency of a proposed plant. The author deals with engineering efficiencies simply and does not consider the over-all efficiency, including standing charges based upon investment, furnishing rather the means for enabling the engineer to estimate the expense of maintenance which may then be corelated with cost. The work is divided into four parts. Part I treats of Individual Apparatus, and considers in separate chapters Boilers; Engines; Electrical Generators; Condensing Apparatus; Feed Pumps; Oil Pumps; Oil Burners; Radiation Leakage; Feed Water Heaters; and Fuel Economizers. It was the original intention to make the analysis applicable only to oil-burning plants, but inasmuch as the same method might obviously be made to apply to any fuel whatsoever it was decided to add such conversion charts as would afford a ready means of applying the results to coal and wood or other fuels.

Part II deals with the Factor of Evaporation. All of the quantities which go to make up this factor are readily obtainable except the temperature of the feed water and this chapter contains "graphs" showing the temperature to be obtained from open and closed heaters for various temperatures of air-pump discharge and percentages of exhaust steam available, and the effect of fuel economizers; and tables showing the percentages of steam used by auxiliaries. Parts III and IV treat of Complete Plant Economy, the first under full and the latter under variable load.

The charts or "graphs" are a prominent feature of the book and present in a condensed yet comprehensive form the information which the author has gathered from exceptional opportunity, and the deductions therefrom.

Practical engineers are prone to hoard the results of their experience as capital in the competitive struggle for advancement. Mr. Hawkins has in this work made available to the engineering profession information which to determine experimentally would entail thousands of dollars worth of experiment or years of varied experience.

Books Received

"Modern Cement Sidewalk Construction." By Charles Palliser. Industrial Publication Company, New York. Cloth; 64 pages, 5x7½ inches; illustrated; indexed. Price, 50 cents.

"Alternating Current Machines." Seventh edition. By Samuel Sheldon, Hobart Mason and Erich Hausmann. D. Van Nostrand Company, New York. Cloth; 353 pages, 5x7½ inches; 237 illustrations; indexed. Price, $2.50.

"Law and Business of Engineering and Contracting." By Charles Evan Fowler. McGraw Publishing Company, New York. Cloth; 162 pages, 5½x9 inches; illustrated; indexed. Price, $2.50.

"Transmission Calculation of Transmission Lines." By L. W. Rosenthal. McGraw Publishing Company, New York. Cloth; 93 pages, 6x9¼ inches; 42 tables; indexed. Price, $2.

"Heat Energy and Fuels." By Hanns V. Juptner, translated by Oskar Nagel. McGraw Publishing Company, New York. Cloth; 306 pages, 6x9¼ inches; 118 illustrations; tables; indexed. Price, $3.

Anniversary of American Institute of Electrical Engineers

The members of the American Institute of Electrical Engineers and their wives, in all three hundred persons, celebrated the twenty-fifth anniversary of the organization of the institute Thursday evening, March 12, with a dinner at the Hotel Astor, New York City.

Louis A. Ferguson, of Chicago, president of the institute, was toastmaster. The speakers were President Jesse M. Smith, of the A. S. M. E., Past Presidents Elihu Thompson and Frank J. Sprague, of the A. I. E. E., and President Alexander C. Humphreys, of the Stevens Institute of Technology, who delivered an address on "Electrical Engineering as a Profession."

Those occupying the rostrum in addition to the speakers were Theodore Beran, John Bogart, C. C. Chesney, C. A. Doremus, William C. L. Eglin, W. W. Freeman, B. Gherardi, Robert Mather, E. E. Olcott, Ralph W. Pope and G. G. Ward.

In his opening speech President Ferguson called attention to the fact that although the youngest the American Institute of Electrical Engineers now was the largest of the four great engineering societies of America.

President Smith, of the Mechanical Engineers, told what wonders the electricians had accomplished. Professor Thomson was greeted with great applause. He joked about the temerity of the men who took upon themselves the title of "electrical engineers" twenty-five years ago, but praised the optimism which prompted them in that self-assertion.

The institute has had twenty-one presidents since its founding in 1884. Of these, three, Norvin Green, the first president; Franklin L. Pope, the second, and William A. Anthony, are dead. Of the living past presidents, T. Commerford Martin, Elihu Thomson, Frank J. Sprague, Francis B. Crocker, Charles F. Scott, Bion J. Arnold, John W. Lieb, Jr., Schuyler S. Wheeler and Henry Gordon Stott were present at the anniversary.

Preceding the speech of Mr. Sprague, Toastmaster Ferguson called on the seven charter members present to stand and as he read off each name the diners applauded vigorously. The seven were Charles L. Clarke, George A. Hamilton, C. O. Mailloux, T. Commerford Martin, Jesse M. Smith, Prof. Elihu Thomson and Elmer A. Sperry.

Plans of Combined Associations of Brooklyn

The delegates of the Combined Associations of Engineers of the Borough of Brooklyn will hold a banquet in the near future to celebrate the first anniversary of the association. This organization, it seems, is the source of the inspiration for the new engineers' and firemen's license law adopted by the Greater New York Charter Revision Committee. The annual summer outing will be held on July 18, at [illegible] Park, N. J., and the annual ball at the [illegible] Engineers' society, on the eve of Washington's birthday, February 21, 1910. Since its inception this organization has divided one thousand dollars among the several associations forming its membership.

Engineers' Blue Room Club Outing

One hundred and sixty members of the Engineers' Blue Room Club of Boston, Mass., paid a most profitable and instructive visit to the Wood Worsted Mill, the latest addition to the American Woolen Company's plant in Lawrence, Mass., Saturday, March 7.

The party started at 10.30 a.m., in two special cars attached to the regular train, and was met upon its arrival in Lawrence by the mayor of the city and officers of the American mills, which, under the guidance of special committees, were thoroughly inspected.

The power plant, of course, was the principal point of interest, and George H. [illegible], the consulting engineer of this great corporation, explained the many latest and interesting devices.

An extended inspection of other parts of the mill followed, after members and guests found themselves in the restaurant of the mill, where the committee had provided a most appetizing lunch. This being done away with, all were called to order by the president of the Blue Room Club, [illegible] H. Parker, who voiced the sentiments of the members in extending thanks for the invitation to the members, and named Past President George H. [illegible], toastmaster.

Mayor "Billy" White extended the welcome of the city to the members and guests and dwelt at length on the advantages of Lawrence as the greatest textile center of the world, [illegible].

Other addresses were made by Mr. [illegible], the agent of the mill; Mr. [illegible], of the Washington mill; George H. [illegible] and Mr. [illegible], who [illegible] Past Presidents [illegible] and [illegible] as well as Mr. [illegible], secretary of the club, and Harry H. [illegible], chairman of the arrangements committee.

A group picture of all present was then taken. Handshaking and good wishes were then in order, and after three hearty cheers for the hosts and "the city," George M. [illegible], the party left for Boston, having enjoyed the most interesting and instructive visit ever made by this club. The committee who so ably conducted the affair consisted of Harry H. [illegible], Harry H. [illegible] and Richard E. [illegible].

Brooklyn Engineers' Club Social and Smoker

The Brooklyn Engineers' Club held its third annual social session and smoker at the Imperial, [illegible] street, Brooklyn, on Saturday evening, March 14. There were more than three hundred persons present and a most enjoyable evening was spent. A vaudeville entertainment was given by the "[illegible]," there being frequent intermissions between the numbers for the serving of refreshments. The efficient committee in charge of this successful event comprised C. L. [illegible], H. F. [illegible] and Frank W. [illegible].

Civil Service Examinations

The United States Civil Service Commission announces an examination on April 21 and 22, 1909, to secure eligibles to the position of [illegible] in the [illegible] service, at an entrance salary of [illegible] a month. The subjects and weights are as follows: [illegible] mathematics (arithmetic, geometry and algebra), 20; drawing to scale from sketches, 30; [illegible] and lettering, 30; training and experience (rated on application), 20. Applicants must [illegible] be required.

Personal

[illegible] B. [illegible], [illegible] engineer, Boston, Mass., has been elected a member of the corporation of the Massachusetts Institute of Technology.

Prof. Charles M. Spofford, of the Brooklyn Polytechnic Institute, has been chosen to succeed Prof. George F. Swain as Hayward professor of civil engineering at Massachusetts Institute of Technology, beginning next school year. Professor Swain will go to Harvard.

George E. [illegible], for the past two years [illegible] engineer with the Middle States Inspection Bureau, an organization maintained by thirty-six insurance companies, has joined the staff of the George H. [illegible] Company. Mr. [illegible] is a graduate of [illegible] College, Cornell University.

L. F. [illegible], professor of mechanical engineering at the University of [illegible], has been [illegible] in connection with the work of the United States Geological Survey, will have charge of the [illegible] at [illegible]. [illegible] Professor [illegible] will return to his duties next September.

Obituary

[illegible]

Business Items

The Kennedy Valve Manufacturing Company announces that William Martin, who is well and favorably known in engineering circles, has joined the forces of that company as manager of the New York City sales department, with offices at 57 Beekman street.

The Parker Boiler Company, Philadelphia, Penn., installed last fall a 258-horsepower boiler for the Convent of the Good Shepherd, Wheeling, W. Va., and has just received an order to duplicate the installation; also, an order for three 300-horsepower boilers for the Gardner Harvey Paper Company, Battle Creek, Mich., and two 234-horsepower boilers for the Mount de Chantal Academy, Wheeling, W. Va.

A Eugene Michel, who has for the past three years been Manager of the George H. Gibson Company, has opened new offices at 1572 Hudson Terminal buildings, New York. Mr. Michel will in future confine his efforts as an advertising engineer to the promotion of steam specialties and apparatus, power transmission appliances and machine tools, and will limit his clientele to the number of firms to whose work he can give personal attention. Mr. Michel is a graduate engineer, associate member of the A.S.M.E., and with eleven years' advertising and engineering training, which includes practical experience in machine design, testing, etc., is well prepared to conduct the advertising of mechanical products.

The space-saving qualities of the angle-compound engine, recently introduced by the American Engine Company, Bound Brook, N. J., is illustrated by the fact that one of these engines of a capacity of 500 horsepower was recently selected to drive a centrifugal circulating pump in connection with the condenser outfit of the Interborough Rapid Transit Company, at the Fifty-ninth street and North river power house, New York City. The American Engine Company also reports a sale of an angle-compound engine to the United States Government for the Coast Artillery School at Fort Monroe, to be installed along with two American-Ball duplex compound engines.

The importance of forest preservation is appreciated by no one more than by those who are vitally interested in hydroelectric development throughout the country. Many individuals are exerting themselves in this cause, and the Appalachian National Forest Association continues to enlarge its membership. An example of a manufacturing company interested in this preservation is the Crocker-Wheeler Company, of Ampere, N. J., builder of electric-power machinery used in hydroelectric development, which has recently become a sustainin member of this association, whose object is the "perpetuation, through wise use, of the remaining forests of our country, national and State."

New Equipment

City of Camden, Ark., will construct water-works.

The Midland Electric Co., Lexington, Ky., will erect a new power house.

The Granger (Texas) Oil Mill Company will install an ice plant and water-works system.

City of Panama City, Fla., contemplates erection of electric-light plant and water works.

It is reported that the Sapulpa (Okla.) Interurban Railway Company will construct power house.

H. E. Johnson, Carson, Iowa, has purchased electric-light plant and will make improvements to same.

It is reported that the Clark Memorial College, Newton, Miss., contemplates installing an electric-light plant.

The city of Mart, Texas, has voted $50,000 bonds for construction of water-works. R. W. Bass, mayor.

The Farley & Loetscher Mfg. Company, Dubuque, Iowa, has completed plans for a new power house.

The Union (Iowa) Electric Light Company, recently granted franchise, contemplates constructing electric plant.

The citizens of Marion, Kans., voted to issue $60,000 bonds for construction of electric-light plant and water works.

The citizens of Camden, Ala., have under consideration the question of establishing a municipal electric-lighting plant.

The Providence Hospital, Washington, D. C., is in the market for a 100 kilowatt direct-connected unit, also passenger elevator.

The plant of the Rockford Electric Light Company, Marysville, Mo., recently destroyed by fire, will be rebuilt at once, it is said.

Plans are being prepared for a three-story cold storage building for Conron Bros. Co., Brook avenue and 153d street, New York.

W. H. Bourke and others, of Spokane, Wash., have been granted franchise to construct and operate an electric-light plant in Lewiston, Idaho.

The Italy Water Company, Italy, Texas, contemplates the erection of a standpipe or steel tank and tower and would like to hear from builders.

The Musketaquid Worsted Mills, Lowell, Mass., has awarded contract for erection of an addition. A new power plant and water wheel will be installed.

The Craig Water Power Company, Roanoke, Va., has been organized with $200,000 capital. Two plants will be erected. A. L. Sibert, president.

The Northern Illinois State Normal School, De Kalb, Ill., contemplates installing new engine, generator and switchboard. Jas. A. Clark, engineer.

Muralt & Co., New York, have been awarded contract for remodeling and enlarging water-power plant at Tower Mills, L. I. New turbines will be installed.

Bennings Power House of Potomac Electric Co.

Essential Operating Features of an Important Central Station in the District of Columbia, which Embodies a Number of New Ideas

BY F. L. JOHNSON

Situated on the eastern branch of the Potomac river, about three miles from the Capitol, is the Bennings power house of the Potomac Electric Power Company, which furnishes current for nearly all the electric lights used in the District of Columbia and power to more than 200 miles of electric railway.

MOUTH OF INTAKE TUNNEL

ELECTRIC TRAVELING COAL HOIST

250-HORSEPOWER ELECTRIC LOCOMOTIVE AND COAL CAR

This power house was built to take over the work of three overloaded reciprocating-engine plants of heterogeneous character located in widely separated districts in the city. Current is generated at 6600 volts and stepped up to [illegible] volts for distribution to 14 substations, where it is stepped down to 2300 volts for general lighting distribution mains and converted into direct current of 575 volts for traction work. Compactness of arrangement and facility of operation seem to have been uppermost in the mind of the engineer who designed the plant.

Hollow concrete blocks, [illegible] inches, were used in building the walls and the two main partitions which divide the building into three sections, the largest of which is the boiler room; through the middle of this section rise three chimneys of reinforced concrete, 12 feet in diameter and 200 feet high. Steel I-beam columns of generous proportions support the roof girders, the boilers, the coal bunkers, the traveling crane (which covers the entire turbine room), the reinforced-concrete floors and the lighter partitions which divide the building into rooms, galleries and alcoves.

BENNINGS POWER HOUSE

One hundred and eight feet of the length of the building, which is [illegible] feet, is occupied by the boiler room, which now contains sixteen of the twenty-four [illegible] Babcock & Wilcox boilers for which it was designed. The boilers are arranged in four rows, with the fronts of those in the outer rows [illegible] those in the inner rows.

Steam is taken from each boiler through a [illegible] and a 7-inch [illegible] angle stop valve to a long-radius bend which extends over the top of the boiler [illegible] from the top of the steam main. The diameter of the main [illegible] from 7 to 12 inches [illegible] between the [illegible] of boilers. [illegible] of 14 inches in diameter. [illegible] the plan of the [illegible] ary plentifully used and [illegible] are [illegible] by bends of long radius.

Coal and Ash Handling

Roney stokers are installed, to which coal is fed in closed chutes with [illegible] bottoms designed to keep the

TRANSFORMERS IN TRANSFORMER STATION

[illegible]

[illegible]

veyer for distribution to the overhead storage bins as desired. These bins are of rather small capacity, holding only about four days' supply. For the storage of a large quantity of reserve coal to tide over any failure on the part of the transportation company to deliver the required amount on time a dumping pit is provided about 1000 feet north of the building. Into this all coal delivered in excess of the regular demand is dumped, to be picked up later by an electrically driven traveling coal hoist and distributed in long piles on both sides of the track.

MAIN FLOOR IN TRANSFORMER STATION

Under the boiler-room floor, which is 14 feet above the main floor of the building, are ash hoppers to catch all ash and clinker. These hoppers are equipped with easily operated valves by means of which their contents may be emptied into small dump cars which, when filled, are pushed over and dumped into a hopper which delivers to the same elevator that handles the coal. By the change of one dumping block on the side of the elevator frame the ashes are made to spill into a large hopper of reinforced concrete, located above the boiler-room door, from which they may be run into cars on the outside of the building through a chute which also serves to control the flow of ashes from the hopper to the car. An empty coal car is left at night over the crusher hopper and under the ash chute, which comes through the wall about 12 feet above the track. In the morning the ashes which have been collected the day before and elevated to the hopper are allowed to run into the empty coal car, which is pushed by the electric locomotive onto the side track of the steam railroad, to be hauled away.

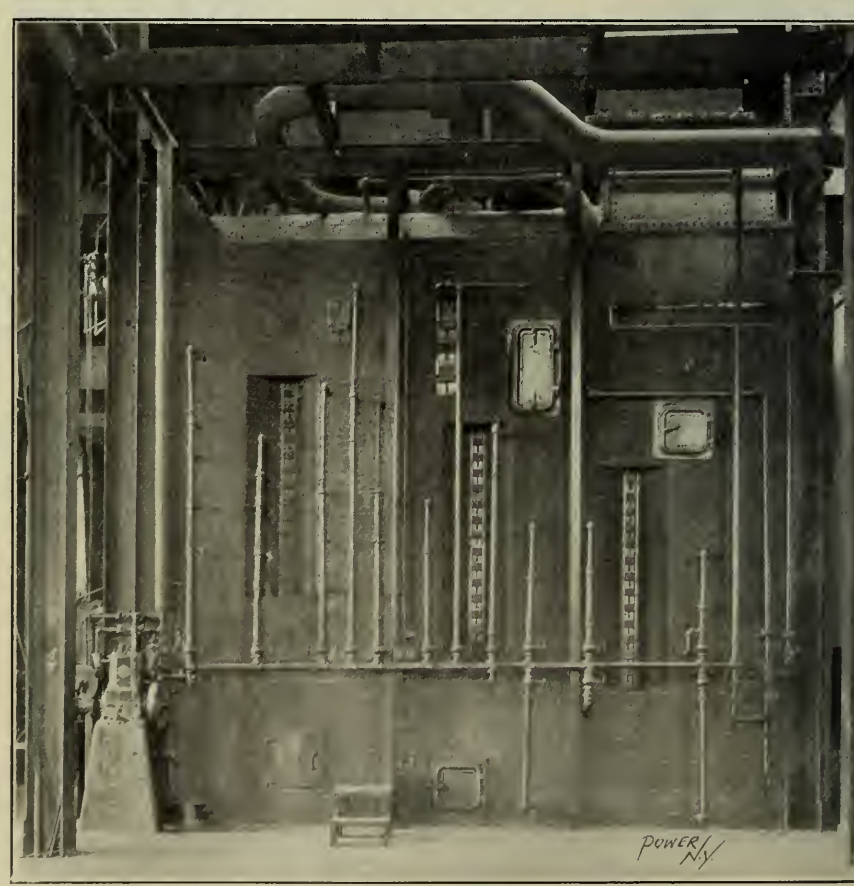
Water is used freely to wet the ashes in the hoppers under the boilers and render the handling of them free from the annoyance due to dust which usually attends most ash-handling operations.

All of the boilers are fitted with "Vulcan" flue blowers by which all of the tubes of all the boilers in the plant may be thoroughly cleaned in less than one hour. Each flue is provided with a damper controlled by a Locke damper regulator, and also with a recording pyrometer. The variations in temperature indicated by the wavy line on the chart show clearly the action of the damper regulator, the low-temperature line on the chart from 1:30 to 5:05 a.m. indicating that the damper had checked the draft while still keeping steam pressure within its usual limits, as shown also by the chart from the pressure gage.

Feed Water

Feed water is delivered to the boilers through extra-heavy brass pipe from any or all of three 16x10x16-inch outside-packed plunger pumps which take water from two Webster open heaters located on the boiler-room floor, one on each side of No. 1 chimney. Exhaust steam from the power ends of the circulating and dry-vacuum pumps, after passing through separators to remove the cylinder oil, is led to the heaters, where it mingles with and heats the condensation from the turbines, which is delivered from the condensers by electrically driven two-stage centrifugal hotwell pumps.

What makeup water is needed is automatically supplied to the heaters by water from two makeup tanks, each of 3000 gallons capacity, located in the boiler room and kept full all the time by the so-called house pumps, which are controlled by a

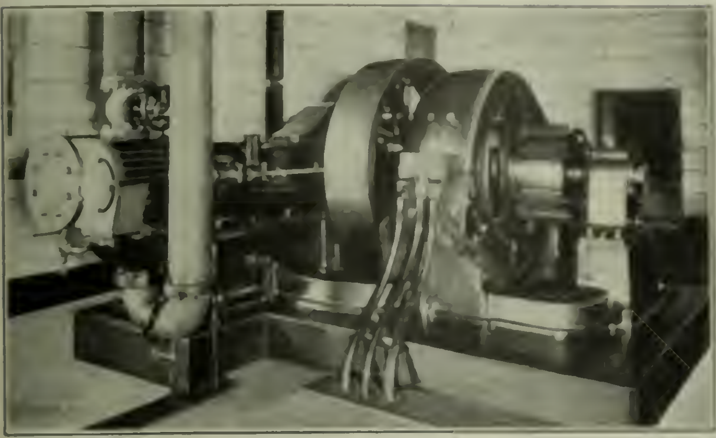


VULCAN FLUE CLEANERS ATTACHED TO BOILER

Ford pump governor. There is a float in each tank which, as the water rises, closes a valve in the delivery pipe of the pump and as the pressure in this pipe increases it checks the steam supply to the pump, reducing its speed to that necessary to keep the tanks just full.

As practically all of the steam made in the boilers is condensed and returned, the problem of feed-water supply resolves itself into the question of a small amount of makeup water, which is furnished by wells near the plant from which plenty of suitable boiler water is drawn.

Varying demands on the boilers from the peak to the lightest load render it necessary to carry banked fires on some of the boilers for twelve or more hours each day. This of necessity cuts into the economy of operating to some extent and an experimental installation of oil burners



ONE OF THE 100-KILOWATT EXCITER UNITS

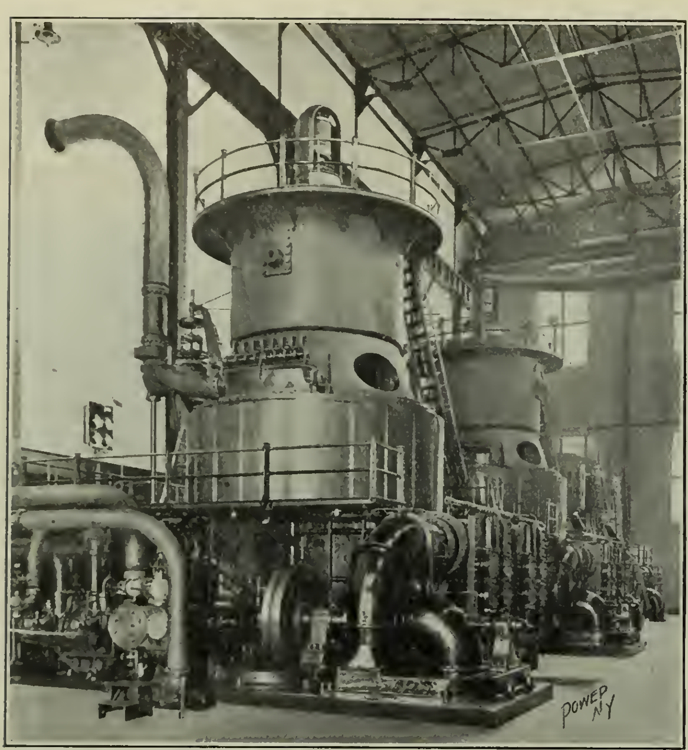
TRANSFORMER GALLERY UNDER SWITCHBOARD

SWITCHBOARD GALLERY IN POWER HOUSE

OIL SWITCHES IN TRANSFORMER ROOM

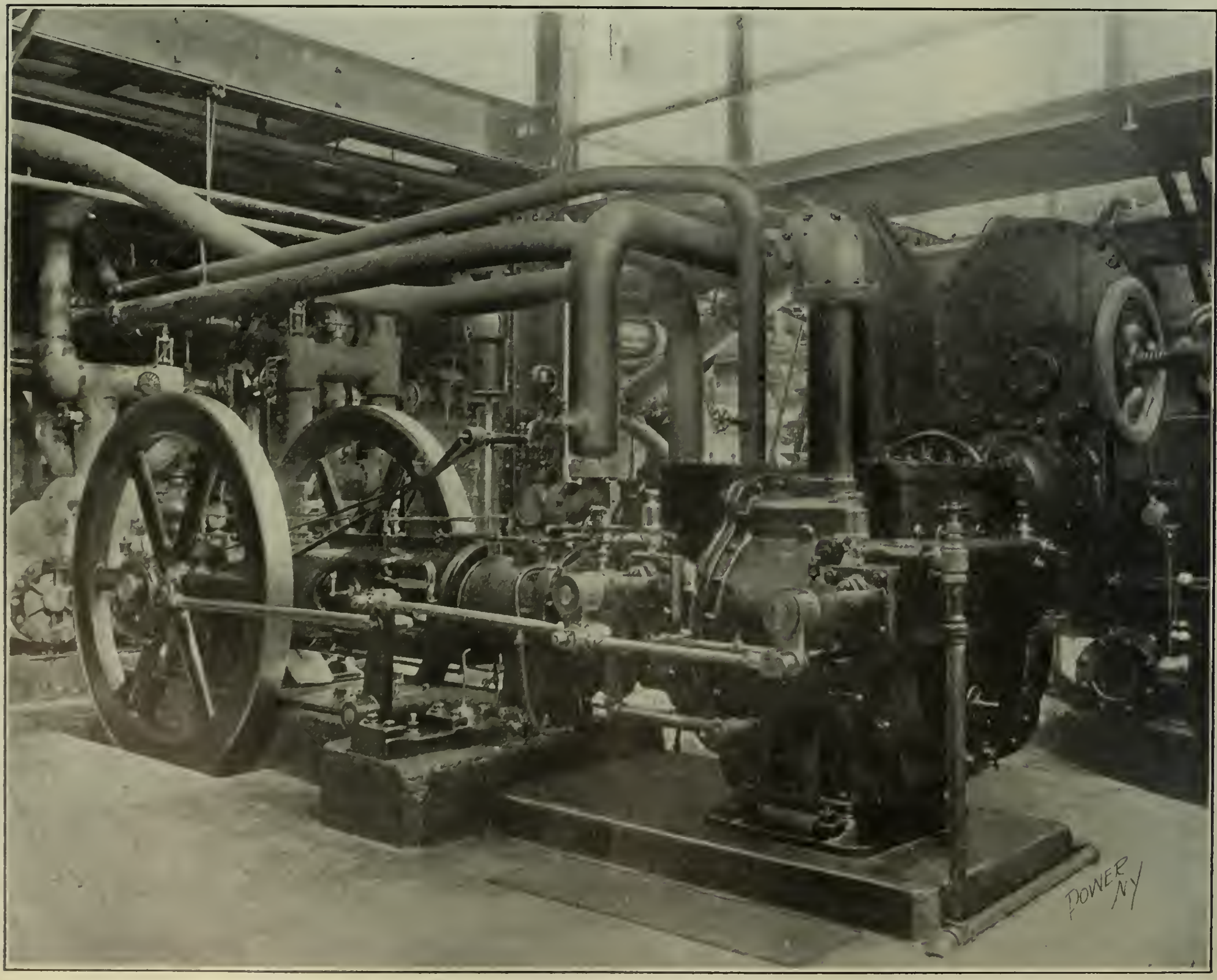
BOILER FRONTS AND STOKERS

[illegible]

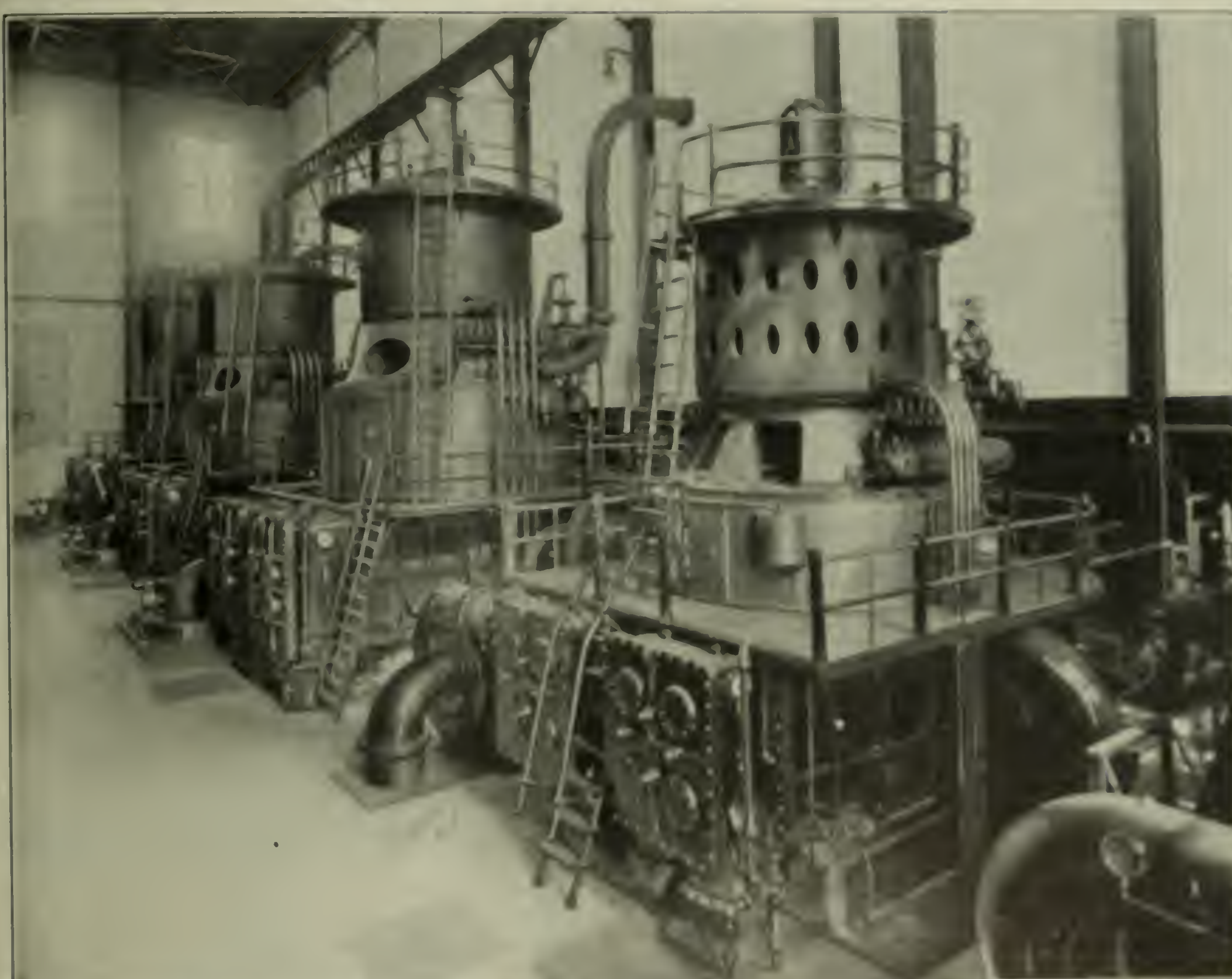


VIEW IN TURBINE ROOM FROM NORTH END

OIL SWITCHES UNDER MAIN SWITCHBOARD IN POWER HOUSE



LAIDLAW-DUNN-GORDON SINGLE STAGE DRY-VACUUM PUMP is being made under two of the boilers to ascertain if, for a short run, it is not more economical to use the more expensive oil fuel than to incur the loss that inevitably occurs from the slow and incomplete combustion that goes on with banked fires. It is also proposed to install one set of oil burners above the grates in one boiler and burn the oil above a coal fire in order to make an attempt to burn the oil in addition to all the coal that can possibly be burned on the grates and thus produce a higher furnace temperature than is possible with coal alone. If it should be found possible with coal and oil together



VIEW OF TURBINE ROOM FROM ENTRANCE TO POWER HOUSE

to get 50 per cent. more evaporation from a boiler than with coal alone, the necessity for banked fires will disappear and no more boilers will be needed when carrying the peak than with the average load.

At this plant the load from 1 to 5 a.m. is about [illegible] kilowatts. From 5 a.m. until 9 a.m. it gradually increases to [illegible] kilowatts, after which it drops to 9000, where it remains until about 4 p.m., when it again increases until a peak of [illegible] kilowatts is reached at sundown. After about two hours the load drops to [illegible] kilowatts, where it continues until midnight, when it again drops off, reaching the lowest point at about 1 o'clock in the morning.

STEAM PUMPS.

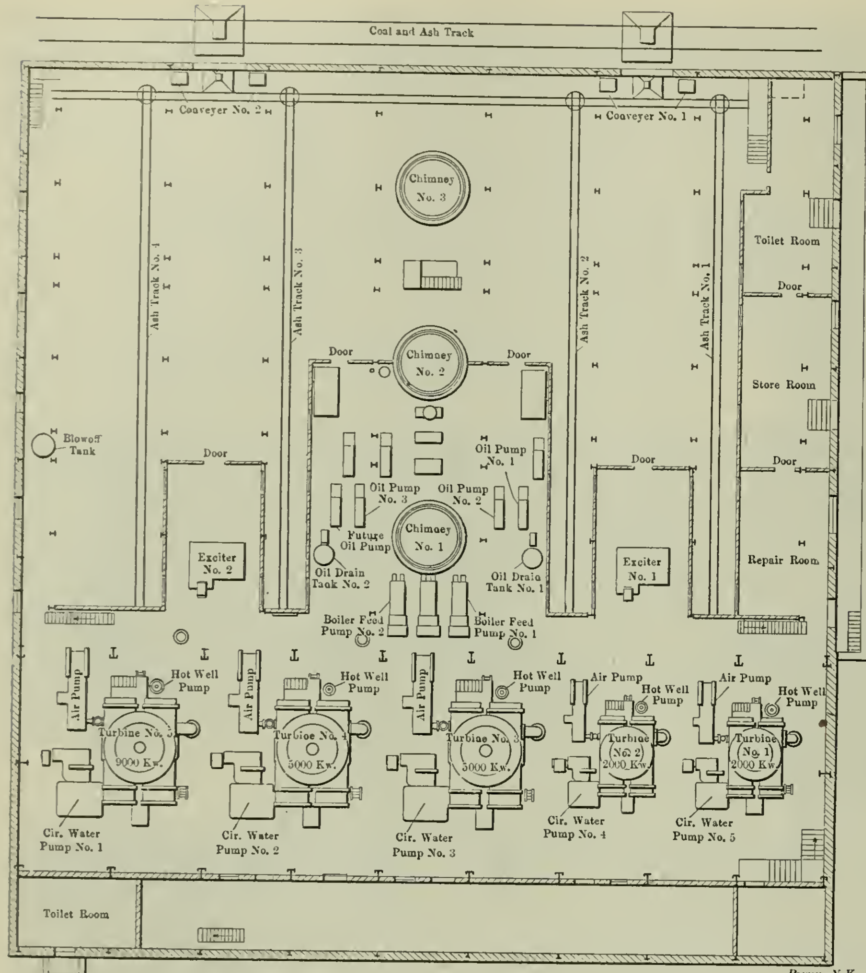
On the main floor of the power house, which is 14 feet below the boiler-room floor, around No. 1 chimney and between it and No. 2 chimney, are grouped all of the steam pumps of the plant. There are three [illegible] outside-packed plunger pumps for boiler feeding, two [illegible] plunger oil pumps, maintaining a pressure of [illegible] pounds per square inch for the step bearings of the larger turbines; three [illegible] plunger-pattern pumps, maintaining an oil pressure of [illegible] pounds per square inch for the steps of the smaller turbines; two [illegible] piston pumps, maintaining an oil pressure of [illegible] pounds, for operating the hydraulic-valve gear and guide bearings, and two small oil-tank pumps which automatically take care of all of the oil that flows to the drip tanks from the step bearings, the guide bearings and the hydraulic-valve gear, and deliver it to the [illegible] oil filters located on either side of the room. There is also one fire pump, which is used occasionally for furnishing water for sprinkling, washing down boilers, or for any purpose for which water under pressure may be needed.

Near No. 1 chimney is located a [illegible] Engineering Company's water meter, to which all of the motor-driven [illegible] pumps are piped. From the discharge tank of the meter a low-duty tank pump, automatically controlled, takes all water passing through the meter and delivers it to the Webster feed-water heaters. Watt-hour-meter and water-meter readings are taken for any length of time desired, and one reading divided by the other gives the pounds of water per kilowatt-hour, the [illegible] of the [illegible] rate [illegible] a very simple matter.

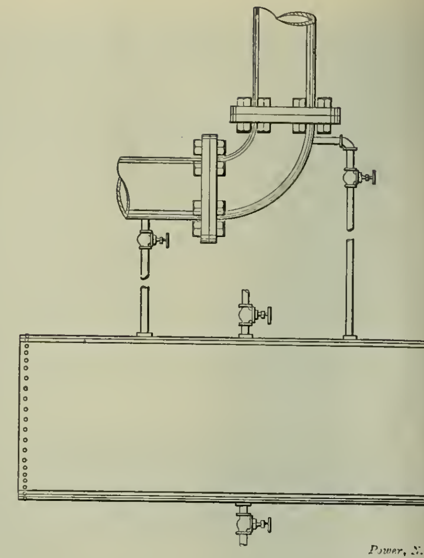
Between No. 2 chimney and the north wall, over the boiler-room basement, is located a building for compressed air, in which two Westinghouse air-brake pumps keep the pressure up to [illegible] pounds per square inch.

At each side of the pump room on the main floor, and also under the boilers, are two sumps, in each of which is a motor-driven [illegible] pump of [illegible] capacity.

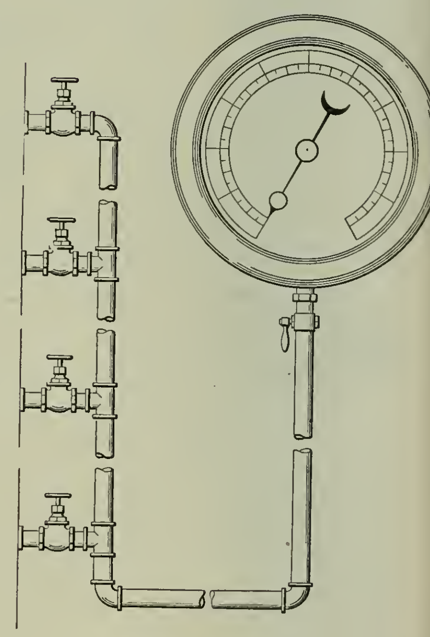
Calculations were made to decide [illegible] the [illegible] should be



GROUND-FLOOR PLAN BELOW LEVEL OF BOILER ROOM



DRY-VACUUM PUMP DRAINING SCHEME



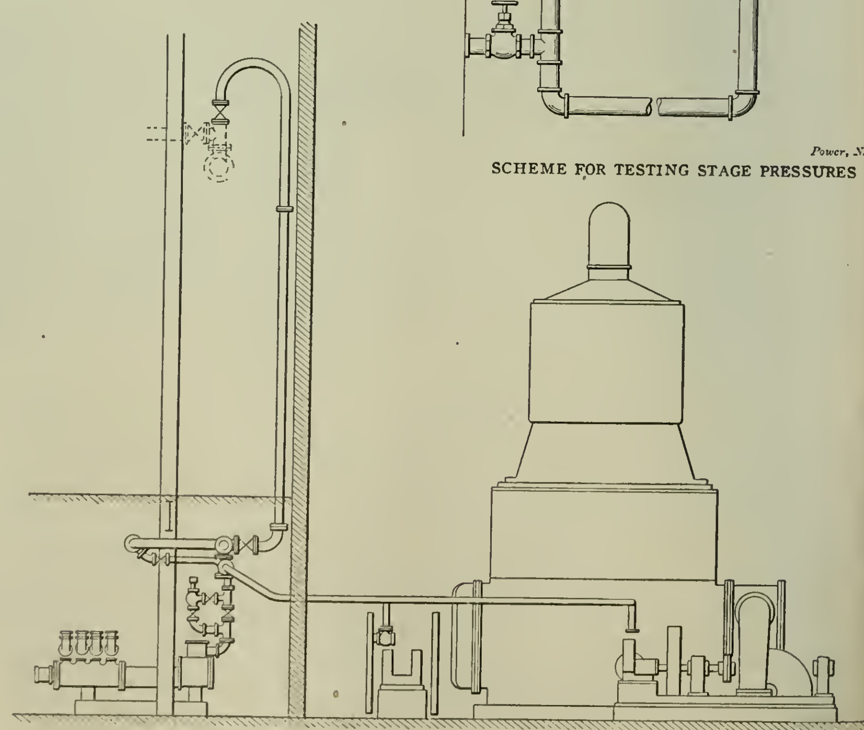
SCHEME FOR TESTING STAGE PRESSURES

steam-driven, it being desired to heat the feed water as hot as possible and yet use no more steam in the auxiliaries than would be condensed in the feed-water heaters. That the balance was very closely calculated is shown by the fact that the average temperature of the feed water for one year was 186 degrees.

The Steam Turbines

On the main floor of the turbine rooms are five vertical Curtis turbines mounted on Worthington condenser bases. One turbine generator is of 9000 kilowatts capacity, two are of 5000 kilowatts each and two of 2000 kilowatts each. As the 2000-kilowatt units are too small to carry the entire load at any time of the day or night it is intended in the very near future to replace these two units with one of 14,000 kilowatts capacity

Steam for the turbines is taken from the side of the main pipe line through pipes with long bends, while steam for the auxiliaries is taken from the top of the same main by risers with return bends of 2-foot 3-inch radius, the long ends of which descend below the boiler-room floor, thence through long ells and bends to the machines where the steam is to be used.



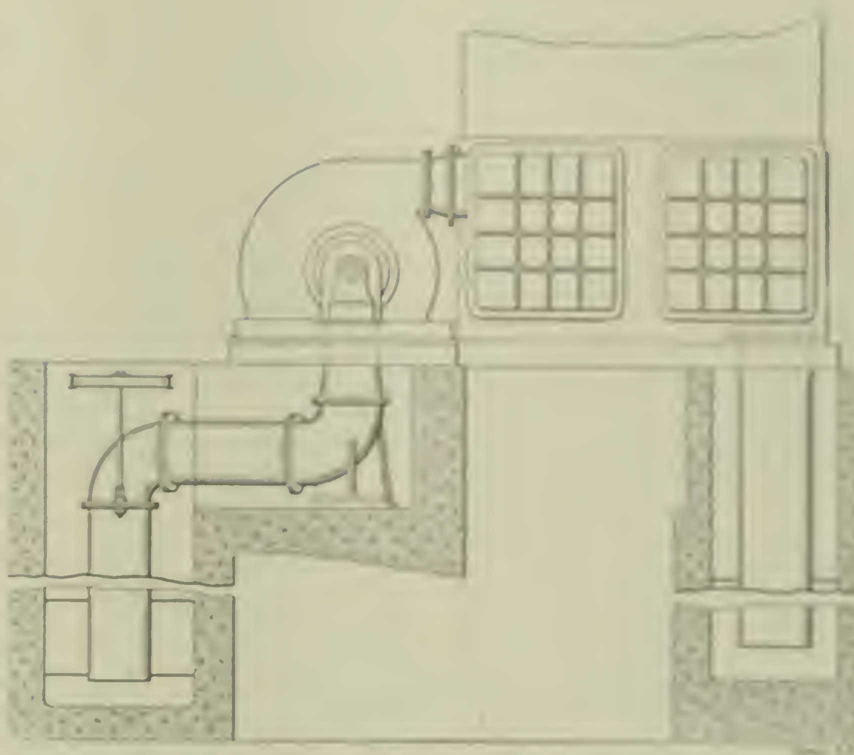
ELEVATION OF AUXILIARY PIPING

In order to obtain condensing water economically a channel about 200 feet long was dredged out from the mouth of the intake tunnel to the river. From this channel the water is taken to the turbine room under the floor in a concrete duct 13 feet wide and 5½ feet deep. Throughout the length of the turbine room the overflow pipe, also of concrete, lies on top of the intake, side pits being provided for the suction pipes of the pumps so that they do not pass through the overflow. As both the intake and overflow are below the river level, the discharge pipes from the condensers are sealed at all times and the work done by the circulating pumps is simply that of overcoming the friction necessary to move the water through the condensers and connections. Each condenser is served by a centrifugal circulating pump, direct-connected to a Fleming engine, a steam-driven Laidlaw-Dunn-Gordon single-stage dry vacuum pump and a motor-driven two-stage centrifugal hotwell pump.

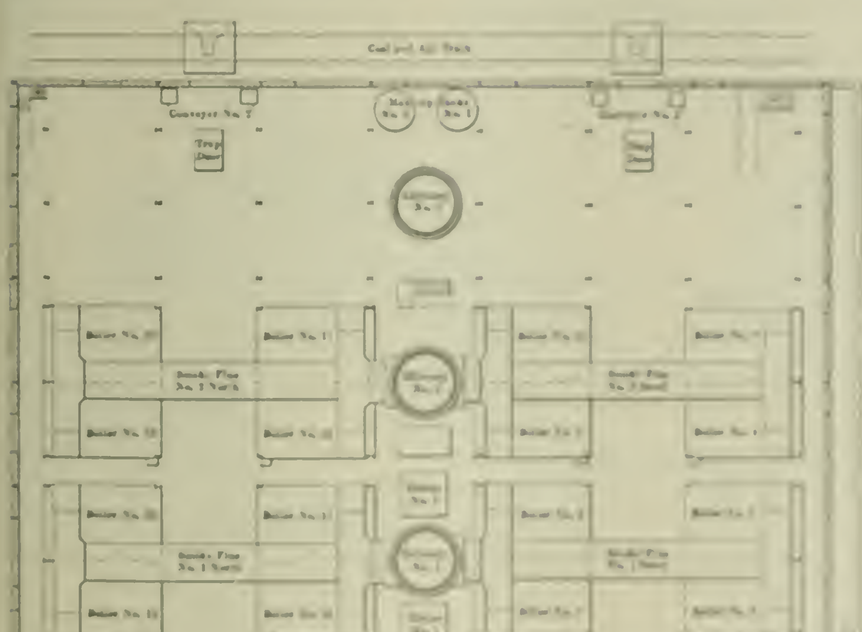
When the plant was first started considerable annoyance resulted from water which collected in the suction pipe of the dry vacuum pumps, necessitating a shut-down once in about four hours to drain the water from the pipe. The chief engineer hit upon the scheme of tapping the suction pipe at two points, one at the bottom and the other above this, and leading both pipes to a closed tank below the level of the suction pipe. When water came along with the air it ran through the lower drain pipe and collected in the tank. At the end of two or three hours the valves in the pipes leading to the tank were closed and the tank opened to the atmosphere, when the water ran out. When the tank was empty it was closed to the air and opened to the suction as before. Since this plan has been in operation no trouble has been caused by water in the dry-vacuum pump cylinders.

There is also an ingenious arrangement by which with a single connected gage the pressure or vacuum in any stage of the turbine can be tested. From the gage on the wall a single pipe leads upward past all four stages of the turbine casing. From each stage a pipe with a valve leads to the gage pipe. By opening one valve with the others closed the degree of pressure or vacuum in that stage is read and may be compared with that of the other stages or with former readings.

Chief Engineer [illegible]



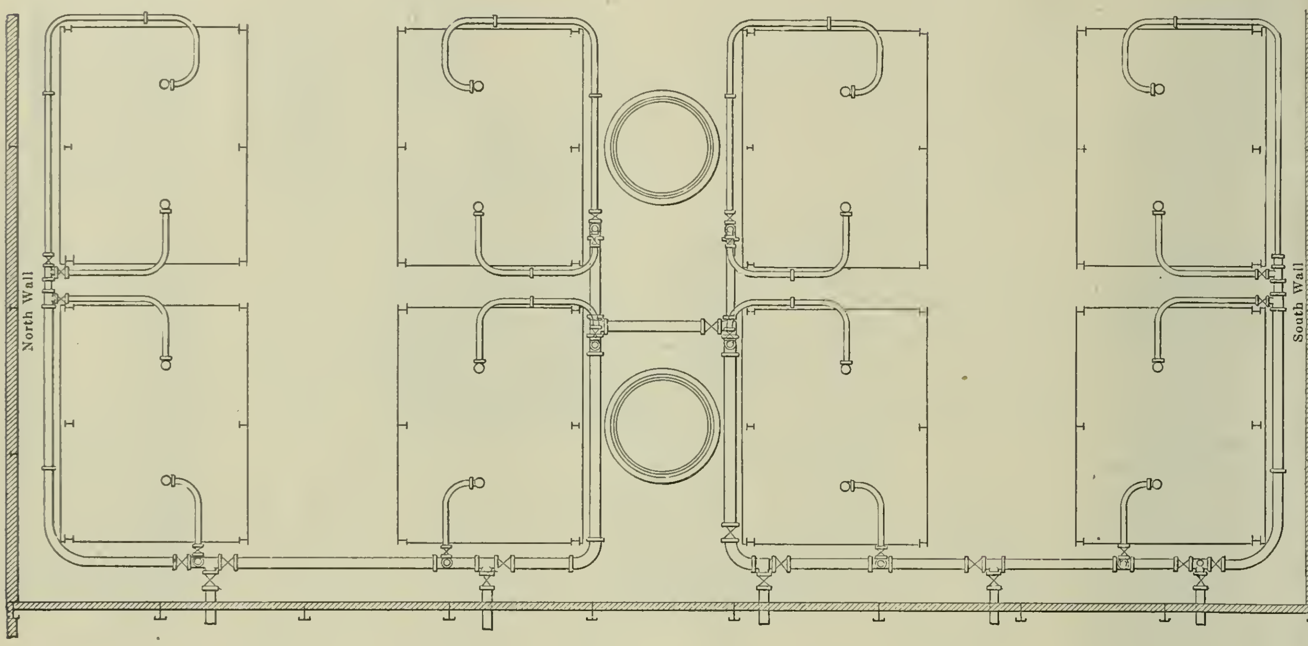
ELEVATION OF CONDENSING-WATER SYSTEM, SHOWING INTAKE AND OVERFLOW



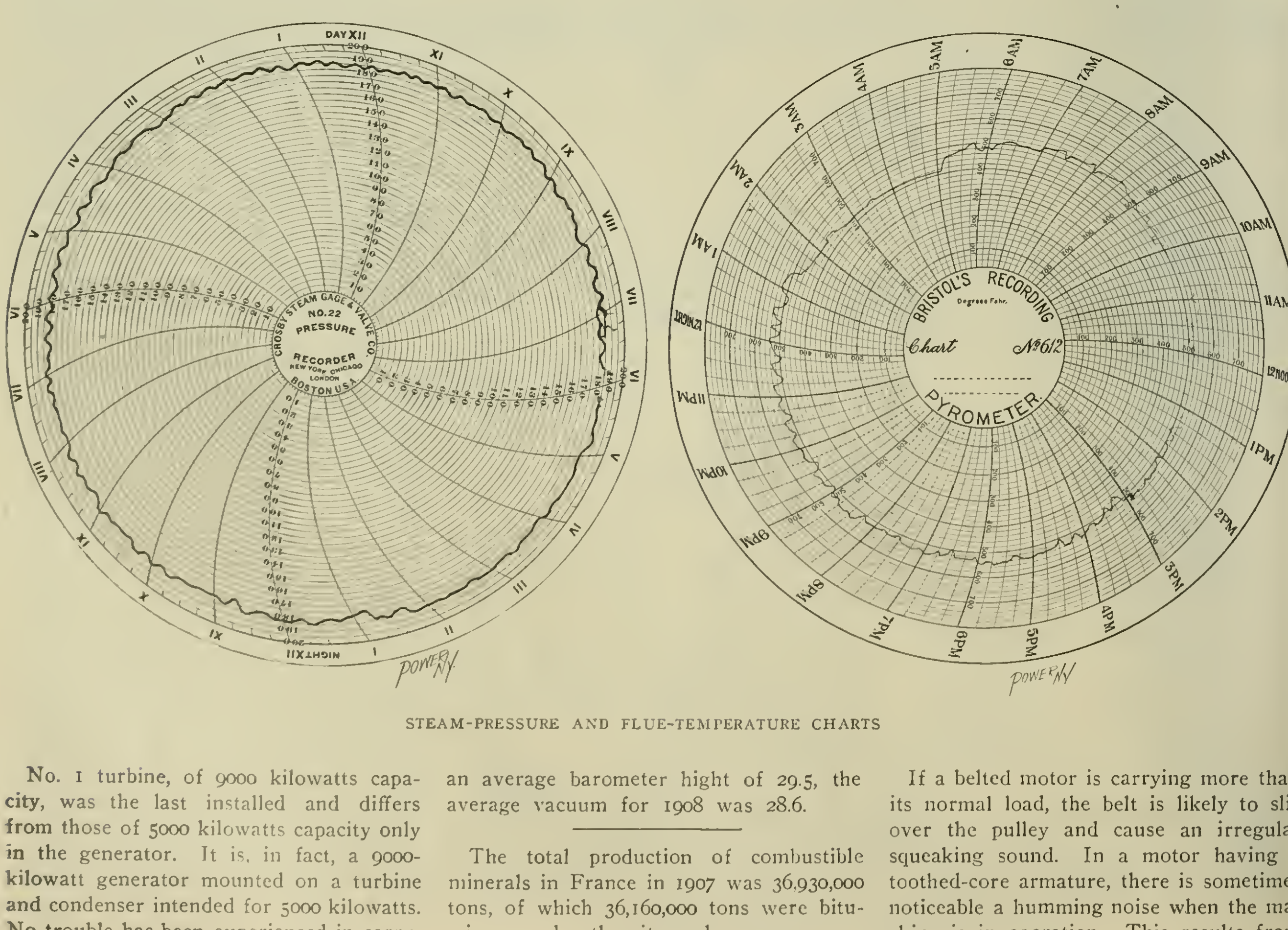
PLAN OF POWER HOUSE [illegible]

thought that their durability will be increased.

Steam is furnished to the turbines at 180 pounds pressure with 138 degrees superheat at the throttle.



PLAN OF MAIN STEAM PIPE OVER BOILERS



STEAM-PRESSURE AND FLUE-TEMPERATURE CHARTS

No. 1 turbine, of 9000 kilowatts capacity, was the last installed and differs from those of 5000 kilowatts capacity only in the generator. It is, in fact, a 9000-kilowatt generator mounted on a turbine and condenser intended for 5000 kilowatts. No trouble has been experienced in carrying a full load of 9000 kilowatts and maintaining a vacuum of 29 inches with a condenser having only 20,000 square feet of cooling surface, which is an overload on the condenser of 80 per cent. With an average barometer hight of 29.5, the average vacuum for 1908 was 28.6.

The total production of combustible minerals in France in 1907 was 36,930,000 tons, of which 36,160,000 tons were bituminous and anthracite coals.

Catechism of Electricity

987. *What causes other than mechanical ones are responsible for noise in a motor?*

If a belted motor is carrying more than its normal load, the belt is likely to slip over the pulley and cause an irregular squeaking sound. In a motor having a toothed-core armature, there is sometimes noticeable a humming noise when the machine is in operation. This results from the passage of the teeth of the core past the field-magnet poles.

988. *Cannot objectionable noise caused by overload on a motor be reduced without decreasing the load?*

Tightening the belt or applying powdered rosin to that part of its surface which comes in contact with the pulleys may be found to answer the purpose. If, however, these remedies fail, a pulley of larger diameter or a belt having a wider dimension must be employed.

989. *Can the humming noise due to a toothed armature core be remedied?*

It can be remedied, but only in the reconstruction of the machine, either by reducing the number of ampere-turns in the field winding or by altering the shape of the pole pieces or that of the teeth in the armature core so that the teeth do not all pass the edges of the pole pieces at the same time.

Motor Speed Too Low

990. *What are the usual causes that tend to slow down the speed of a direct-current motor?*

Overload; friction between the armature and the pole pieces; friction between the armature shaft and the bearings; a short-circuited coil or ground in the armature; low voltage in the supply circuit.

991. *What indications accompany an overloaded motor running slow?*

There is usually bad sparking at the commutator, the armature is very warm and in the case of a belted machine the belt is very tight on the tension side and may slip excessively.

992. *Is there any remedy for the case mentioned in 991 except reducing the load?*

No.

993. *What symptoms indicate that friction between the armature and the pole faces is keeping down the speed?*

A roughened armature surface, a tendency of the armature to stick when turned slowly around by hand, or a scraping noise when the armature is rotated.

994. *How should friction trouble of this kind be remedied?*

By binding down the protruding portion of the armature winding, or by properly centering the armature in its bearings or by filing out the pole faces where the friction occurs.

995. *If there is sufficient friction between the armature shaft and the bearings to cause drop in speed, will they not become very warm?*

They will, and the armature will be difficult to turn by hand.

996. *What remedy should be applied in such a case?*

The bearings, if out of alignment, should be readjusted. If the shaft surfaces are rough they should be smoothed, cleaned and oiled.

997. *How may a short-circuited coil or a ground in the armature be found?*

A short-circuited coil in the armature will cause the motor to draw excessive current. A ground occurring at two points in the armature will produce the same effect as a short-circuit, but a ground at only one point will not be noticeable. Continuity tests with a magneto bell, made by connecting the terminals of the magneto to the armature core and to the wire of the coil and turning the generator crank, will show up a ground if there is one. If the magneto bell rings, there is a ground; if it does not ring, there is probably not any ground.

998. *How should a short-circuited coil be remedied?*

If the trouble is due to a piece of solder or other metal getting between the commutator bars or their connections with the armature winding, the remedy consists simply in removing the solder or the metal. If the short-circuit is in the coil itself, the coil will have to be replaced by a new one.

999. *What should be done to remove a ground in an armature coil?*

If the ground is at a point where it can be reached, it can usually be remedied by inserting a strip of insulating material between the coil and the core. Otherwise, the coil must be rewound.

1000. *What produces a ground in a motor?*

Sometimes a ground is caused by a spark of static electricity, generated by friction between the belt and pulley, puncturing the insulation of a coil.

1001. *Is there any way to prevent trouble from the static electricity produced by the belt?*

If the frame of the motor be grounded, the static charge will be led directly to ground before it does any harm. As it is not generally desirable to ground the motor frame, a moistened thread, a heavy pencil mark on a piece of unglazed porcelain, or any other high resistance connecting the frame to ground that will carry off a static charge, which is of very high potential and very small magnitude, but will not allow the passage of an appreciable current, will answer the purpose.

Motor Speed Too High

1002. *What are the usual causes that tend to make a direct-current motor run too fast?*

Weak field magnets, too light a load, or too high voltage in the supply circuit.

1003. *Does a weak field magnet always cause a motor to run fast?*

A weak field magnet causes a shunt-wound motor to run fast if it is lightly loaded. If the motor is very heavily loaded, however, a weak field magnet will usually cause it to run slow. In case the field circuit is accidentally broken while the motor is running lightly loaded, it may even reverse its direction of rotation and run backward.

1004. *Is the speed of a motor likely to become dangerously high owing to the load being light?*

It is in the case of a series-wound motor, but not so in a shunt-wound motor. A series-wound motor is therefore generally geared or direct-connected to the load instead of being belted to it because if the belt should break the motor would increase in speed until the armature destroyed itself.

1005. *What special care should be exercised in running series-wound motors to prevent the load being removed?*

If the load is not direct-connected to the motor an automatic governor should be used in connection with the motor to reduce the current if the speed becomes too high.

1006. *What way is there of learning whether a high voltage in the supply circuit is causing the motor to speed up?*

Measuring the voltage across the supply wires with a voltmeter.

1007. *Where should trouble be looked for if a direct-current motor fails to start?*

An open circuit in the motor or in its connections to the supply wires; no current in the supply wires; improper connections; excessive friction between the moving parts; too heavy a load.

1008. *In what parts of a motor or in its wiring to the supply wires is an open circuit most likely to occur?*

One of the wires connecting the field winding or circuit may have slipped out of its connection, in which case the path [illegible] will not permit it. The brushes may not be in contact with the commutator. In the wiring to the supply circuit one or both of the fuses may be melted, the circuit breaker may be tripped or the main switch open.

1009. *What should be done in case an open circuit is suspected?*

Turn off the current, if need be, and examine the wiring and motor at the points mentioned in the previous answer. If they appear to be in good condition test the field circuit, armature, and connections to the supply wires by [illegible] a magneto bell as already described. If the trouble is not located, [illegible] the voltage in the supply wires.

Expensive versus Inexpensive Back Pressure

Several Interesting Examples That Were Taken from Actual Practice which Afford Reliable Information upon a Very Important Subject

BY W. H. WAKEMAN

This title may be considered a misnomer by readers who firmly believe that back pressure on the piston of an engine is always expensive, but this is not true, either in theory or practice, as it depends upon what use is made of the exhaust steam; for if all of it is utilized and live steam saved by the process, it matters not whether the back pressure is 1 or 10 pounds. There are cases, however, where back pressure is expensive and Fig. 1 illustrates one of them.

In this mill the exhaust pipe is 8 inches in diameter, and after the steam has passed through a suitable feed-water heater it is discharged into a vertical pipe fitted with a back-pressure valve as shown. Just below this valve there is an 8-inch tee that was installed for the purpose of securing exhaust steam for use in three vats. An 8-inch nipple was screwed into this tee, followed by an 8x6-inch reducing coupling. This carries a 6-inch nipple, followed by a 6x3-inch reducing coupling, after which 3-inch pipe was used and provided with three 1¼-inch outlets, one for each vat.

As the cylinder of this engine is 20 inches in diameter, and a heavy load is the rule rather than the exception, the exhaust pipe is none too large where it is 8 inches in diameter, with a cross-section of 50 square inches, but when the diameter is reduced to 3 inches with a cross-section of only 7 square inches, making a difference of 86 per cent., a very radical change has been made which is not warranted by the conditions of service. But even this great reduction of capacity is not prohibitive, provided good judgment is used in operating the device, for if a light weight is put on the back-pressure valve lever, limiting the pressure to 2 or 3 pounds a certain portion of the steam would go into the vats, and the remainder would be discharged into the air through the main pipe. This light pressure under stated conditions, however, would not supply the vats with sufficient steam to fulfil the requirements; consequently, the superintendent (who knew nothing about successful steam engineering) ordered the engineer to fasten the back-pressure valve lever down by means of a strong wire attached to a hook screwed into the floor, as shown. This created a heavy back pressure which caused more steam to be discharged from the cylinder, raising the back pressure still higher, until the engine speed was reduced enough to cause the safety-stop motion to operate and shut steam off from the cylinder. As feed water was passing rapidly through the heater and the vats were condensing steam at a high rate, a partial vacuum was formed in the exhaust pipe. Atmospheric pressure acting on the surface of material in the vats forced a thick, pulpy mass up into the pipes and heater.

Before starting the engine again, the engineer opened the back-pressure valve, but even then the piston moved slowly as if carrying an extra load, until there was a commotion in the heater, followed by a series of thumps on the roof, after which the flywheel speed was rapidly increased until the governor controlled the cutoff and the machines were running at normal speed. Investigation showed that a large quantity of partially manufactured material had been thrown out on the roof, and laborers were sent to reclaim it.

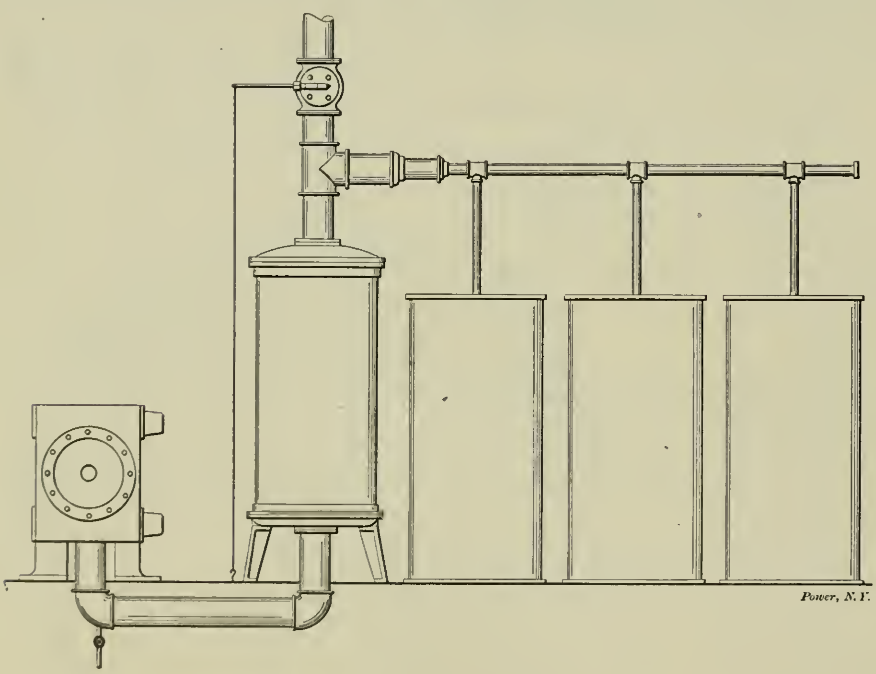


FIG. 1

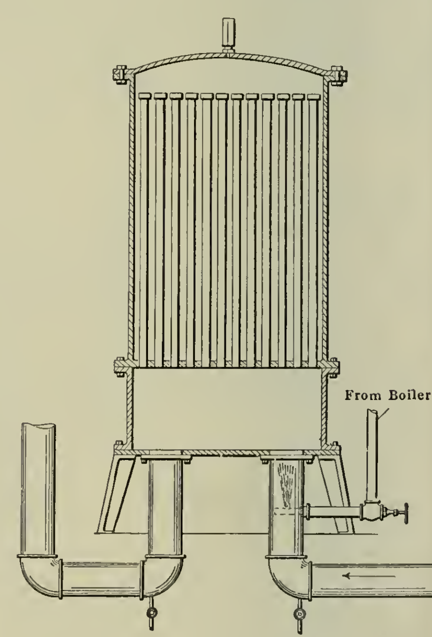


FIG. 2

Back pressure in this case was very expensive, although there was no necessity for it, as it was nearly all due to an inefficient system of piping. If live steam was to be used in these vats, the pipes would probably not be made smaller than 1¼-inch; and they were not increased for exhaust steam. If the outlet from this 8-inch tee had been continued full size as far as the third vat shown in the cut, and then reduced to 6 inches to convey steam to other parts of the mill, it would have proved much more satisfactory. The outlet to each vat ought to be 2½ inches in diameter, supplying four times as much steam as the arrangement shown, because a large quantity at low pressure would do the work well.

The adoption of this plan would make it possible to use all of the exhaust steam, provided it is needed in the vats, and if only a part of it is wanted here and elsewhere in the mill, the remainder would go to the atmosphere through the back-pressure valve, causing it to open at 2 pounds pressure.

A properly designed system of exhaust-steam piping costs more than pipes installed without system by a man who does the work in an ignorant manner, because he does not understand the requirements and makes no intelligent effort to find out what is wanted; but the results in practice will be much more profitable and satisfactory, because an abundance of steam will be available (provided a sufficient quantity is exhausted from the engine), there will be no useless back pressure and the engine will not be overloaded on this account, as it always was in the case mentioned.

Outlet Pipes Too Small

Fig. 2 illustrates a portion of the 8-inch exhaust-steam piping which conveys steam from another engine, with a cylinder 20 inches in diameter, through a feed-water heater of peculiar design and thence to the atmosphere, or to be partially used in heating the mill, as desired. Just beyond the heater and below the back-pressure valve, a 6-inch outlet is provided for conveying exhaust steam into a dry kiln, where much of it is condensed.

Another 6-inch pipe supplies heat for the mill, and out of this pipe numerous branches take steam for heating different rooms. This appears to be a good plan and it is, when the details are arranged to correspond, but it is not perfect in this case, because the pipes which branch from these 6-inch outlets are too small to convey all of the steam easily; therefore, it is necessary to carry a comparatively high back pressure in order to force steam to all parts of the mill, but owing to the lack of a steam gage on the exhaust pipe when the plant was examined, it was not possible to determine the exact pressure. It certainly was high because some of it escaped through a leak in a flange joint and came out with a sharp hiss that cannot be secured from steam at low pressure. A steam gage ought to be connected to the exhaust pipe of every engine (below the back-pressure valve), so the back pressure may be plainly indicated at all times. As this is not an expensive instrument, it is sure to prove a paying investment. It should be a low-pressure gage in order that the pointer may move a considerable distance for each pound, permitting its indications to be read easily.

The term "high pressure" as applied in this article to exhaust steam means 2 pounds or more above the atmosphere, and "low pressure" signifies less than 2 pounds. My reasons for this distinction are that a convenient line of separation is thus provided; also, because with a properly designed system of exhaust-steam piping less than 2 pounds is always sufficient to keep the pipes full of steam; consequently, anything in excess of this is properly termed "high pressure."

My attention was called to this plant by the cloud of exhaust steam issuing from the pipe above the engine-room roof on a cool day, as exhaust steam always seems to be of greater density and consequently more wasteful under such conditions than when a higher temperature of the air causes less rapid condensation.

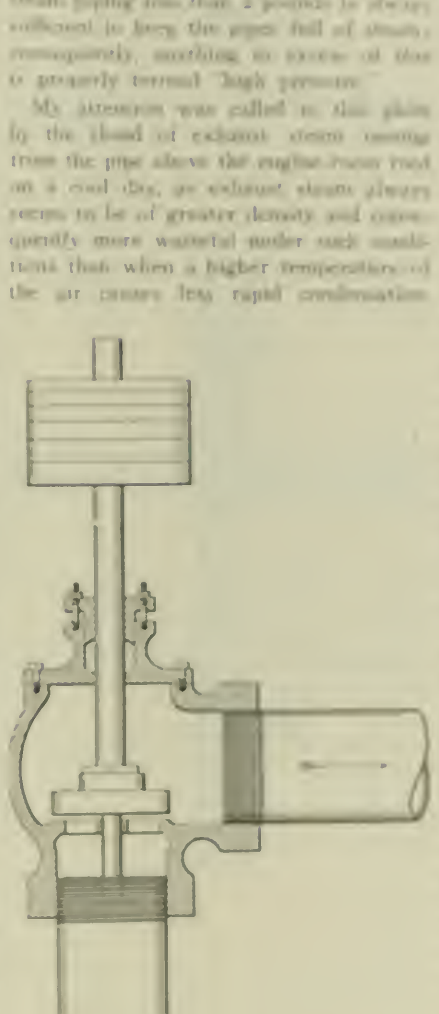


FIG. 3

Investigation showed that the back-pressure valve was not fastened open, as a casual observer might suppose, but was weighted down in the usual way. However, it opened at every stroke of the engine and allowed part of the exhaust steam to escape, while the remainder was used for heating purposes as stated. The valve was located above the roof where it was exposed to the elements at all times, and in order to change the weights or give it any other attention required, it was necessary to climb a ladder and walk several rods on a sloping roof, which was not desirable in cold and stormy weather.

Difference Between Dead-weight and Lever Valves

Fig. 3 illustrates the back-pressure valve formerly used on this exhaust pipe, although it was located under the roof. It is of the dead-weight type; therefore, the weight necessary to keep it shut under a given pressure is found by multiplying the area of the valve by the pressure. The area of this 8-inch valve is 50 square inches, and if the pressure is 5 pounds, it requires

$$50 \times 5 = 250$$

pounds to hold the valve down, including the weight of the valve. A certain engineer, when filling out an application for a license, stated that his safety valves were 4 inches in diameter and of the dead-weight type. If this statement was correct it would have required 1256 pounds of cast iron on the stem to carry 100 pounds on the boilers. The weight of the valve in this case would prevent it from opening until the pressure was slightly above 100 pounds, but this is necessary in order to secure the required boiler pressure without wasting steam through the safety valve. These valves were in reality of the lever type, thus differing materially from the dead-weight type, a difference which ought to be more thoroughly understood.

A few days after observing the cloud of exhaust steam, I secured indicator diagrams from the engine named while the back-pressure valve was closed, except when the pressure of exhaust steam raised it. Some of these are illustrated in Fig. 4 and they show nearly 5 pounds back pressure. Other diagrams taken the same hour with the valve open show practically no back pressure; therefore, the 5 pounds shown in Fig. 4 should be charged to the heating system. The power required to secure a portion of the exhaust steam for a useful purpose is found by multiplying the horsepower constant by the back pressure. The former is 4.127 for this engine; therefore, it requires

$$4.127 \times 5 = 20.6$$

horsepower to force steam through the small pipes. With the present system of piping in the mill the cheapest way to secure the required heat is to use the exhaust steam, although the conditions are unfavorable, and this was proved by allowing the engine to exhaust freely to the atmosphere, using live steam for heating purposes. Under these conditions it was necessary to maintain pressure enough on the boilers to keep the engine up to required speed, so the experiment was simple. It showed, as much more fuel was used than before.

Another point to be considered in this connection is that each horsepower is used to secure only one-half of the exhaust steam, while the other half is [illegible]; consequently the actual cost per [illegible] pounds of steam used for heating is just double what it would be if all of the exhaust steam was utilized. Fortunately, it is possible to prove [illegible] heating system for this mill that would use all of the exhaust steam in cold weather with one-half of the back pressure now carried, thus reducing the cost per 1000 pounds of steam used to one-quarter of the expense under present conditions.

The heater shown in Fig. 2 consists of tubes expanded into the middle head, with caps on their upper ends. Steam is discharged into these tubes and as they are surrounded by the cool feed water it is condensed and the resulting water falls downward, thus giving place to more steam. It heats the water to 200 degrees Fahrenheit. The angle valve shown is for the purpose of admitting live steam to the system when the engine is shut down. The connecting pipe, which is 1¼ inches in diameter, carries a 1½-inch bushing, to the inner end of which is fastened a brass nipple, whose inner end is securely closed by a plug. A hole was bored in this nipple and turned upward when it was put in, thus sending live steam in the proper direction to prevent any portion of it from going toward the engine, and almost the full boiler pressure is expended in sending steam through the pipe. If there is a chance to use a bushing about three sizes larger than the live-steam pipe, a long thread may be cut on the pipe and a cast-iron ell screwed onto the end, as the hole in the exhaust pipe will be large enough to admit the ell. It is possible to make one as illustrated in Fig. 2 without a bushing.

When the engine is started, live steam flowing through this fixture draws air, water and steam from the cylinder, thus assisting in heating the pipes quickly, without increasing the back pressure.

Care should be taken to know that the outlet of such a device is turned in the right direction, as otherwise it will do more harm than good. It ought always to discharge into the heater, as shown, in order to heat the feed water in case it is necessary to run the steam pump when the engine is shut down; and the pump should exhaust into the heater for the same reason.

Economical Exhaust-steam Heating

Fig. 5 illustrates part of the piping for exhaust-steam heating in a shop the machinery of which is driven by another engine with a cylinder 20 inches in diameter. After the exhaust steam is discharged from the cylinder it passes through a horizontal feed-water heater under the floor. It is then turned upward by an ell and, coming through the floor in the vertical 8-inch pipe shown, enters a cross. As the valve above this cross is now closed, the steam is divided and, passing out through two 6-inch pipes, goes into various departments in the shop. There is a valve in each of these branches by means of which the steam is shut off in warm weather. The weight which hangs near the floor, as all such

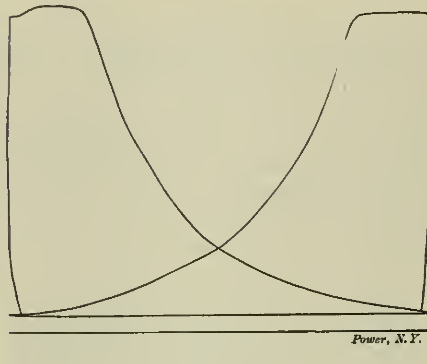


FIG. 4

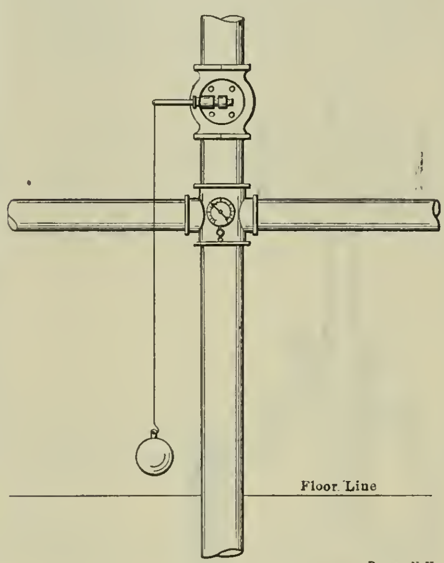


FIG. 5

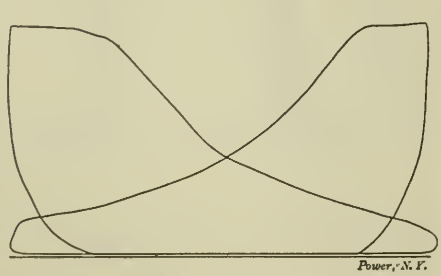


FIG. 6

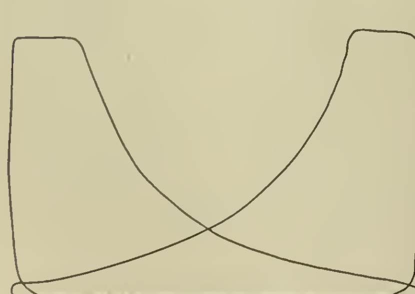


FIG. 7

weights should, is then removed and the valve is fastened open to allow free passage for the steam.

Fig. 6 shows a pair of indicator diagrams taken from this engine when the exhaust steam was used for heating purposes. They indicate not more than 1 pound back pressure. The horsepower constant of this engine is 5.994, therefore it requires

$$5.994 \times 1 = 5.994,$$

or say 6, horsepower to force all of this steam through the heating system. Even this power is not wasted, because all of the steam required to develop it is sent into the shop and utilized for heating the several departments. There can be no question about the economy of exhaust-steam heating in such a case, as there is no loss to charge against it.

Fig. 7 shows diagrams from a 16-inch engine, the horsepower constant of which is 2.12. The counter-pressure line is so near the atmospheric line that they barely form two separate lines. Measuring from center to center of these lines shows that the back pressure does not exceed 1 pound. This does not represent even a slight loss; neither would it if there was 5 pounds, because all of the exhaust steam is used for heating purposes. The heating system of this plant is unique, because all of the pipes are 6 inches in diameter, consequently there can be no contraction of area in the discharge lines.

The back-pressure valve and branch lines are illustrated in Fig. 8. A 6-inch pipe is large enough to allow all steam from a 16-inch cylinder to escape freely, but this soon branches into two 6-inch lines, giving the steam a still better chance to escape, especially when a portion of it is condensed in the heating process. This system was not efficient in practice because the steam expanded to a very low pressure and was all condensed before it filled the pipes. If there had been a greater load on the engine due to more machinery, or even a greater back pressure, the shop would have been heated much better, but the entire waste from this engine is used without cost.

Fig. 9 is a single diagram from another 16-inch engine. The horsepower constant is 2.923. About one-quarter of the steam from this engine is used for heating purposes and the remainder goes through the back-pressure valve. The heating pipes are small for the service required and a trap prevents the free escape of steam at the outlet, which in this case would be an advantage, and nothing would be wasted by such an arrangement.

Effects of Incompetency

The diagram shows about 2 pounds back pressure, therefore

$$2.923 \times 2 = 5.84$$

horsepower is required to force the steam through the system, proving very wasteful in practice. Coils of pipe were installed in one room for the use of live steam, but no trap was used in this case, and the men who occupied this room always opened the drip valve as wide as possible, thus wasting more steam. The combination found in this mill showed the effects of incompetency in designing and operating a heating system.

Fig. 10 is a diagram from the same engine after an incompetent engineer had been in charge of it for several months. Employees in the mill were cold because there was not sufficient radiating service to heat the rooms properly; consequently, they put more weight on the back-pressure valve lever, until the engine could not maintain its rated speed. Investigation showed that about one-third of the average pressure above the atmosphere was required to carry the useless load, even when the mean effective pressure was 100 per cent. higher than in Fig. 9.

The back pressure in Fig. 10 is 19 pounds, therefore it requires

$$2.923 \times 19 = 55.5$$

horsepower to dispose of the exhaust steam, which is much more than it ought to be. If this was the only loss due to bad conditions, it would be enough to warrant investigation and improvement, but the reduction of engine speed reduced the output of the mill, although the expense of operation was the same as before, and this is more serious than the cost of fuel to produce lost power. The back pressure was reduced to normal when the extra weights were removed.

The term "average pressure" is used advisedly in this case and it should not be mistaken for the "mean effective pressure," because they are not the same, although the difference is not always recognized; therefore, special attention is called to this point. The "average pressure" as used in this connection is represented by the average hight of the steam and expansion lines above the atmospheric line, while the "mean effective pressure" is the remainder after subtracting the average hight of the counter-pressure line from the foregoing result.

Where the counter-pressure line is nearly straight, as shown in Figs. 4, 6 and 7, the back pressure can be determined by measuring at the center, with the proper scale, the distance between the two lines; but when it is irregular, as in Fig. 10, the back pressure should be determined by the same method that is adopted for finding the mean effective pressure.

Fig. 11 illustrates a pair of diagrams from a 16-inch engine in a paper mill, with a No. 60 spring in the indicator. The horsepower constant is 2.023 and the back pressure is 8 pounds; therefore, it requires

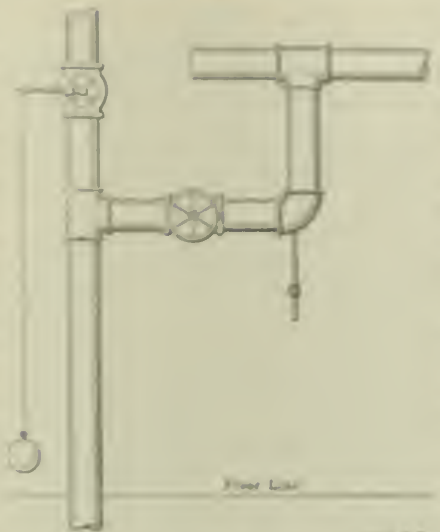


FIG. 8

FIG. 9

FIG. 10

FIG. 11

FIG. 12

$$2.023 \times 8 = 16.184$$

horsepower to dispose of the exhaust steam. Every pound of this steam is used in making paper, so no loss results from this back pressure.

Fig. 12 was taken from an engine used with a cylinder 14 inches in diameter, the horsepower constant of which is 1.4. At this time it was exhausting against 9 pounds back pressure; therefore, it takes

$$1.4 \times 9 = 12.6$$

horsepower to force steam out of the cylinder after its work is done. The mean effective pressure of these diagrams is 6 pounds, so the engine was developing

$$1.4 \times 6 = 8.4$$

horsepower in driving machinery. This demonstrates that the load due to back pressure above the atmosphere is 50 per cent. greater than the power required to operate the machinery. It does not necessarily follow, however, that this engine is run under wasteful conditions, and when these conditions are understood it is apparent that nothing is wasted in this connection.

During all the time that this back pressure is in evidence the exhaust steam goes into a heating system, where it is all condensed and the resulting hot water is returned to the boilers. During part of the time this is sufficient to do the required heating, but when the outside temperature is down to the freezing point, much live steam must be used to heat the buildings, and in zero weather more live steam than exhaust steam is used for that purpose; therefore, the steam required in the cylinder to overcome back pressure goes into the heating system instead of an equal quantity of live steam.

All the steam that is condensed in the cylinder of this engine is lost because the exhaust pipe is drained into the sewer. Steam is expanded to atmospheric pressure in this case, which is a condition that does not represent excessive cylinder condensation. When the point of cutoff in the cylinder of an engine is so short that the terminal pressure falls below the atmosphere and a loop is formed in the diagram, much steam is wasted in the cylinder, but no loop is formed here, except at one point, and that is not large enough to be seriously considered. The counter-pressure line crosses the expansion line in both diagrams, but these lines are wholly above the atmospheric line, being what is generally called [illegible]. If the back pressure were reduced the point of cutoff would be shortened, the terminal pressure would go below the atmosphere, causing more cylinder condensation, and the condensed water would go into the sewer, causing a direct loss of heat.

As a general rule the [illegible]

secure best results; but they close slowly here and no loss results from it. A more sharply defined point of cutoff would give a lower terminal pressure, the effect of which is explained in the preceding paragraph.

Pressure Wasted in Carrying a Useless Load

The single diagram shown in Fig. 13 was taken from an engine with a cylinder 12 inches in diameter, the horsepower constant of which is 1.6265. The back pressure is 5 pounds; therefore,

$$1.6265 \times 5 = 8$$

horsepower is required to overcome resistance to the passage of exhaust steam,

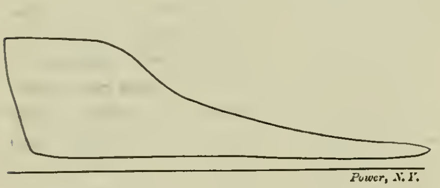


FIG. 13

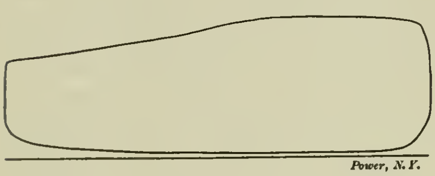


FIG. 14

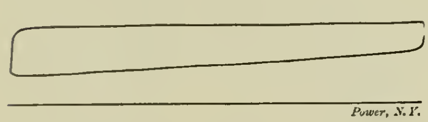


FIG. 15

and this is an unqualified loss because the steam is not utilized. This engine exhausts into a feed-water heater and the steam which is not condensed in heating water passes through a short pipe into the outer air; consequently, the back pressure is undoubtedly caused by contracted exhaust ports and passages in the engine.

The mean effective pressure is 26 pounds, therefore the average pressure above the atmosphere is

$$26 + 5 = 31$$

pounds. This demonstrates that about 17 per cent. of the average pressure as before determined is wasted in carrying a perfectly useless load. If this were eliminated, the point of cutoff would be shorter but the terminal pressure would not be low enough to form a loop in the diagram. Steam users should investigate this point when contemplating the purchase of an engine, as the defect illustrated in this diagram is a constant source of expense for which no benefit is secured. When more machinery is added to this plant, and there is no power to spare, this back pressure will become a greater detriment than at present, and a remedy is not easily secured in such cases, as a rule.

Fig. 14 is a diagram from another engine with a cylinder 12 inches in diameter. The speed is regulated by a throttling governor. A peculiar feature of this engine which is in contrast with the preceding case is the efficient way provided for allowing the exhaust steam to escape, for although the terminal pressure is nearly as high as the initial pressure, the line falls instantly at the completion of the stroke, and the average back pressure is only 4 pounds. The horsepower constant is 1.0988; therefore, it requires

$$1.0988 \times 4 = 4.4$$

horsepower to dispose of the exhaust steam. While this result is as good as could be expected with such a high terminal pressure, the power thus used is a total loss because the steam is discharged into the atmosphere after a portion of it is used to heat the feed water. The puffs of exhaust steam are sharply defined with clear spaces between them, which proves that the appearance of the exhaust steam from an engine is not an indication of its economy in the use of steam.

A peculiar feature of the diagram shown in Fig. 15 is that the load on the piston caused by resistance to the escape of exhaust steam is almost exactly equal to the load due to machinery in the shop, for this diagram was not taken from a direct-acting steam pump, as its appearance indicates, but from a throttling engine in a machine shop. It is not necessary to know the horsepower constant of this engine, nor the back pressure in pounds, in order to determine the comparative loads, for these are shown at a glance by the areas of the spaces which indicate these separate loads.

However, these are given as a matter of interest in this connection as follows: The cylinder of this engine is 10 inches in diameter. The horsepower constant is 0.6925 and the back pressure is 20 pounds; therefore, the load due to back pressure is

$$0.6925 \times 20 = 13.85$$

horsepower. The indicated horsepower is practically equal to this load. If the mean effective pressure is 20 pounds and the back pressure is the same, what causes the piston to move forward? This question will be asked by many readers, and in reply I would say that the mean effective pressure does not represent the force acting on each square inch of the piston area to move it forward. If it did, this engine would stand still; but the average pressure above the atmosphere is 40 pounds, and the back pressure is 20 pounds, consequently there is no mystery about the resulting motion.

Some Recent Developments in Marine Safety Valves*

The phenomenally rapid rate of evaporation attained by water-tube boilers fired with liquid fuel has made the safety-valve accumulation tests of such boilers an exceedingly onerous business. As is well known, the accumulation test consists of gagging every outlet from the boiler, except the safety valves, which must then be capable of carrying off all the steam generated when burning the maximum amount of fuel.

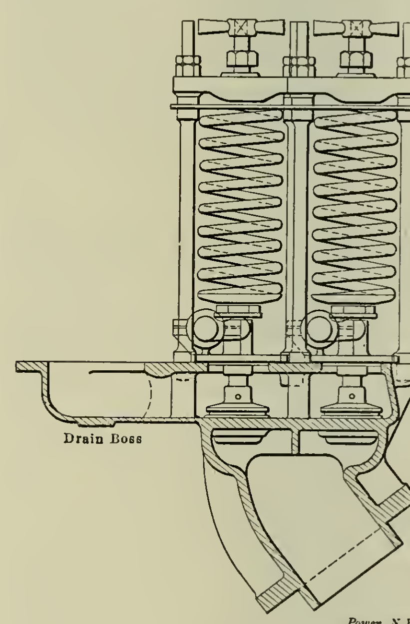


FIG. 1

The test generally lasts about 30 minutes after everything has settled down, and during this time the boiler pressure must not rise above a certain predetermined amount. Otherwise the safety valves are deemed to be inadequate for their duty, and either larger valves must be substituted, or certain other modifications made to the valve lips, the capacity of valve boxes, or the arrangement, size, and number of the waste-steam pipes.

An interesting series of experiments was recently carried out by Cammell Laird & Co., Limited, at its Birkenhead shipbuilding works, and we are enabled to give the results, which in many respects are remarkable, and indicate a striking advance in safety-valve design.

The boiler was a large unit, of the firm's well known "Express" type, capable of evaporating 61,000 pounds of water per hour when fired by liquid fuel.

The safety valve was quadruple, as

*J. Hamilton Gibson in *Engineering*.

shown in Fig. 1, and, as will be seen, was of the usual admiralty type, with exposed springs.

A preliminary test showed that the safety valves were incapable of carrying off the steam without undue accumulation, even when burning fuel corresponding to only half power. Calculations proved that the circumference and area of the valves were ample, but something evidently prevented them lifting to the required amount.

That something turned out to be the pressure in the valve box above the valves, which, though open to the atmosphere through the waste-steam pipe, rose to 60 to 70 pounds, and, acting on the top area of the valves, tended to keep them closed, thus forcing up the boiler pressure. There was the usual characteristic chatter of the valves on their seats, caused by the violent fluctuations of pressure in the box as the valve lips became exposed to the dynamic action of the escaping steam. By slightly easing the valves with the hand gear, and thus increasing their lift, the accumulation was kept within reasonable limits. This suggested the expedient of attaching to the easing gear a small piston, working in a fixed cylinder, and moved automatically by the steam pressure above the valves,

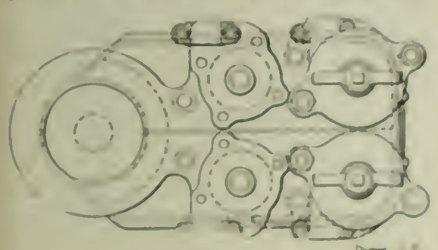


FIG. 2

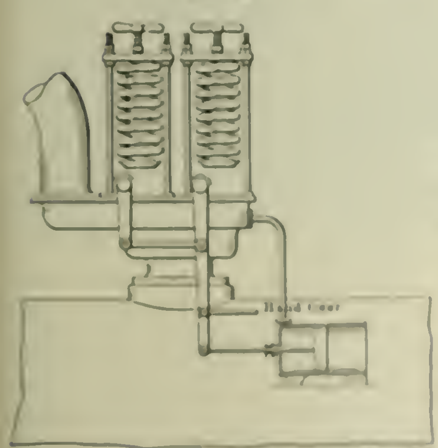


FIG. 3

as shown in Fig. 3. The device was successful, but was not considered a practical fitting, being extraneous to the safety valve itself. It was rightly concluded that any such device should be self-contained, and form part of the safety-valve fitting.

Accordingly, the modification shown in Fig. 4, suggested by Engineer-Commander Liversidge, was adopted, and proved entirely satisfactory. New covers were made containing on their inside a short cylinder, in which worked a closely fitting disk, the under side being exposed to the variable pressure in the valve box, and the upper side open to the atmosphere. The disk was rigidly attached to the valve, being, in fact, cast with it, and balanced the load on top of the valve, so that the valves were quite independent of any fluctuations of pressure above them, and lifted to the full amount permitted by the spring.

The time-honored lips at the rims of the valves and seats were cut away; this resulted not only in steadying the valves, but permitted them to close quietly without any appreciable drop. Incidentally, we may remark that this improvement is of equal importance to the increased lift attained, as the hammering of the valves on their seats is eliminated, and there is

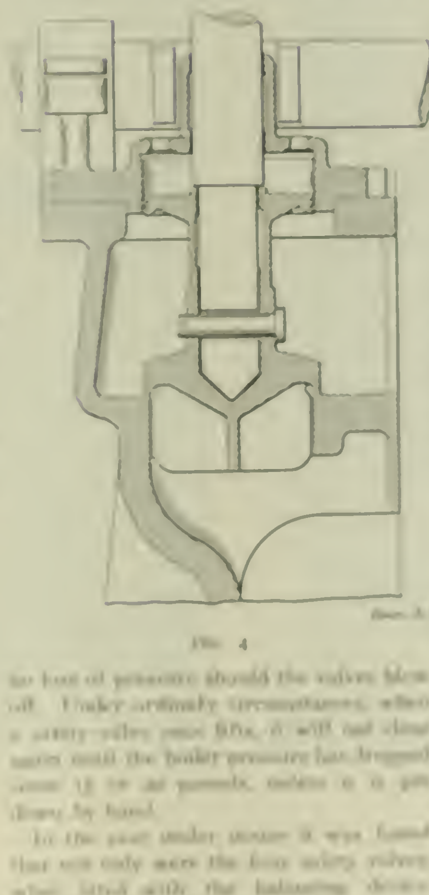


FIG. 4

no loss of pressure should the valves blow off. Under ordinary circumstances, when a safety valve once lifts, it will not close again until the boiler pressure has dropped some 15 to 20 pounds, unless it is put down by hand.

In the past under review it was found that not only were the four safety valves, when fitted with the balancing device, quite large enough to take away all the steam that could be generated without exceeding the limits of accumulation, but when one pair of the valves was gagged the remaining three were amply sufficient for the purpose. Fig. 5 shows the diagram from the results obtained on this boiler with only three valves and a single waste-steam pipe, whereas it was found at one time that four larger valves would be required, with a larger valve box having double waste pipes. Referring again to Fig. 4, it will be seen that if the diameter of the balancing disk is made larger than the valve, an augmented lift is allowed. This was clearly demonstrated during the series of tests, and offers a ready means of increasing the discharge, while still maintaining the valve at a steady, intermittent opening when the boiler is generating steam at, or above, full power.

On the whole, we think we are justified in the assumption that a considerable advance has been made in regard to marine boiler

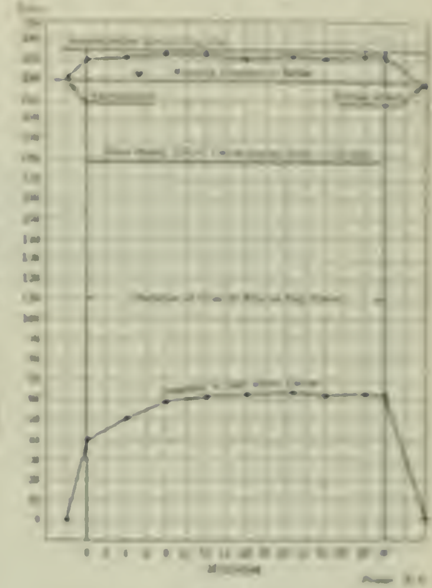


FIG. 5

safety valves, and that anything tending to reduce the size of these important fittings, which have been growing to abnormal proportions of late, is a step in the right direction.

Reading Ammeters and Voltmeters

To read an ammeter or voltmeter correctly the eye must be over the needle if the instrument is in a horizontal position, or directly in front of the needle if in the vertical position. The error in reading due to the wrong position of the eye is caused by the fact that the needle does not touch the scale. This error may be easily prevented by use of a mirror in the scale card. By looking at the needle and mirror so that the needle hides its own reflection, the correct reading will be obtained.

In order to avoid undue injury to instruments and incorrect readings the instruments must be handled carefully; they must be screened away from all magnets and conductors [illegible] when taking measurements an instrument must not be placed on a [illegible]; instruments should not be used on alternating-current circuits, and vice versa. The glass front of a meter should not be rubbed immediately before taking readings, because the pointer may be influenced by static electricity, causing [illegible] of the pointer [illegible] of the instrument.

Engineering in the Eighteenth Century

Interesting Facts about Steam Engineering Practice One Hundred and Fifty Years Ago, with Illustrations of the Quaint Engines Used

BY EDWARD P. BUFFET

The best cure for pessimism is to take a look back one or two centuries into the days of rack and thumbscrew. The best answer to the man who claims that this is not an enlightened age, mechanically, is to tell him something about the century before last. Just why steam engineering so long remained crude and undeveloped may be open to differences of opinion, though the prevailing view seems to be that it was because mankind were awaiting the appearance of POWER.

Records of eighteenth-century engineering are scarce, chiefly for the reason that there was then so little to record, but also because comparatively little of what then was done became embalmed in print. Specialized practical mechanical journals were, of course, unheard of. When an inventor was smitten with an uncontrollable attack of "itch for scribbling" he relieved himself either by writing a letter to the newspapers or else by seeking the patronage of some noble and "easy" lord for the wherewithal to confide his lucubrations to the public in pamphlet form.

For this reason it is a happy discovery when we unearth the files of any old periodical treating even occasionally upon engineering subjects. Probably not many readers of POWER have ever perused *The Universal Magazine of Knowledge and Pleasure,* a sixpenny monthly which was published in London, by J. Hinton, and lasted from 1747 to 1803, or longer. Many of its numbers contain descriptions, with copper-plate illustrations, of machinery used in its day, and these articles, although intended for popular reading, are presented technically enough to be instructive for the engineer. A set of the magazine constitutes, therefore, a most informing history of engineering progress in the eighteenth century. It is from skimming such a file that I propose here to serve up the cream.

The Newcomen Engine

In the very first volume of the magazine we find an elaborate description of "The Engine to raise Water by Fire"—in short, a Newcomen steam engine (Plate 1). Its writer may tell the tale in his own language:

"To the Authors of *The Universal Magazine,* Gentlemen:

"I have observed in the Circle of my Conversation that it appears very mysterious to those who are not learned in Hydraulics, how a Town or a House can be supplied with Water from a River, or Spring, that is in a Situation much below the Place into which it runs; when it is very certain that Water is of that heavy Nature as always to descend, when left to its own Course. Therefore I have sent you inclosed a Draught and Description of an Engine invented for this Purpose. And, though there are many other Sorts, I have rather selected this particular Engine because it is the most admirable, curious and compounded Machine amongst all those Inventions which have been owing to modern Philosophy, and affords the greatest Advantages to Mankind; as could be exemplified from the Water works near Chelsea, on the West of this great City, and again by those lately erected near Stratford in Essex, on the East of London, which are able to supply the adjacent Country, several Miles in circumference, with the necessary Provision of good and wholesome Water, at a moderate Charge, which before was wanting, both for household Service and in the Danger and Loss by Fires. To this I could add the Impossibility of working several Collieries without its Assistance, as the Proprietors of Elsick, Heaton, Biker &c. near Newcastle upon Tyne, can bear me witness. This Engine also is improveable for many other great and valuable Uses, as the Reader will be able to judge, when he has well considered what follows.

"About the year 1663 the Marquis of Worcester, having proposed, in print, the raising of great quantities of water by the *force of fire, or by turning water into steam,* mentioned an engine of that kind, at that very time in being, which could raise a continual stream, like a fountain, 40 feet high, by the means of two cocks, which alternately and successively were turned by a man to empty the hot, and to force and refil the vessel or cylinder with cold water, the fire being continually kept up; I must adjudge this invention to that noble Lord, tho' it must with justice be confessed that it has received many improvements since his time.

"This invention, great as it was, lay dormant, till Capt. Savery, treasurer to the sick and wounded office, having read the Marquis's book, took the hint, and pretended to find out the secret of nature by such a chance as upon experiment is found could not give him any such idea; and to secure the credit thereof to himself, he bought up, and burnt all the Marquis's books he could find. Thus Capt. Savery claimed the credit of this machine to himself, and obtained a patent for the sole erecting thereof, as I have been told."

Our writer informs us that the captain made a good many experiments to bring this machine to perfection and that he erected several with good success on gentlemen's estates, but "he could never bring it to bear for working of coal pits or mines, or to supply towns with water, where the water was to be raised high and in great quantities; because such a work required a steam too dangerously strong to be attempted in his way.

"These discouragements had certainly sunk this necessary machine into oblivion had not Mr. Newcomen, an ironmonger, and John Crowley, a glazier, at Dartmouth, about 35 years ago removed the objections, by improving it to its present state, or rather by inventing a new machine, which is the same you perceive herewith.

"This improvement differs much both in point of method, and in regard to the force of the engine first erected; but yet it is wrought by the same power, which is the expansion of water into steam, raised by fire.

"Now to describe *this engine: B* is a large boiler, whose water is converted into steam. *C C* is the cylinder. *D d* a pipe, about 4 inches diameter, joins them together; on the lower orifice of which, within the boiler, moves a broad plate *E,* by means of the steam-cock or regulator *10,* which keeps in or lets out the steam occasionally.

"The steam of the boiler ought always to be a little stronger than the air, that, when let into the barrel *C C,* it may be a little more than a balance to the pressure of the external air, which keeps down the piston at *d n.* The piston being by this means at liberty, the pump-rod will by its great weight, of at least 9 or 10 hundred of iron, descend at the opposite end to fetch a stroke; but, as the piston and weights at the other end do not exceed half that weight, the end of the lever at the pump will always preponderate, and descend when the piston is at liberty.

"When the piston, by pulling back the handle *10* is got up to the *C,* or a little higher, the plate of the regulator stops all communication of steam with the cylinder. Then the lever, commonly called the *F*, under the said handle, must be lifted up, so as by its teeth to turn the key of the injection-cock at *N*, and that will permit the water brought from the cistern *g*, by the pipe *g M N*, to enter the bottom of the barrel at *n*, which jet of cold water being driven all over the cylinder, condenseth the steam into water again by its coldness, and, as by this means its bulk is become 14,000 times less than it had when steam, it makes a *Vacuum* sufficient for the pressure of the atmosphere to act again unbalanced, and chance to be too full will run down the pipe *V* to the waste well at *Y*.

"*F f* is a pipe about 3 feet long, going a foot within the water in the boiler, to supply the water which is wasted in generating steam; *f* is a cup at the top of this pipe, and is supplied with tepid water from the cup *I* at the top of the cylinder. *G* represents two Gages of different lengths, to prevent the surface of the water from being too low or too high: which is known thus. If the stop-cock of the shorter pipe, being opened, gives only steam, and that of the longer, only than the air, may burst the boiler. The method of trying this strength is to lay a piece of lead fastened to the wire upon the valve; and if the steam shall raise up more than 15 pounds weight of lead to an inch square (which is the weight of air, nearly, on every inch square) it is known to be stronger than the air. For tho' the steam is of a variable strength, it is never 1/10 stronger or weaker than common air; it having been found by experience, that an engine will work well with one pound weight on every square inch of the valve *k*. [illegible] that the

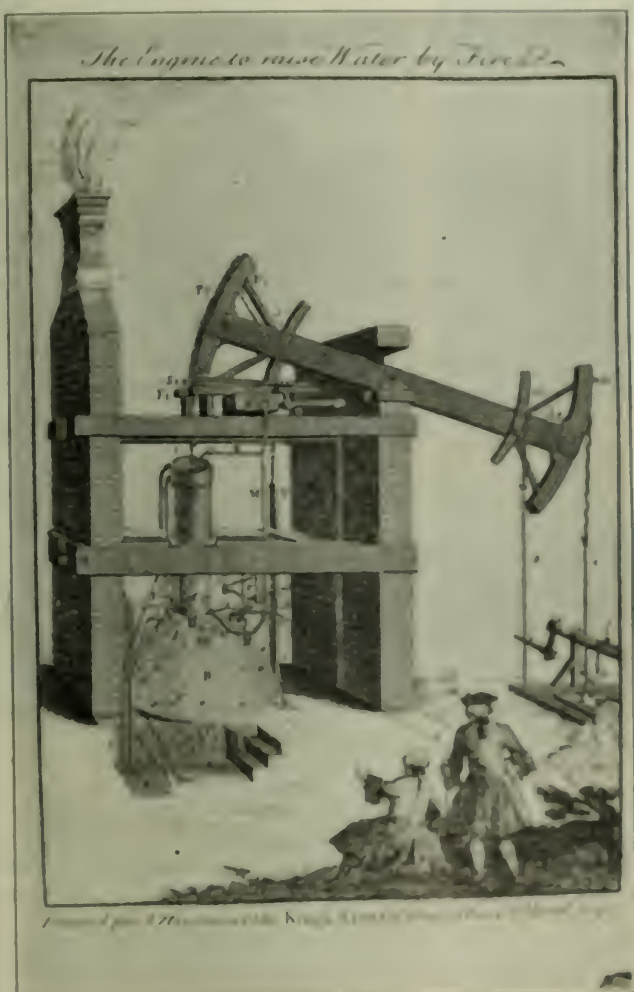


PLATE 1. THE NEWCOMEN ENGINE

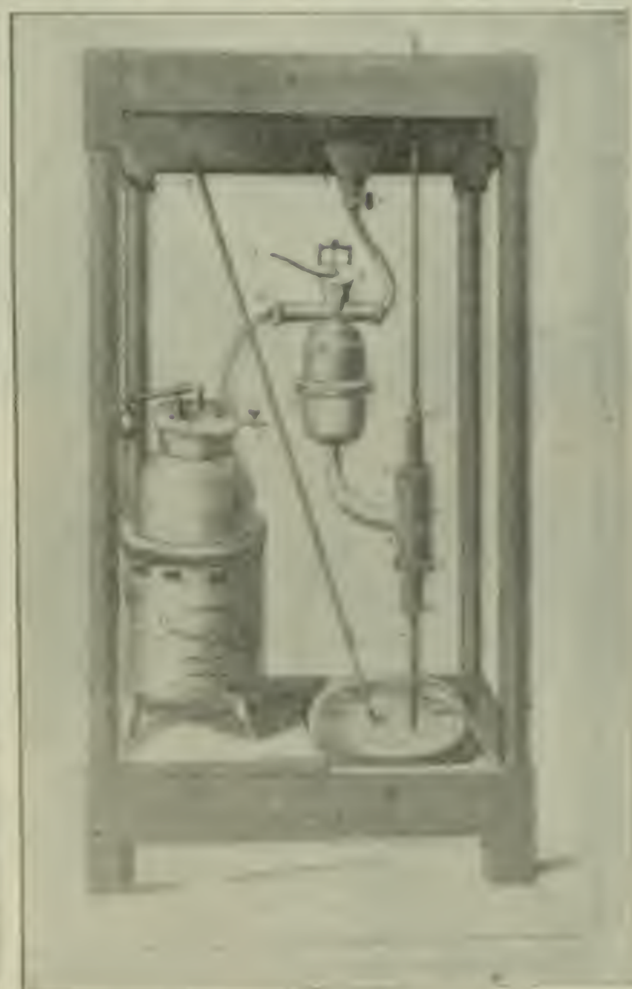


PLATE 2. THE SAVERY ENGINE

to raise the other end of the beam with its pump to discharge the water at *A*. And this whole operation of opening and shutting the steam-regulator and injection-cock, being performed in little more than 3 seconds, it will easily produce 16 strokes in 1 minute.

"The cistern *g* is supplied with water from a well or pit near the mouth [illegible], by means of pistons and the pump-rod *k*, fastened to the arch [illegible], and, that the leathers of the piston *C* may be always air-tight and supple, it is supplied with a small stream of water by the arm [illegible] from the pipe *M*. The *I* at the top of the cylinder is a cup or hollow to hold the water that lies on the piston, which if it water, all is right; but if both cocks give steam, then the surface is too low; or, if both give water, it is too high. Hence the cock which feeds the boiler at *F* may be opened to such a degree, as always to keep the surface of water to its proper height.

"*X Y Z* is the Eduction-pipe to carry off the cold water ejected into the cylinder to condense the steam. It is turned up at the bottom in the well *Y*, with a valve to prevent the air pressing up into the pipe, which might hinder the discharge of the water.

"*x* is the puppet-clack or a valve to try the strength of the steam; which, if it be too strong, or inconsiderably stronger [illegible] stronger than common air.

"The small pipe *q*, on which is a small cap, is called the snifting-clack, and serves to let out the air mixed with the water, [illegible] than the outward air.

"In the infancy of this mechanical invention, the regulator and injection-cock, as I should before, were managed by a man, [illegible]

"Thus you see a chain fixed to the arch *Z*, at a proper distance from the arch *P*, to which chain is hung a working-beam *Q*. This beam goes quite down into a hole in the ground, which it exactly fits. This piece has a long slit in it, and several pin-holes and pins, for the movement of several small levers, by which the said cocks are opened and shut, as the service requires. It is called the *Working-plug*; which being once set a going according to art, this engine is most harmless and manageable of all others.

"This machine thus prepared, and set a going, may work about five hours upon a stretch. It will of itself give notice when to stop working; for, if you perceive the *Gages*, as mentioned before give steam, you must replenish the boiler, or it will be in danger of bursting, for want of a due supply of water.

"I will therefore conclude this theory of the *Engine to raise water by Fire*, with practice; for with large boilers, the piston will make 20 or 25 strokes *per* minute; and a pump of nine inches bore will discharge more than 320 hogsheads per hour: So every other size in proportion."

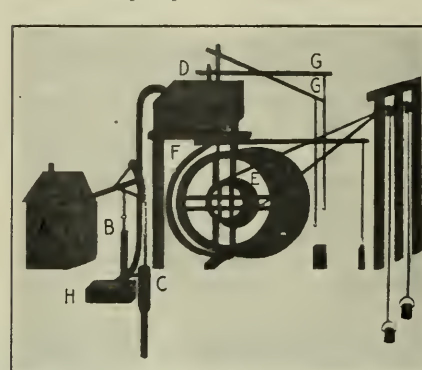


PLATE 3. WORKING MINE WITH NEWCOMEN ENGINE

A CALCULATION OF THE POWER OF FIRE-ENGINES.

Diameter of Bore.	Will Hold in a Yard.	Will Draw by a 6-Feet Stroke.	Weighs in One Yard.	At Sixteen Strokes a Minute.	63 Gallons to a Hogshead		In One Hour.		Diam. of Cyl., Inches. The Depths in Yards.												
In.	Gal.	Gal.	Lb. Aver.	Gal.	Hog.	Gal.	Hog.	Gal.	15	20	25	30	35	40	45	50	60	70	80	90	100
12	14,4	28,8	146	462	7	21	440		18½	21¾	24	28½	30½	32½	34¼	37¼	40				
11	12,13	24	123,5	338	6	20	369	3	17	19¾	22	24¾	26¼	28	29¾	31¼	34¼	37	39½		
0	10,02	20,04	102	320	5	5	304	5	15½	18	20	22	23¾	25¼	27	28¾	31¼	33¾	36	38	40
9	8,12	16,2	82,7	259,8	4	7	247	7	14	16¼	18	20	21½	23	24½	25	28	30½	33	35	36½
8½	7,26	14,5	73,9	232,3	3	43	211	2	13½	15¼	17¼	19	20¼	21¾	23	24	26¼	28½	31	32½	35¼
8	6,41	12,8	65,3	205,2	3	16	195	2	12½	14½	16½	18½	19	20½	21½	23	25	27	29	30½	32½
7½	5,66	11,3	57,6	181,1	2	55	172	3	11	13¾	15	16½	18	19	20	21¼	23¼	25	27	28½	30¼
7	4,91	9,8	50,0	157,1	2	31	149	4	10¾	13	14	15½	16¾	18¾	19	20½	22	24	25½	27	28½
6½	4,23	8,4	43,0	135,3	2	9	128	5	10	12	13	14	15½	16¼	18	19	20	22	23	24½	26¼
6	3,61	7,2	36,7	115,5	1	52	110	1	9½	11	12	13	14	15½	16	17	19	20½	22	23	24½
5½	3,13	6,2	31,8	99,2	1	36	94	3		10	11	12	13	14	15	15¾	17	19	20	21	22¼
5	2,51	5,0	25,5	80,3	1	7	66	6			10	11	11¾	13	13¾	14	15½	16¾	18½	19¼	20¼
4½	2,02	2,4	20,5	64,6	1	1	60	6				10	11	11¾	12	13½	14	15	16	17	18¼
4	1,6	3,2	16,2	51,2	0	51	48	51					9	10	11	11½	12	13½	14	15	16

AN EXAMPLE FOR THE USE OF THE TABLE.

Suppose you require 150 hogsheads per hour, at 90 yards deep; in the 7th column I find the nearest number 149; and against it, in the first column, I find a 7-inch bore for the pump; then under the depth 90, on the right hand, in the same line, I find 27 inches for the diameter of the cylinder, fit to raise 150 hogsheads per hour. And thus any other number in this table may be found.

Mr. *Henry Beighton's* most curious and useful table to calculate the power of fire-engines, according to the various diameters of the cylinder, and bore of the pump, that are capable of raising water from 48 to 440 hogsheads *per* hour, at any depth from 15 to 100 yards.

"He founds his calculation upon this principle, That the ale gallon of 282 cube inches of water weighs 10 pounds 3 ounces *avoirdupois*, and a superficial square inch is pressed with the weight of 14 pounds 13 ounces of air, when of a mean gravity. But, allowing for several frictions, and to give a considerable velocity to the engine, it is found by experience, that no more than 8 pounds of pressure must be allowed to an inch square on the piston in the cylinder, that it may make about 16 strokes, about six feet reach, in a minute.

"But it must be also observed that these calculations are only for common

The Savery Engine

Twenty-seven years after its account of the Newcomen engine, the *Universal Magazine*, February, 1774, contained a description of the older type of engine exploited by Capt. Savery. This later article cites the former one as if only a short interval had intervened since its publication, and the incident thus furnishes striking evidence of the lack of progress in steam engineering at that period—aside, of course, from Watt's researches, which are another story. Referring to Plate 2, I quote:

"The method of constructing a fire-engine according to the original institution of the Marquis of Worcester and Captain Savery, wherein the water was to be raised solely by the pressure of elastic vapor or steam, is very useful and very cheap in respect to the other sort, and, when the height to which the water is to be raised does not exceed one hundred or one hundred and fifty feet, then this engine is applicable with great advantage, it requiring but a small fire, not bigger than what is generally used in a parlour-chimney; is of a very simple and easy structure, and admirably adapted for supplying a Gentleman's house with water, and for playing of fountains to a very great height.

"*A* is a boiler; it has a copper cover screwed on, which contains the steam pipe *G G*, and two gage-pipes *C*; on the cover at *C* is a valve, over which lies a steelyard with its weight to keep it down, the strength of the vapour being this way most exactly estimated.

"The steam is carried from the boiler to a copper vessel *H* by means of the pipe *G G*, and is let into the same by turning the handle *L*.

"The receiver *H* communicates at bottom to the sucking pipe *I B* going down to the water in the well *R*, and above with the forcing pipe *O O*: Between these two pipes are two valves, *N P*, both opening upwards. The steam, being let in upon the water of the receiver *H*, forces it up through the valve *O* and the pipe *O O* to the reservoir *S*. The steam in the receiver is condensed by a jet of cold water coming from the forcing pipe by the small tube *X Y Z*; the handle turned from *Y* admits a passage to the steam into the copper receiver *H*: This steam in the receiver is condensed by a jet of cold water being let in and shut off by a cock at *Y*. The steam, being condensed by this jet, will be reduced within a very small space, and so make a vacuum, upon which the water in the well will rush up the forcing pipe to restore the equilibrium, and thus again fill the receiver *H*, the little air being compressed within a small compass at the top of the receiver *H*.

"*F F* are registers for regulating the fire in the furnace: *B* is a cock inserted into the boiler: *D* is the hearth, and *E* the ash-hole.

"*T V* is a pipe for carrying back the water in the reservoir *S*, when this instrument is used only for making experiments: *Q S*, is the frame of the instrument."

Improved Method of Applying the Power of a Newcomen Engine in Mining

In February, 1782, we find shown "A new Machine, or Fire Engine, invented by Mr. Hunt, of London, for draining Mines and Coal Works, and at the same Time raising the Ore or Coal from the Bottom of the Mine to Surface, without the assistance of any additional Fuel."

This improved mechanism dispensed with the use of a number of horses required under the older, and less economical system. To Plate 3 are given the following references:

"(*A*.) The common steam, or fire-engine, for draining mines and coal works.

"(B.) The force-pump, which receives the water that is raised from the mine by the main pump (C) and forces it up into the large back or cistern (D).

"(E.) The water wheel. The wheel is of a peculiar construction, having two tiers or rows of buckets, the one formed with their mouths upwards, the other

PLATE 4. COOKE'S ROTARY STEAM ENGINE

with their mouths downwards, by which means the wheel is made to move alternately by the right and left. On the same axis that carries this water-wheel, another wheel is fixed, (but of smaller dimensions) by which the rope is coiled or wound round, at the end of which are suspended the buckets that bring up the ore or coal. These buckets, by the alternate motion of the water wheel, constantly ascend and descend.

"(F.) A strong wooden lever, which being pressed hard against the sides of the water wheel, by means of a man pulling a rope, immediately stops its motion and gives time to the man who attends to unhook the loaded buckets.

"(G, G.) The two levers belonging to the sluice-gates, which being alternately pulled up, let out the water on the wheel or water-wheel.

"(I.) A strong wooden [illegible], [illegible] two feet below the surface of the earth, to receive the water that is [illegible] up from the mine or pit by the [illegible] pump. Into this cistern the lower end of the force pump is fixed."

John Cooke's Rotary Steam Engine

This single machine is found in the Universal Magazine, 179[illegible]. I illustrated it in Power, April, 1904, but it will bear repetition. Referring to Plate 4, the casing of the engine is a closed cylinder provided with hinged blades which open to a radial position or fold flat on the circumference as the wheel turns. Steam enters the casing at the lower left-hand corner

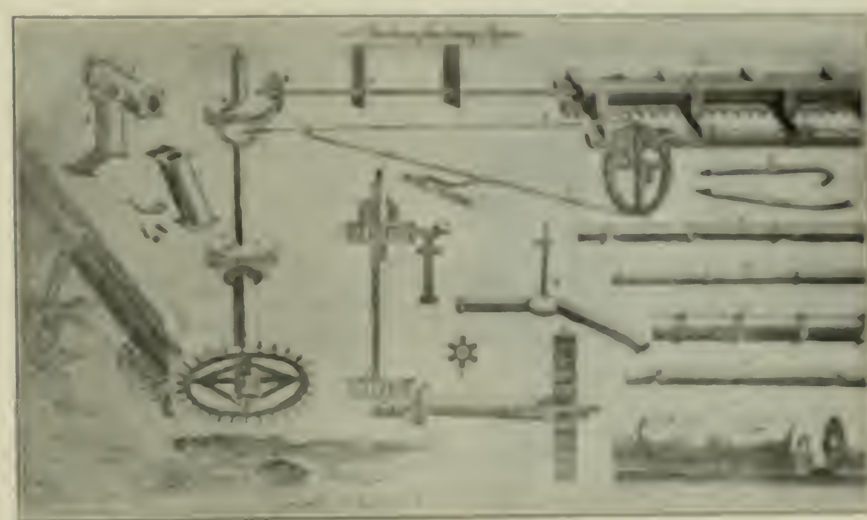


PLATE 5. [illegible] AND ITS MANUFACTURE

and is exhausted at the lower right-hand corner. The rod *h* is a connecting rod from a crank upon the axis, to work the condenser, i.e., (presumably) to drive a circulating pump.

The Art of Piping

A machine for boring pipes was described (February, 1754) and is shown in the accompanying Plate 5. The water wheel in the southwest corner of the picture drives a set of cog gearing with results which are pretty apparent upon inspection. The pipe is made of a wooden log laid on a carriage which is advanced to meet the auger by a ratchet and-pawl feed. The pawls *D*, *E*, which pull and push respectively, are shown in an enlarged detail view. The auger is 9 to 12 feet in length and "of a proportionable bigness."

The same plate contains figures showing several examples of piping used at the time it was published. *T* is [illegible] piping; *M* lead piping; *N* [illegible] iron pipes; *O* wooden piping; *P* wooden piping of a larger size. In the northeast corner will be seen some sections of iron pipes with bolts and screws indicating the manner in which they are to be coupled.

Holland's Quadruple Pump

An ingenious hydraulic machine was illustrated in August, 1755, designated as "Mr. Holland's Engine, at [illegible], for raising Water." We present it in Plate 6.

[illegible] the [illegible] of the [illegible] [illegible] in [illegible] [illegible] feet long and 24 inches diameter.

"C, C, C, C, an undershot wheel, 30 feet diameter, the ladles of [illegible] [illegible] feet [illegible] [illegible] feet [illegible].

"D, E, F, G, four moveable rings or cil[illegible] placed on the shaft, [illegible] [illegible] feet [illegible] inches [illegible].

"H, I, K, L, four [illegible], rising and falling alternately by means of these cil-

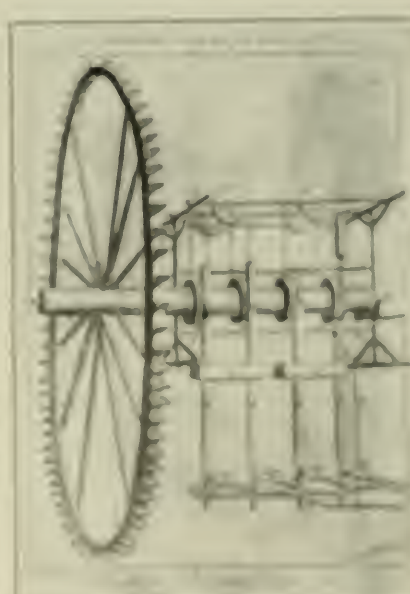


PLATE 6. HOLLAND'S QUADRUPLE PUMP

[illegible] [illegible] [illegible] [illegible] [illegible] by the [illegible] and the [illegible] of the [illegible] [illegible] [illegible] [illegible] at *D*, *E*, *F*, *G*. The [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]. As the [illegible] [illegible] [illegible], the wheel will [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] *F*, [illegible] of [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] *K* at *a* [illegible] [illegible] [illegible] end of the [illegible] in the [illegible] *L* [illegible] [illegible] [illegible] the [illegible] *K*, [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] of the [illegible] *L*, and [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] half; by which time the collar G will have carried its trigger 2 up to the bar $i\,i$, which will unlock its trigger; and the trigger 3, in the collar F, will be brought backward down to Y, and there lock the collar F. Then, the motion continuing, K will be depressed four feet and a half, and the chain $I\,I$, over the pulley R, will raise L four feet and a half. And thus the two forcers and collars continuing ris-

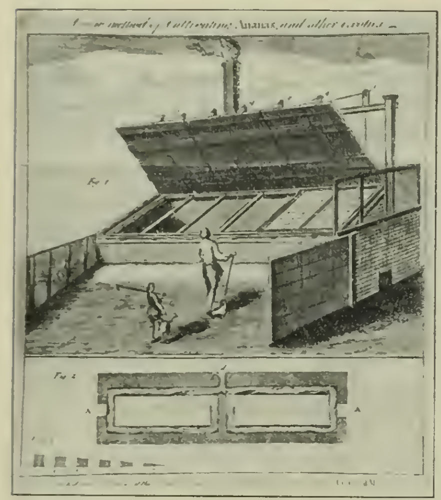


PLATE 7. HEATING A GREENHOUSE

ing and falling, moving forwards and backwards, locking and unlocking alternately.

"And in like manner, the other two collars, D & E, move with their forcers, H and I.

"But to prevent one collar's moving the backward way, faster than the other moves forwards, there is a gauge-chain 4, fixed to the collar G, passing over another pulley T, to the collar F at 5, which regulates their motions. These chains are lengthened or shortened by screws, as occasion requires.

"M, N, O, P, are four brass cylinders, or pumps, seven feet long; the bores of M and N are six inches diameter, and those of O and P seven inches and one-quarter; having, at l, l, l, l, each a valve below, which are for taking in the water; and at m, m, m, m, valves in the horizontal parts.

"The branches mn, mn, mn, mn, communicate the water of their two forcers by mn, mn, and so with two pipes, o, n. These two pipes o, n, join together, at a small distance beyond what is represented on the plate, so that the whole water is forced along one pipe; which makes a jet *d'eau* of seventy feet, and raises the water to the house about seventy feet perpendicular.

"Ninety-five hogsheads are forced up, per hour, to the jet *d'eau*, and forty-seven to the garden.

"g, h, are two cisterns, supplied by a pipe p, to keep the forcers or pistons always wet.

"$a\ b\ c\ d\ e\ f$ is a frame of wood to carry the pullies Q, R, S, T, and the bars i, i, and K, K.

"The water-wheel goes about five times per minute to force the water to the house; and three, when the water is raised eighty feet to the gardens."

I would respectfully call Mr. Holland's attention to a book of machines published by Agostino Ramelli in 1588, which shows a pump of startling similarity in appearance.

"Machine To Travel without Horses"

The foot-power cycle, even with some of its more complicated modern features, was known long ago. Several such vehicles are described in the *Universal Magazine*. One of them, illustrated in 1774, was the invention of Mr. Ovenden. It comprised a four-wheeled carriage in which one or two gentlemen could ride at pleasure while a footman, seated behind, trod upon levers actuating the rear axle by ratchet clutches after the manner of the old "Star" and "Springfield Roadster" bicycles of our boyhood days. "The above machine," says the writer, "is doubtless the best that has hitherto been invented, since it is capable of travelling with ease, six miles an hour; and, by a particular exertion of the footman, might travel nine or ten miles an hour on a good road, and even would go up a considerable hill where there is a sound bottom. But this carriage is in general only calculated for the exercise of Gentlemen in parks or gardens, for which it answers extremely well."

One might have supposed that it was the footman who got the exercise.

Furnace Construction, Ventilators, etc.

Long before the days of steam heating the art of warming greenhouses was known. From the magazine for March and May, 1751, are taken two illustrations showing hothouses with furnaces built into their walls, and the arrangement of the flues. See Plates 7 and 8.

Nor were there lacking power-driven blowers for ventilating purposes. Such a system was installed for changing the air of Newgate prison, which had become a stench in the noses of citizens dwelling in its vicinage and, worse yet, found its way into the courthouse, jeopardizing the health of honorable judges and counselors learned in the law. To these circumstances may be attributed the philanthropy which prompted the installation, for it would have been more consistent with the penal discipline of that period to pump foul air into the jail than to remove it.

The ventilating blowers, as described in the magazine for June, 1752, and April, 1764, comprised rectangular boxes with hinged diaphragms inside and crude valves. On the prison building, adorned with statues of Justice, Mercy, Truth and *Liberty*, was mounted a windmill to drive the blowers *when the wind blew*. The system did not prove a wild and delirious success.

I fear that the editor will not allow me space to describe any more of the antique mechanical contrivances that are found in the volumes of the old magazine. Among the subjects described and illustrated are a windmill in a smokestack; a testing outfit for "examining the goodness and strength of ropes;" a rolling and slitting mill; a paper mill; the working of iron mines; clock and watch manufacture and electrical experiments; also many improved agricultural machines.

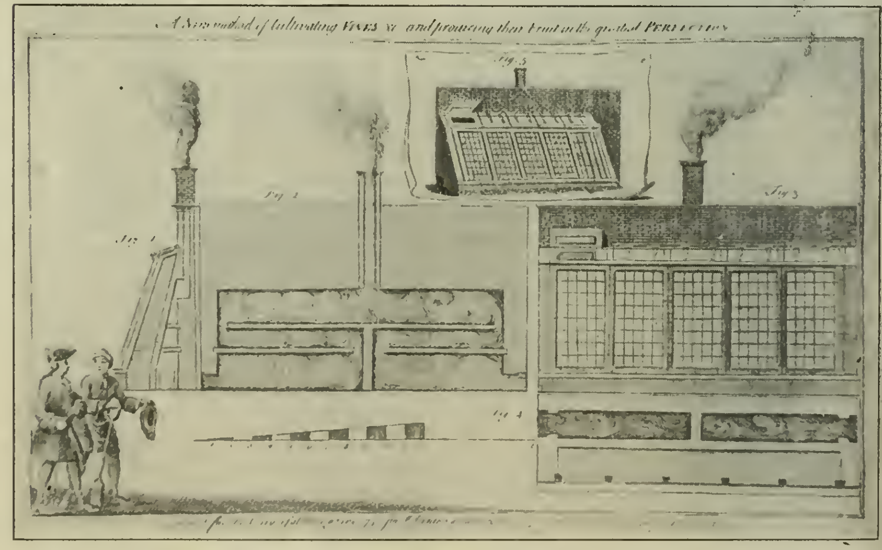


PLATE 8. ANOTHER GREENHOUSE HEATING SYSTEM

To the eighteenth century must be allowed credit for making the steam engine an accomplished fact, and that is no small praise. Yet otherwise we are impressed with the stagnancy of mechanical arts in that period. From the eighteenth to the nineteenth centuries engineering progress was vastly greater than for several hundred years previous.

Purge Device for Ammonia Condensers

By F. E. Matthews

Given two batteries of ammonia condensers, one of eight and the other of two stands, with ½-inch purge valves on the discharge lines leading to each separate stand of condensers: If the ½-inch valves be connected to a header leading to a vertical cylindrical tank 10 inches in diameter by 6 feet high, over which cooling water is run, would it be possible to blow off the air without shutting down the plant? Will the tank fill up with gaseous ammonia? Will the cooling water be necessary? Can the valve at the bottom of the tank be left open all the time?

In answer to these questions it may be said that the object of purge valves on an ammonia condenser is to enable the engineer to blow off the *permanent* gases that accumulate in the system. These gases may be of two different origins. They may be due to the decomposition of ammonia, in which case they constitute a mechanical mixture of hydrogen and nitrogen, or they may be little more than air which has got into the system accidentally when some part has been opened up for repairs, or through leaks around the ammonia rods when a vacuum has been pumped on the system.

Now, it is a common fallacy that air is lighter than ammonia and that it will accordingly flow to the highest point in the system, or more accurately speaking, that it will be freed to the top because of the tendency of the heavier gases to gravitate to the lower parts of the system. This fallacy is particularly in evidence in view of the fact that almost everyone implies a knowledge to the contrary by looking for more pure air near the floor when necessity requires that they work in an atmosphere heavily saturated with ammonia.

Compared to air the specific gravity of ammonia is 0.589, which means that, other things being equal, the ammonia of an air and ammonia mixture will flow to the top and the air to the bottom of the containing vessel. Air does, nevertheless, collect in the condenser whether it be the highest point in the system or not. The reason for this is that it is carried along with the ammonia gas, and the gas, being liquefied in the condenser under the proper conditions of temperature and pressure, leaves the air behind. It might tend to gravitate out of the condenser at the bottom, but it would be prevented from doing this by the presence of the liquid ammonia, which, although it is comparatively light for a liquid (having a specific gravity of 0.6 as compared with 1 for water), is still many times heavier than air. Furthermore, ammonia condensers are usually built so that the outlets are liquid-sealed, making the escape of a gas in that direction impossible.

As a matter of fact, the permanent gases most commonly encountered in ammonia-refrigerating systems are the hydrogen and nitrogen resulting from the decomposition of the ammonia. The hydrogen constituent will rise to the top of the condenser because of its lightness compared to nitrogen or even to the ammonia. As compared to air taken as unity, the specific gravity of hydrogen is 0.0692, that of nitrogen is 0.971 and that of ammonia 0.6.

From the preceding it will appear that there should be no difficulty in purging off the hydrogen content of the condenser, but that nitrogen and air would be somewhat more difficult to dispose of. It would also appear that such would also be the case if the purge line of the condensers was equipped with the device previously described. Even the hydrogen which enters the condenser with the ammonia in comparatively small quantities would find difficulty in separating itself from the ammonia sufficiently to enter the purge line as it is passing it on its way to the condenser, and it certainly would never find its way back against the tide of incoming gas while the system is in operation. The other gases would undoubtedly tend to enter the condenser and to settle gradually to the bottom pipes.

What would seem to be the rational method of getting rid of all the fixed gases, including not only the hydrogen, but also the air and nitrogen, would be to shut off one of the twelve stands of ammonia at a time. This would amount to only about 8 per cent. of the total condensing surface and would probably not result in a prohibitively high head pressure if the machine were allowed to operate at full speed. If the head pressure did become abnormal a reduction of speed of not to exceed 8 per cent. would remedy the trouble. The water should be left running over the closed condenser stand until it is thought that the ammonia gas is well liquefied. The purge valve may then be opened and the gases be allowed to escape, preferably through a small rubber hose, into a pail of water. The opening of the purge valve will produce a reduction in pressure within the condenser, and this reduction in pressure will allow some of the liquid ammonia lying in the bottom of the condenser to vaporize, expand and push the permanent gases to the upper coils of the condenser and out of the purge valve. On account of the small cross-section of the condenser pipe the tendency for commingling of the gases is but slight, and not only the lighter but the graver gases above the ammonia will be expelled. All of the permanent gases can be readily recognized, as they will escape in the form of bubbles from the water in the pail. The presence of ammonia in [illegible] [illegible] in the water with a sharp crackling noise and no bubbles will appear.

In more specific reply to the questions, it may be said that some of the hydrogen gas resulting from decomposition of the ammonia could undoubtedly be blown off from the tank while the plant is in operation, but it is doubtful if nitrogen, or perhaps even all of the hydrogen would find its way back from the condenser against the stream of incoming hot gas and the [illegible] other gases of greater specific gravity (except in the case of the hydrogen) and eventually collect in the purge chamber.

If such a device were employed there would be no objection to leaving the valve at the bottom between the tank and the purge header open all the time. In fact, the segregation of the permanent gases would be so slow that the tank would not be at all effective unless left open to the system for some time.

Washing and Coking of Rocky Mountain Coals

Investigations conducted at the fuel-testing plant of the United States Geological Survey at Denver, Colo., during the fiscal year 1908, into the washing and coking of the coals of the Rocky mountain region have just been reported upon by the survey. In the time that the plant has been in operation results have been achieved which will prove of the greatest importance to the entire western part of the country. Of 27 coals tested from the Rocky mountain region, all but three produced good coke under proper treatment, although a number of these had been considered noncoking.

A bulletin detailing the tests conducted at the Denver plant by A. W. Belden, E. [illegible] and J. W. [illegible] has just been issued by the technologic branch of the Geological Survey. In this bulletin the following general statement is made by Mr. Belden:

"The investigations described in this report were undertaken by the Government for the general purpose of increasing efficiency in the utilization of the fuel supply of the United States by devising improvements in washing and coking coals, these being two of the methods of conserving one of the country's most important mineral resources.

"Specifically, the washing tests of coal were made to determine the possibility of so improving the quality of the coal as to render it available for the production of coke, for the coal used in coking must be as free as possible from ash, sulphur and other impurities, because of the [illegible]

The coking tests were made to determine the possibility of utilizing the various coals in this way, or to devise improvements in coking practice. The washing tests have already demonstrated the fact that many coals which are too high in ash and sulphur for economical use under the steam boiler or for coking may be rendered of commercial value by proper treatment in the washery. The coking tests have demonstrated that many coals which were not supposed to be of economical value for coking purposes may be rendered so by proper treatment in the washery and coke oven. Of more than 100 coals from the Mississippi valley and the Eastern States, some of them regarded as noncoking, which had been tested at St. Louis in 1906, all except six had been found, when carefully manipulated, to make fairly good coke for foundry and other metallurgical purposes, and similar results with Western coals have been now obtained at Denver.

"The tests detailed in this bulletin are a continuation of the work started several years ago in St. Louis at the Government fuel-testing plant there. On the completion of the work at St. Louis the writer made a trip through the Rocky mountain region for the purpose of selecting a site for washing and coking tests on coals of the western half of the United States, with the hope of getting into closer touch with the fields from which little or no coal had been received at the testing plant in St. Louis.

"The different points available were visited, and after investigation Denver was selected as the most suitable on account of its central location and railroad facilities."

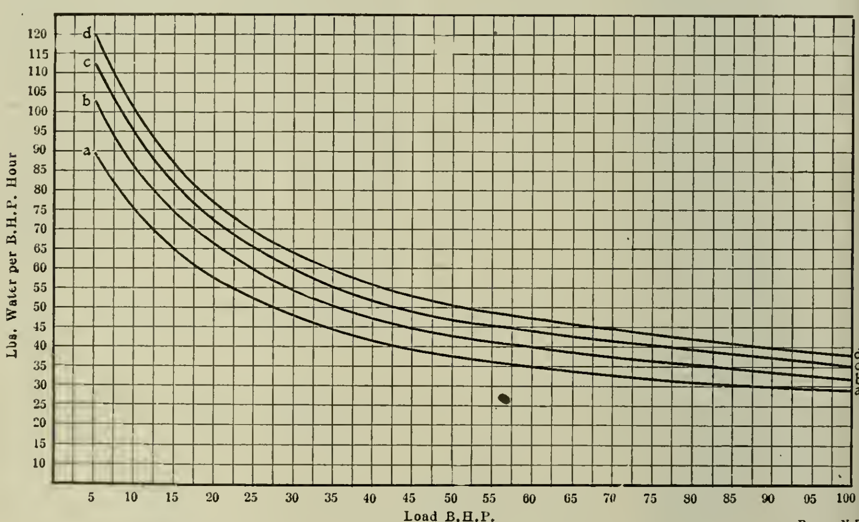
The Truth About the Small Reciprocating Engine

By William E. Snow

Ever since the days of Newcomen and Watt the minds of the ablest engineers have turned to the problem of the efficient transformation of heat energy into work. The efforts of such men as Corliss, Porter and Reynolds have made the reciprocating engine of today a perfect product. Question any present-day engine builder and he can tell you to a nicety just how many pounds of steam per horsepower his engine requires, and the advantages of superheat, vacuum, etc., and he can produce copies of tests galore to prove the correctness of his figures.

All this information is very interesting and is, in the case of medium- and large-sized engines, a fair indication of their performance under actual working conditions. In the case of the small engine, however, these figures are of little value to the prospective purchaser. In fact, in many cases they are extremely misleading, based as they are upon engines cutting off at 1/4 or 1/3 stroke, a condition under which small engines are seldom installed to operate. Keenness of competition has forced the manufacturer to install his small engines to operate on 1/2, 5/8 and in some cases even 3/4 cutoff. By this means a smaller engine can be used to deliver a given horsepower than when operating on the more economical cutoff of 1/4 or 1/3 stroke, and the engine can be sold at a correspondingly lower price.

The purchaser may be perfectly aware that his engine will use more steam on the longer cutoff, but does not know how much more, and therefore frequently tries to delude himself with the idea that the saving in initial cost effected with the smaller engine fully offsets the increase in steam consumption due to the later cutoff. Frequently not even the salesman knows the exact per cent. of increase in the steam consumption due to the later cutoff, his knowledge being obtained mainly from the standard-performance tables of the manufacturer, which are invariably based upon engines cutting off at 1/4 or 1/3 stroke and give no figures for the later cutoffs.



SHOWING RELATIVE INCREASE IN STEAM CONSUMPTION DUE TO LATER CUTOFFS

The relative increase in steam consumption due to these later cutoffs will be seen in the accompanying chart. The line *a* shows the steam consumption of simple, noncondensing engines ranging in size from 5 to 100 horsepower, when operating on a steam pressure of 125 pounds gage at 1/3 cutoff. The lines *b*, *c* and *d* show respectively the steam consumptions at 1/2, 5/8 and 3/4 cutoff.

What It Means to the Purchaser

To see what this means to the purchaser in actual dollars and cents, take the case of a 50-horsepower engine. The steam consumption of an engine of this capacity operating on 1/3 cutoff, as indicated by the line *a*, is 37 pounds per brake horsepower per hour. An engine of this capacity operating on 5/8 cutoff has a steam consumption, as indicated by the line *c*, of 47 pounds per brake horsepower per hour. In other words, it requires 21 per cent. more steam to produce 50 horsepower with a small engine operating on 5/8 cutoff than is required for a larger engine on 1/3 cutoff.

Assuming the engine to be operated 300 days a year, 10 hours per day, and requiring at 1/3 cutoff 4 pounds of coal per horsepower-hour, the total yearly coal would be $300 \times 10 \times 4 \times 50 = 600{,}000$ pounds. If the price of coal was $4 per ton the total yearly cost of coal would be $1071. The smaller engine, operating on 5/8 cutoff, would use 726,000 pounds of coal for the same service at a total yearly cost of $1296. From this it will be seen that the saving effected each year by the use of the larger engine at the more economical cutoff would be $225.

The average price of a simple, noncondensing 8x10 throttling engine, which is the size required to deliver 50 horsepower at 1/3 cutoff on a steam pressure of 125 pounds, is $510. This same power can be obtained from an 8x8 engine operating on 5/8 cutoff and this latter engine sells for $375.

It will be seen from the above that while the purchaser can save $135 on the initial cost by installing the smaller engine, he will in reality lose $90 the first year on account of the increased yearly cost of coal. Each succeeding year thereafter he will lose $225. In three years the amount he would lose would pay for the larger engine complete.

Until the engine builder sees fit to publish reliable tables showing the steam consumption of his smaller engines under the usual conditions of operation, namely, 1/2, 5/8 and 3/4 cutoff, the prospective purchaser will do well carefully to investigate this subject on his own account before deciding upon the particular size of engine best suited to his requirements. A dollar saved in initial cost at the expense of three in running expenses is a negative kind of economy at best.

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

A Water Motor

The illustration shows something new in a water motor. It is designed to be placed perpendicularly in any running stream. The upright shaft in the center is stationary, with one sprocket wheel keyed onto it and connected to two blades by an endless chain running on a sprocket wheel placed on the top of each blade. When the small sprocket wheel between the blades acts as a tightener, blade *A* is across the stream and gets the full force of the water. Blade *B* is partly turned and might create some back pressure. Blade *C* is turned to cut through the water on the return revolution, and blade *D* is just coming across the stream.

MODEL OF A WATER MOTOR

The lever on top of the upright shaft in the center is to regulate the speed, as by turning the lever the blades can be placed at any angle to get the force of the water, and if turned far enough the motor will stop. It can readily be seen that a governor can be put on to regulate the speed.

The illustration shows a working model. It will develop a limited amount of power, and I thought it might interest fellow readers.

J. Chamberlain.

Chicago, Ill.

Bridgewalls

W. H. Wakeman, on page 452 of the March 9 number, has an article on the above subject, written from a very practical standpoint, and although in the main it is perfectly correct, the writer desires to take exception to one or two points. Having had considerable practical experience regarding the effects produced by varying the hight, position or shape of the bridgewall, especially with respect to troubles from leaky seams, the writer believes that some of Mr. Wakeman's statements are likely to mislead the inexperienced engineer.

First, Mr. Wakeman (as a great many other engineers do) uses the total area of the tubes as a guide to determine the proper area of other passages for the products of combustion to pass from the grate to chimney. That this is not a logical way to arrive at these areas will be made evident by a little reasoning.

The capacity of a horizontal tubular boiler is practically determined by its heating surface; that is, so far as the capacity of the boiler alone is concerned, and this capacity is directly proportional to the length of the boiler. For instance, if there are two boilers of the same diameter, containing the same number of tubes of the same size, but in one the tubes are 16 feet long while in the other they are 20 feet long, the larger boiler will have practically 25 per cent. greater capacity than the shorter one, while the areas for the passage of gases through the tubes are identically the same. To make the additional boiler capacity available there must be 25 per cent. additional furnace capacity under the larger boiler, which means that there will be about 25 per cent. additional volume of furnace gases to be handled, requiring 25 per cent. additional area for the same velocity. As the increased volume of gases must pass through the same area of tubes in a given time the velocity will be necessarily higher and the drop in draft through the tubes greater, which would require that the chimney draft be of greater intensity in the case of the longer tubes to produce similar results at the furnace. It can be seen that in the case cited (and the variations in capacity given are not at all unusual), if the gas passages were designed on the basis of tube areas, the larger boiler would be at a considerable disadvantage in obtaining maximum capacity.

It is not unusual in the vertical type of fire-tube boiler to have the same tube areas where the capacities vary as much as 100 per cent. The furnace capacity or amount of coal to be burned in some fixed interval of time is the correct basis upon which to figure the area of gas passages required, and if this is used, taking into account any unavoidable contraction of the area through the tubes, and length and shape of flue connection in determining the required chimney capacity, uniform results will be obtained in each case for the same furnace conditions.

Another point which the writer would like to draw attention to is the apparent intent of Mr. Wakeman's article to belittle the effect of shape, position or hight of the bridgewall on the steaming qualities of the boiler. Mr. Wakeman cites an instance where he reduced the distance between the bridgewall and shell of the boiler to 4 inches, and when leakage at the girth seams developed he remedied the trouble by changing the feed from the blowoff to the top of the boiler. Now anyone with wide experience in boiler operation knows that the bottom feed is a fruitful source of girth-seam leaks, but he also knows that there are thousands of boilers fed in this manner which never give trouble from leaking. It is probable that had Mr. Wakeman changed the hight, position or shape of his bridgewall, the trouble would have disappeared as effectually as it did by changing the feed.

It is very likely that the combination of bridgewall and bottom feed was the cause of the leak and both should have been changed to have the boiler operate under the best conditions. The kind of bridgewall illustrated in Mr. Wakeman's Fig. 6, if located with respect to the girth seam as shown, is very likely to cause trouble. Of course, a well built boiler that is kept perfectly clean internally can be run with such a bridgewall without showing evidences of distress, but that is no excuse for subjecting it to such treatment. The best methods of boiler setting cannot be determined very readily by single instances but by a wide experience with many different forms, with careful analysis from cause to effect in noting the results obtained in each case.

J. E. Terman.

New Haven, Conn.

Power Increase Due to Compounding

When considering the discussion on the above subject, opened up some time ago by Mr. Wakeman, the accompanying indicator diagrams are worth inspecting. Those shown in Figs. 1 and 2 were taken from an 18 and 34 by 36-inch cross-compound Corliss engine, coupled in tandem to a four-stage air compressor before the valve gear was overhauled for repairs.

The constant for the high-pressure cylinder is 3.7 and for the low-pressure cylinder 13.2, which, under the conditions shown, give 270 and 145 horsepower, respectively, or a total of 415 for both sides. This with a cutoff of from 5/8 to 3/4 stroke.

Fig. 3 shows the original high-pressure card with additional dotted lines plotted for the maximum point of cutoff, and the counterpressure line, if this side were run as a simple engine against a 5-pound back pressure. In plotting these lines, the compression curves are omitted for the sake of clearness, but I think the contained area at either of the points of cutoff, *A* or *X*, indicates that the engine would be developing all the power that could reasonably be expected. Under the given conditions, and without going into the calculation from a laboratory standpoint, the power developed at 5/8 cutoff would be

$$87 \times 3.7 = 322$$

horsepower; and at 7/8 cutoff

$$93 \times 3.7 = 344$$

horsepower.

The increased power of the engine running compound over that when the high-pressure side is run simple, would be in the one case,

$$415 - 322 = 93$$

horsepower, or 29 per cent.; and in the other case

$$415 - 344 = 71$$

horsepower, or 20½ per cent.

In the January 19 number George W. Harding expresses the opinion that nearly all the power developed in the low-pressure cylinder of an engine is clear gain, and submits two sets of diagrams to bear out his contention. These diagrams, however, prove nothing more than that the load is fairly well divided between the two cylinders. Mr. Harding makes the mistake of overlooking the fact of the high-pressure cylinder exhausting against receiver pressure, and asks, "Why are engines compounded if not to develop more work by using the steam again that has done work in the high-pressure cylinder?"

The main reason is to lower the steam consumption for a given load carried, by reducing the temperature range, and the consequent condensation, in the two or more cylinders as compared with what this loss amounts to when the complete expansion takes place in one cylinder.

From either a mechanical or an economic standpoint it would seem to be the better way to get the increase of power required by compounding if possible, rather than by replacing the cylinder with a larger one, but this would be governed largely by local conditions.

J. A. Carruthers.

Bankhead, Can.

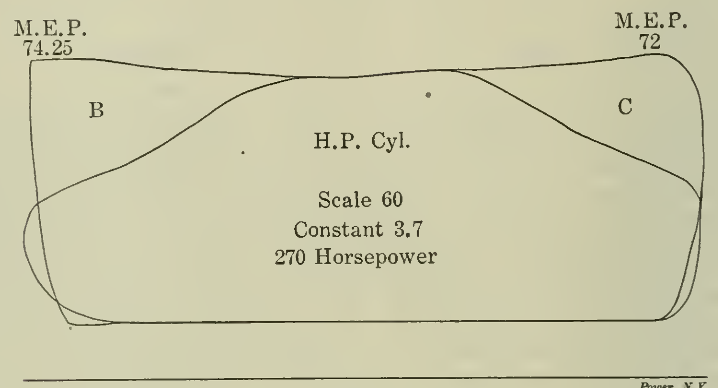


FIG. 1

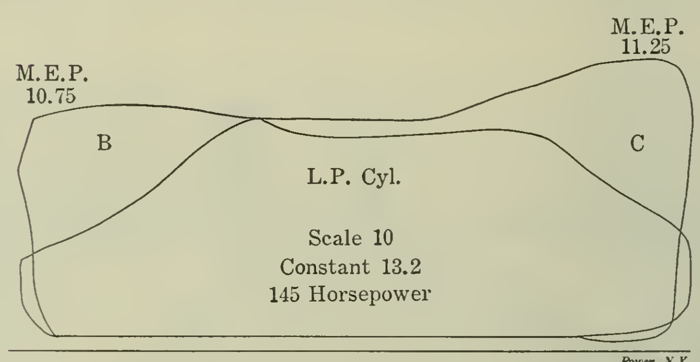


FIG. 2

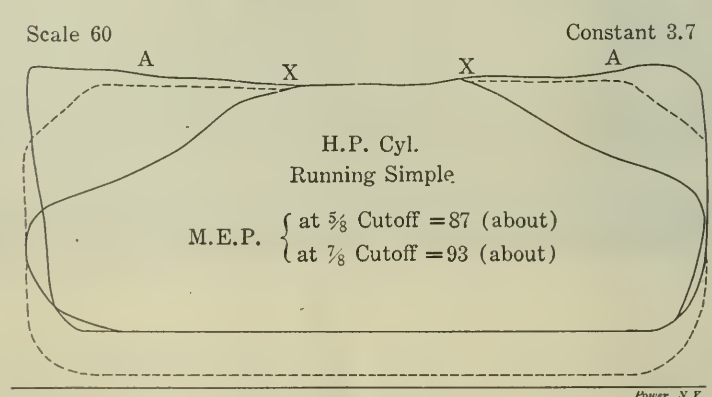


FIG. 3

It Should be Plus

In reading the March 9 number, I note on page 476, under the subject of "Safety Valves," the following formula:

$$A = \frac{22.5\,G}{P \times 8.62},$$

to be used in Philadelphia, given by Philip G. Darlington.

According to my understanding, the plus mark should be used instead of the multiplication sign, i.e., the pressure should have 8.62 added to it and not multiplied by 8.62. The correct formula should read

$$A = \frac{22.5\,G}{P + 8.62}.$$

JOHN J. MARTIN.

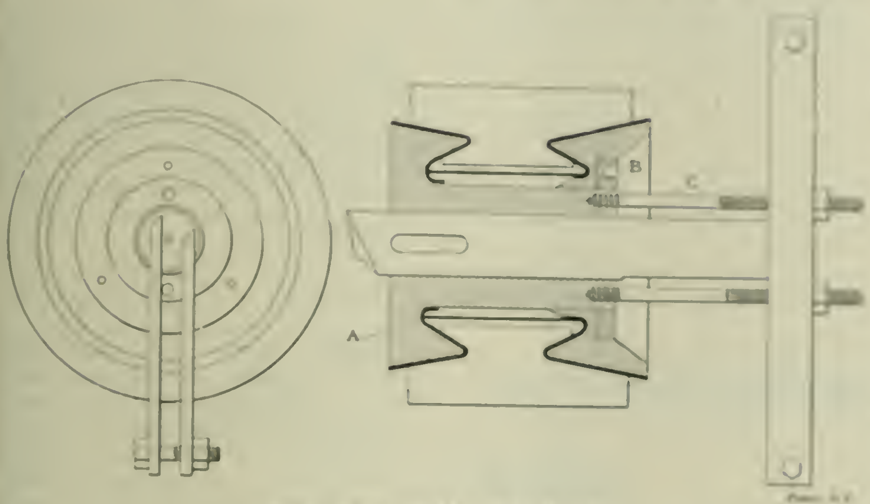
Philadelphia, Penn.

Removing Commutators

As a reply to question No. 924, "Catechism of Electricity," regarding the best method of removing commutators, I have used and found the following method successful:

Most commutators of small size—say on machines of less than 100 horsepower—are provided with holes of suitable size, generally ¾ inch or smaller, drilled and tapped in the front end of the commutator spider A (see sketch). If this method is used to draw the commutator, it takes all strain off of the clamping nut B. Commutators generally start hard, due to being forced on at the factory by means of an hydraulic press, under a pressure of from 10 to 20 tons. If the holes are not already provided, they can be easily drilled and tapped at any suitable distance from the shaft. The pulling studs C should be of cold-rolled steel to prevent stripping.

The pulling bar shown has been found to be very handy. To make it, take two pieces of [illegible]-inch bar iron, 16 inches long, and drill two 9/16-inch holes about 1 inch from each end. Put them together loosely with ½-inch bolts, 2¼ inches long. No matter what the distance may be between the centers of the holes in the commutator spider, if less than 14 inches this one bar will answer. The bolts at the end can be adjusted for a slip to open when ever size of stud is used.



METHOD OF REMOVING A COMMUTATOR

To start a tight commutator, put the studs under a fair tension with a wrench, then heat the studs to a dull red with a blowtorch and tighten the nuts. In cooling, the commutator starts, being easily removed by tightening the nuts on the studs.

L. A. WARREN, JR.

Schenectady, N. Y.

Remedying a Packing Trouble

Recently it became necessary to use a small boiler feed steam pump in one plant on a job which subjected it to a greater pressure than it had been designed for. Very great attention [illegible] with the perception that the packing would not hold. In the accompanying sketch the packing at C, at the bridge separating the discharge and suction passages, would not hold high in resistance. I tried three different brands of packing, one with a wire-mesh composition, but each failed to hold, it split at the [illegible] that after each packing I "followed up" on the bolts.

Taking a small sized [illegible] at [illegible], as shown by the dotted lines, and after packing again found that the trouble had been remedied.

With the packing screwed down into the groove it became necessary for the rib thus formed to be sheared off before the packing could move.

For some time, now, I have been using different kinds of packing for the water pistons in small steam pumps, and I find that I get the best satisfaction and longest wear from rings cut from rubber belting. I purchase the regular rubber belt, made with two-ply canvas laid in rubber, and of a width that will cut economically. I cut the rings with an adjustable cutter inserted in a brace. Should it require more or less than a certain number of whole rings to fill the packing space, one of these rings can be separated to the desired thickness.

M. MARCY ORR.

Brantford, Ont.

[illegible]

Regrinding Valves

In the January 5 number, page [illegible], Mr. Wakeman shows a type of globe valve (his Fig. 7) which he says is difficult to regrind. In reality they are as easy to regrind as any other type. To do so first remove the disk and place in the recess into which the stem fits a thin washer or small coin. Then replace the stem and screw in the collar which holds the disk to the stem. Then replace the disk, stem and bonnet and regrind by revolving back and forth through about one revolution, using the bonnet as a feed. That is, as the stem is turned in one direction, turn the bonnet in the same direction and just enough to keep the bonnet pressure [illegible] the disk and the seat. In this way the valve can be ground to a perfect fit.

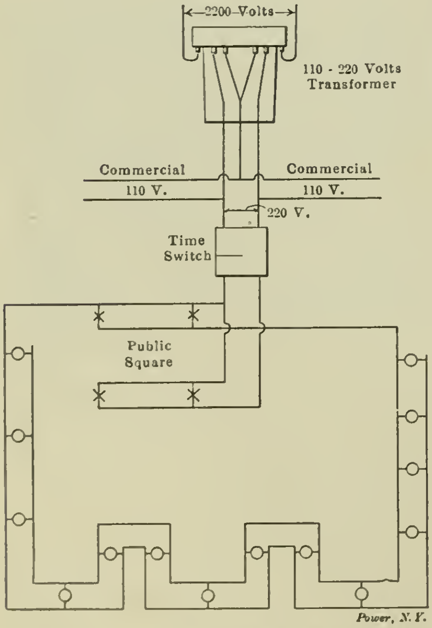
C. H. ROWLAND.

[illegible]

A Lighting Problem

In reply to Mr. Rolph's article in the February 2 number, I will say that his plan for street lighting would not be one which would give him satisfactory results. If the system is installed according to the accompanying diagram, very good results will be obtained. The street lighting is done entirely from the 220-volt wires, the incandescent system being so connected as to insure a very even drop of potential. No. 10 weatherproof wire will be suitable for the incandescent system, but if the poles are set very far apart it would be very desirable to use a No. 8 wire, as a No. 10 wire is not of sufficient strength to prevent it from stretching or breaking during winter storms. If desired, a time switch can be very easily installed, as shown.

The writer does not favor street lighting by the low-potential series system, owing to the fact that it is very hard to locate trouble; also, if one of the lights is cut out for any reason there is usually no way provided to keep the remaining lights from receiving an excess of current.



MR. BYLES' WIRING DIAGRAM

If the street lights are to be on the same poles with the wires used for house lighting, one of the house-light wires can be used to supply current to one side of the street lights, thereby dispensing with one of the street-light wires in the common multiple system. This scheme is only suitable for small installations and short lines.

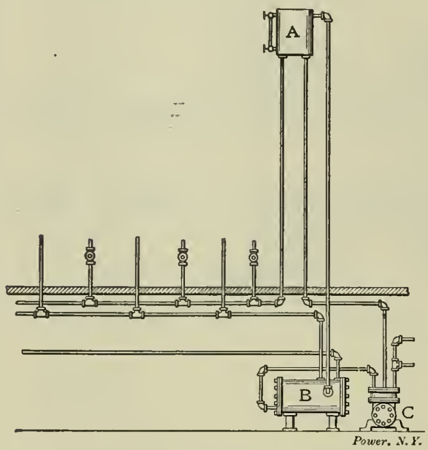
If the commercial system in the foregoing plan is to be of any magnitude the three-wire system should be used, at least on the main lines and the larger of the branch lines.

FRANK A. BYLES.

Bennington, N. H.

Gravity Feed Oiling System

In the illustration is shown a 100-gallon sheet-tin tank placed near the ceiling. It is fitted with a sight glass. In the basement, under the engine room, is located the filter *B*. The small pump *C* is so connected that it can be run with either steam or compressed air, and pumps oil from the filter to the tank *A*. An overflow pipe is connected at the top of the tank *A* and extends down to the filter.



GRAVITY-FEED OILING SYSTEM

A main pipe runs from the bottom of the tank *A* to the basement and along under the floor, where connections are made to each engine and auxiliary. Each engine and auxiliary has a separate valve just above the floor so that the oil can be shut off from any engine without disturbing the flow of the oil to any other engine or auxiliary. Pipes are run to each air-tight cup on the engine. They have the regular needle-point screws to regulate by. Each oil cup has a valve and can be cut out without affecting any other cup. We have cups placed on all parts of the valve gears where possible, and have very little use for the oil can.

We also have a return system. Each crankpit, foundation plate and eccentric pit has a pipe connection to one large pipe which leads to the filter. We run oil from a barrel in the storeroom into a can below and the oil flows to the filter and thus enters the system. In the can under the floor of the storeroom are coils of pipe through which steam circulates in cold weather. We do not, however, permit the oil to get hot enough to injure it.

This system is somewhat expensive in first cost, but there is hardly any operating cost and the great saving of oil in a short time will pay for the system.

I. Y. WHITE.

Handley, Tex.

Composition Disks for Globe Valves

In the February 16 number, Mr. Wakeman says that composition disks for globe valves are as good as they were 20 years ago, and suggests the superiority of globe over gate valves for big work, and then goes on to intimate that if gate valves are used composition disks can be made.

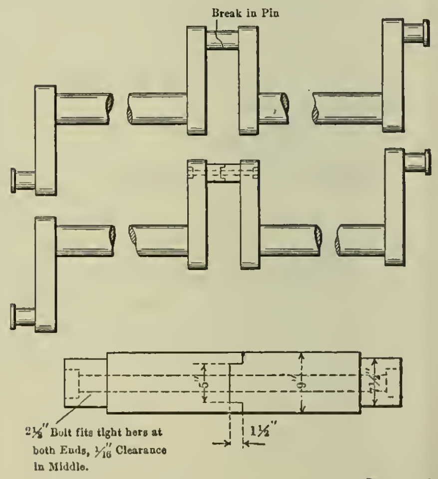
Things have changed in 20 years, and gate valves have the preference, and not only composition disks but bronze disks and seats have been changed for steel where superheat is used.

W. E. CRANE.

Broadalbin, N. Y.

Repairing a Center Crank

I repaired a center-crank engine two years ago and it has run nicely ever since. The pin of the center crank was broken, as shown in the sketch, and it had been bolted together and run in that way for about five years. The bolt was not fitted properly and the hole and pin were badly worn. I sent the shaft to a machine shop and had the shaft trued and the pin cut off. The crank-pin holes were bored out, also. Then we fitted both halves of a new pin to the holes and, after forcing one in, found that the bore was not in line. With both ends turned to size and no steel to make a new pin with, we had two steel thimbles forged and, after boring them out, shrank them on the pins. The crank shaft belongs to an ammonia compressor and runs twenty-four hours per day.



REPAIRING A CENTER CRANK

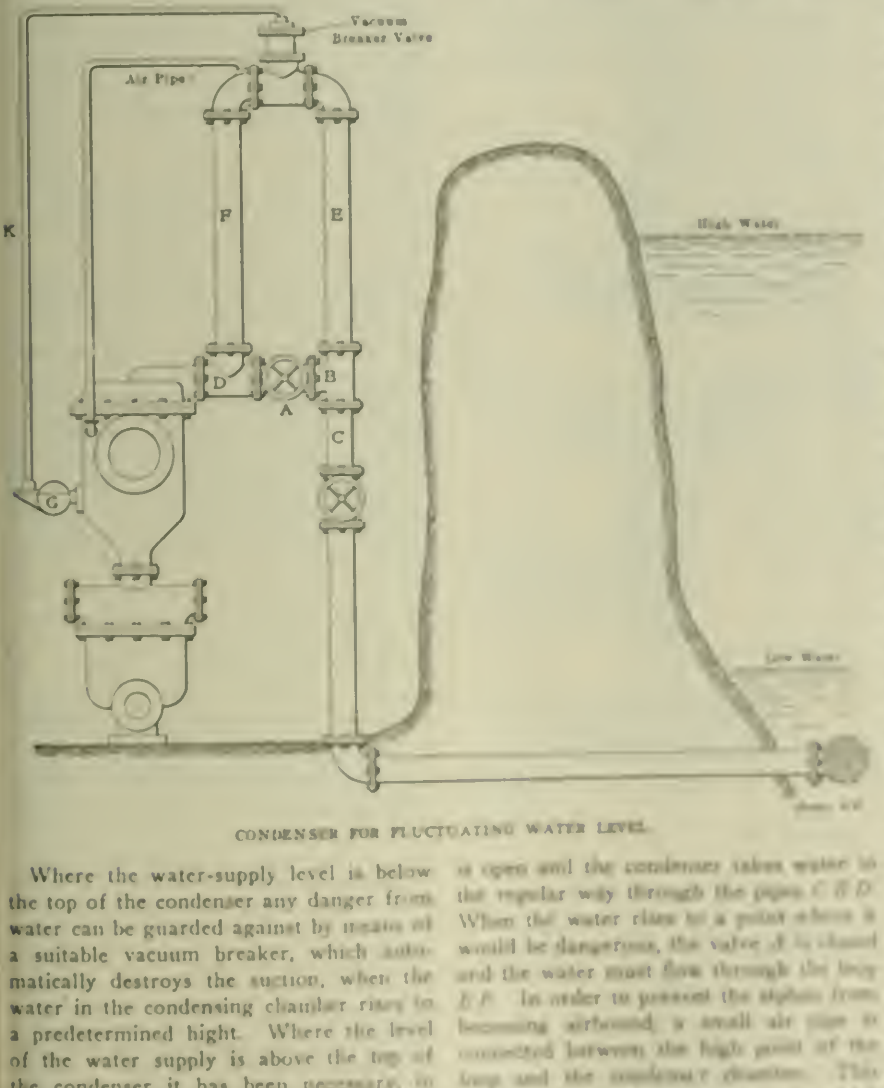
My theory for so many of these breakdowns is that the engine being horizontal and the compressors vertical the center bearings do not wear down as fast as the side bearings, the machine running only a short time until there is a springing action on the shaft, and it is only a matter of time until it breaks. I think my patched crank pin, considering this feature, is better than a new pin.

DENNIS HANLON.

Vincennes, Ind.

Condensers for Fluctuating Water Level

A jet condenser must always lift its own water, never take it under a head. Such has been the general rule in regard to the installation of these machines, the reason being that if the water came to the condenser under a head and for any reason the vacuum pump should stop or fail to remove it, there would be no means of preventing the water from overflowing into the exhaust pipe and back to the engine.



CONDENSER FOR FLUCTUATING WATER LEVEL

Where the water-supply level is below the top of the condenser any danger from water can be guarded against by means of a suitable vacuum breaker, which automatically destroys the suction, when the water in the condensing chamber rises to a predetermined hight. Where the level of the water supply is above the top of the condenser it has been necessary, in order to insure safety, to run the water into a well below the condenser level and have the condenser draft its supply from the well. An automatic float valve or an overflow serves to keep the well at the proper level.

Another condition that frequently occurs is that of a water supply fluctuating between widely varying levels. Many rivers have such a variation that a condenser set high enough to be out of danger at times of high water would be out of suction reach of the water at normal stages.

In order to meet either of the foregoing conditions the following scheme has been devised by the writer. The sketch and description refer to a fluctuating water level and some of the connections could be omitted in case of a constant water level higher than the condenser.

The vacuum pump and condenser are so located that the injection inlet is in the neighborhood of 18 or 20 feet above the low-water level. The injection pipe is arranged as shown, and is carried up so that the "vacuum breaker valve" is about 10 or 12 feet above the high-water level. So long as the water level remains below the injection opening, the valve *A* is open and the condenser takes water in the regular way through the pipes *C B D*. When the water rises to a point where it would be dangerous, the valve *A* is closed and the water must flow through the loop *E F*. In order to prevent the siphon from becoming airbound, a small air pipe is connected between the high point of the loop and the condenser chamber. This pipe serves to draw out the air which would otherwise collect at the top of the loop.

At *G* is located a chamber containing a copper float. If for any reason the pump should stop, the water would rise in the condensing chamber until it raised the float. This float actuates a small pilot valve controlling the pipe *K* and the rising of the float opens the valve and makes connection between the vacuum and the pipe *K*. The vacuum is thus applied to the top of a differential piston, which opens wide the vacuum-breaker valve, and thus allows the flow of air through a large opening into the top of the loop. This instantly breaks the siphon and stops the further flow of water into the condenser.

By means of a suitable number of crossover pipes, with valves, between the pipes *E* and *F*, the arrangement can be suited to any amount of fluctuation in water level.

H. M. CHASE.

Holyoke, Mass.

Heat in Steam

On page 213 of the January 26 number Joseph H. Hart, in his article, "Heat in Steam," makes the following statement: "After water is changed to steam, the steam then possesses practically nothing but specific heat, or, rather, increase in temperature means an addition only in the kinetic energy of the molecule. This is actually the case in what is known as superheated steam, in which case the steam behaves as a perfect gas and obeys Boyle's and Charles' laws absolutely."

The last statement of Mr. Hart is inaccurate, as superheated steam only when far removed from the point of saturation follows very nearly the laws of perfect gases. In the case of superheated steam in common practice, experimental investigations by Zeuner, Knoblauch, Battelli and others have proved that the combination of the laws of Boyle and Charles do not hold, i.e., that the ratio of the product of the volume and pressure to the temperature is not a constant. Several equations have been proposed to express the relation between pressure, volume and temperature of superheated vapors. The one best known is by Zeuner, which in the English system is expressed by the following formula:

$$PV = 93.5\,T - 971\,P^{\frac{1}{4}},$$

where

P = Pressure in pounds per square inch,

V = Volume of 1 pound in cubic feet,

T = Absolute temperature on the Fahrenheit scale.

The constants for this equation have been worked out on the supposition that the specific heat at constant pressure is a constant and is equal to 0.48.

Professor Peabody in his book on thermodynamics, gives some of the newer and more accurate formulas. Of these the one by Knoblauch is:

[illegible]

A simpler equation by Tumlirz is:

$$PV = 85.85\,T - 0.256\,P$$

This last equation has an error of about 1 per cent., as compared with that of Knoblauch.

A. A. Potter.

Manhattan, Kan.

Keying Flywheels

In an ice plant having a 22x26-inch upright Corliss engine, connected to a 16x22-inch compressor, running at 58 revolutions per minute, the bolts of a marine-type connecting rod gave way and one of the boxes fell into the crankpit and stopped the crank, but the engine being under full steam pressure, and aided by the momentum of the flywheel, the shaft was twisted about 15 degrees before it came to a stop. The broken bolts of the connecting rod were 1½ inches in diameter, but the holes in the boxes were about 1¾ inches, and it was thought judicious to make stronger bolts. The butt and strap were reamed out, and the new bolts turned to fit the boxes snugly. The chief felt safe about them, but to his surprise they broke about two weeks later. A few weeks previous to their failure the piston rod had loosened and worked down into the crosshead until the piston struck the lower cylinder head. The pounding had been allowed to go on for some time, as the chief did not believe in stopping for such a trifle. I think this started a crack in one of the bolts and caused the breakdown. The new bolts had comparatively smooth running. The condenser pressure ran at times up to 200 pounds with about 25 pounds suction. The strain on the bolts was 35,850 pounds less the weight of the piston, crosshead and connecting rod, or about 14,500 pounds per square inch on the old and about 10,000 pounds on the new bolts. The new bolts showed dents on the butt and strap ends, indicating bending stresses; the old ones had clearance enough to avoid them. Faulty alinement is harder on connecting-rod bolts than the working strain.

Another cause of failure is the habit of cutting the threads too sharp at the bottom and allowing the tool to dig in at the end of the thread. A smaller pitch would be better practice than standard bolts. Bolts that have been in an accident and subjected to abnormal strains should be looked over very carefully before being used, but I would scrap them.

To insure a satisfactory job in securing a wheel to a shaft with a sunk key it is necessary that the bore of the wheel should fit the shaft reasonably tight, and that the keyway in the wheel should be of the same size, parallel to the keyseat of the shaft and not taper more than ⅛ inch to the foot. If the wheel bore is larger than the shaft by more than 0.004 inch it should not be used on that shaft. If the keyway is not parallel to the keyseat, it can be corrected in the following manner:

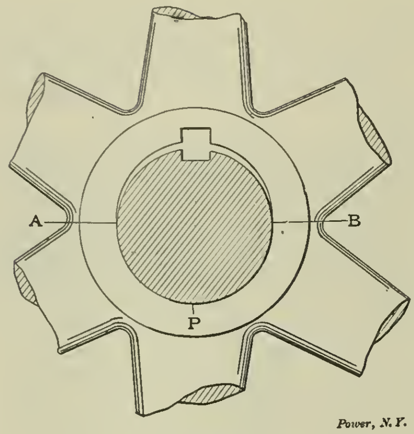


FIG. 1

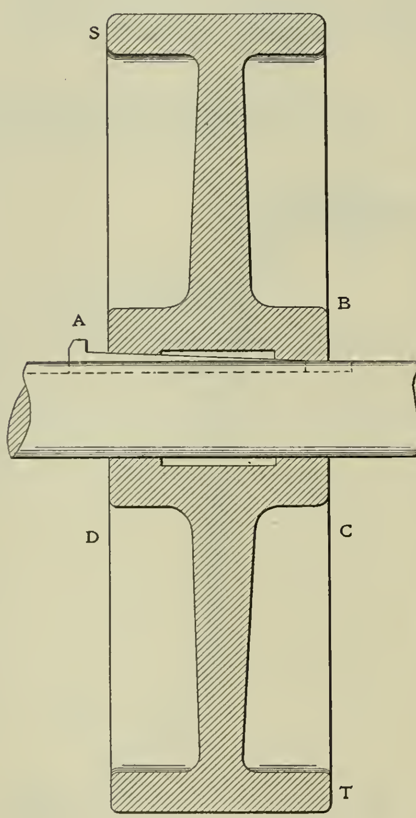


FIG. 2

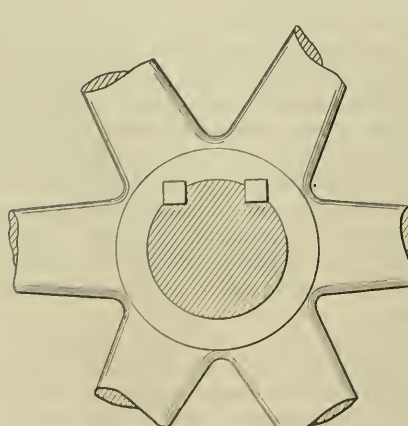


FIG. 3

Suppose a wheel with 7-inch bore is to be fitted to a shaft with a sunk key 1½ inches wide. The keyway of the wheel, when placed edge to edge on the keyseat of the shaft, is found to run to the left 1/16 inch at the other side. The wheel should then be turned 1/32 inch to the right, in order to divide up that divergence. The protruding edges, viz., right front and left back of the shaft and left front and right back of the wheel, should be carefully marked, as they must be filed or machined. A key 1 17/32 inches wide will now be necessary, and it can be fitted on all sides, as there are straight and even surfaces to deal with.

It is troublesome to make special keys in factories where keys of standard sizes are kept in stock and, besides, the work has to go out on regulation time, so it happens that the wheel, shaft and key are left as they are. It also happens that if the bore of the wheel is 1/100 inch or more larger than the shaft, it is used anyway.

The keyfitter or erecter in trying to make up for all these defects drives the key home as hard as he dares, thus setting up an undue strain in the hub. The key will bend the shaft and the wheel on the protruding edges only and the combination will look like Fig. 1. Such a wheel will soon begin to work, rubbing the shaft at *P* and battering it at *A* and *B*. It does not take long before it will cut at *P*, creating an additional strain in the hub, and if the speed is high and the reversals of force sudden something will happen. If the fitter has been careless or ignorant enough not to file the edges of the key before trying to fit it, matters will be worse, but the wheel after wearing away the edges will begin to pound and give notice of its bad condition.

Another bad practice is the attempt to remedy a wobbling wheel with the key. If a wheel has been sprung when clamped to the boring-mill table, during the operation of boring and facing, it will wobble when running on the shaft. If this wobble is in or near the radial direction of the key, as at *S* and *T*, Fig. 2, an attempt is sometimes made to throw the wheel in line by filing the key down in *B*, in order to make the wheel bear hard at *D* and *B* and loosen up a little at *A* and *C*. I have never seen it done successfully, but it is resorted to quite frequently. The drawback to the wheel is apparent. I would rather have a wheel wobble a little than have it "fixed up" in such a way. I do not know that "broad keys fitted upon flats" hold a wheel or even a pulley in place successfully, but I have experienced many cases where such keys had to be replaced by broader ones and finally by sunk keys before they gave satisfaction.

To use two keys, as shown in Fig. 3, is

no improvement over the single sunk key, as either one or the other key has to stand the strain, according to whether the wheel is receiving or giving up momentum. Such keys are, therefore, liable to work loose. I have seen set screws used to prevent it.

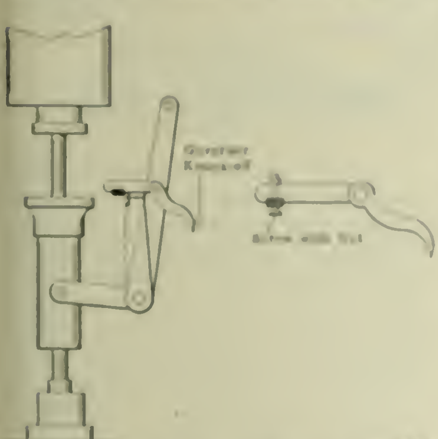
Set-screw holes drilled into the keyways are not desirable, as they weaken the hub through its least cross-section. I remember of two such wheels being cracked through the keyways. This method of keying is of advantage on governor wheels, where it is sometimes desirable to shift the wheel to suit the accurate position of the eccentric. This can easily be done to a certain limit by increasing the thickness of one key and reducing the other. To use a split wheel and clamp it down without a key can hardly be considered, as it would have to be tightened too often and the shaft would certainly suffer in a short time. A single sunk key in connection with a split wheel or hub is, in my judgment, the most convenient and efficient method of holding wheels.

H. WIEGAND.

Indianapolis, Ind.

Cause of a Runaway Engine

One day my Slater engine started to run away, but I managed to stop it before any damage was done. The cause was due to one of two screws which held the steel hook-up block becoming unscrewed from the latch, allowing the valve to take steam full stroke on both ends, as it had



CURING THE CAUSE OF A RUNAWAY ENGINE

put the governor "out of commission."

The way I fixed the engine so that a like occurrence could not happen was to drill a hole clear through the hook-up latch, tapping and putting on a longer screw on which I placed a nut to prevent the screw from turning out.

GEORGE E. W[illegible]

East Bridgewater, Mass.

A Return Steam Trap

The accompanying sectional view is of a return-steam trap that has given satisfaction and one that can be manufactured at a very moderate cost. The trap is the invention of W. J. Sterling, Portsmouth, Va. The body is cast in two parts and bolted together. Located on the side of the upper portion is a brass cylinder connected by flanges. The condensed steam enters from the top and is discharged at the bottom. The copper float is made with a ½-inch pipe passing through its entire length, the ends of the pipe being brazed to the float so that it may move loosely on the stem and still be water-tight. The stem on which the float works is connected to a bell crank, which in turn connects to the valve stem operating the piston valve. The valve has a ⅛-inch hole passing through its entire length, so there will not be a vacuum formed behind the valve when it moves. All the fittings are made of brass and the body is of cast iron.

SECTIONAL VIEW OF A RETURN-STEAM TRAP

D. C. WILLIAMSON.

Norfolk, Va.

Will the Load on the Bolts Change?

Allow me to submit a problem for publication. The illustrations, Figs. 1 and 2, represent sectional views of one end of two separate steam cylinders.

Fig. 1 represents a cylinder and head having a ground joint between them. Fig. 2 represents a cylinder and head having some elastic material as packing. The area of both cylinders is [illegible] square inches, and each respective cylinder head is held on by 12 studs and nuts. Each nut on the 12 studs is screwed up to such a point that the studs are under an initial stress of [illegible] pounds.

If steam or other pressure is forced in so that the area of the head on the inside of the cylinder is subjected to [illegible] pounds pressure per square inch, will the

FIG. 1 FIG. 2

pressure on the bolts, in either case, increase, decrease or remain the same? In each case what is the load in pounds per bolt?

G. A. C[illegible]

[illegible], Wis.

Setting of Steam Eccentrics

[illegible]

[illegible]

the single wristplate. In those days engineers laid out and built the engines and they were built convenient to handle. The starting bar came out straight and was convenient to one hand, and the throttle to the other. The two new wristplates were thinner than the single one and were placed side by side, with slots in each, and a thin starting bar for each slot. One bar had an offset so that both bars were brought out parallel and the two together taken in one hand and operated as a single bar (the only sensible way), and I had a pair of wristplates operated by hand the same as the old single plate. Why should anyone do differently? At present most engines are laid out by draftsmen and starting bars stick out at all angles, sure to be the most inconvenient.

The change in the engine by giving the exhaust a clear release resulted in a marked saving in fuel. The lengthening in the range of cutting off made the speed steadier and also allowed more load to be put on the engine, which, after a time, was done. There was rolling-mill work done by this engine, with all kinds of load, and occasionally a card would be taken that showed the steam following three-fourths stroke, the steam eccentric set at 90 degrees.

When a piston is at the middle of the stroke its speed is so high that if the valve is tripped at that time the piston will have gone some distance before the valve is closed.

We had a 30x60 George Corliss engine and we asked a price from the builders for making the parts to fit it up the same way. They refused to make them, saying: "We don't want our engines run that way." So we got the parts from the Harris people. Of course, this was fitted up the same as the 28x60, and the two wristplates worked by hand as easily and nicely as the single one. There were no more valves to handle.

This engine was in a rolling mill and there was occasionally a card showing a three-fourths cutoff, so there was no question about getting a range of cutting off up to three-fourths stroke. This was before the days of compounds, although there had been a few built. One large mill corporation in Massachusetts had one mill separate from the rest and it was so fitted up that an accurate test could be made of any change made on the engines, which in this mill was a pair of cylinders on one shaft.

Mr. Babbitt, superintendent at the Harris shops, proposed fitting up this pair with the extra eccentrics and a contract was finally made that if the change made a saving of 10 per cent. the corporation was to pay a certain price. If there was not a saving of 10 per cent., nothing should be paid. The change was made and on the last day of the trial a check was mailed to pay for new parts. The blowing through on starting up did not appear to make much loss. In order to do away with it, have a little block and raise the governor sufficient to cut off and block it up. This is a good idea with a single as well, as much less steam is used when getting up to speed than at full stroke.

In 1892 our people were having a new engine built and among others that wanted the jŏb was the Corliss company, which was ready to put on two eccentrics. They got the order for a 28 and 52 by 72-inch engine, to run at 60 revolutions, and it was to be built just as I directed. After this engine was put in and before any large loads were put on I got through with this firm, so that I did not see any cards with heavy loads, but understand it has gone way beyond 2000 horsepower with 125 pounds steam pressure.

Along about 1895, Hewes & Phillips built a 16 and 30 by 42-inch engine and erected it in the lighting station at Elizabeth, N. J. It so happened that the load of the station was so adjusted that a peak load came on this engine for about two hours every evening, calling for a cutoff of about three-fourths stroke, and the little engine was right on the job every time.

The first that I heard that there was any trouble with that manner of setting the valves was about twenty years after I put on the first one. It seems that some street railway had put in too small an engine and the load would pull the governor right down on the pin, so they did away with their safety stop, put the eccentrip back and put in effect the 60-degree hitch-up.

This throws the stop-motion out of use and the only excuse is a man made a mistake.

After about 1894, builders turned their attention more to putting on two eccentrics and some of them could not believe that the piston at its highest speed in the cylinder could advance after the valve had been tripped, and they studied out the 60-degree arrangement and called it their long range of cutting off, but years before men had been getting the long range of three-fourths stroke with the eccentric at 90 degrees.

If three-fourths stroke can be obtained without crippling the engine in any way and allow it to be handled by the starting bar so as to do anything one wishes, what excuse is there for crippling it so that bars with a lot of men or tackle blocks have to be used?

When the steam eccentric is set at 60 degrees, if the valve is not tripped, the eccentric will not close it until the crank is 30 degrees beyond the center and the piston is one-fourth of its way on the return stroke. For this reason, with eccentrics set in this manner the valves must always trip before the eccentric has completed its full throw.

When the wristplate is at one-half travel, or vertical, the steam valve is wide open. But one steam valve can be hooked on at the same time and the wristplate cannot be held in its central position, but must be thrown over to nearly its full throw, so that the valve may be closed, as there is very little lap.

To start the engine is a simple matter, but to manipulate it and bring it to a stop at any point nicely is different. Let us suppose that less than one-half stroke is all that is required. The engine is brought to nearly the point, and how are you going to stop or throw steam into the opposite end of the cylinder? You have not got hold of the valve at the opposite end, and if you had it would have been wide open all the time and you would not have moved at all. To get hold of this valve you must throw the wristplate over and pick it up.

You cannot hold onto the starting bar strongly enough to move it and unhook the steam valve; besides, it would take time. The only way to do is to throw the wristplate over, but this also opens that valve wide during the operation.

Suppose that opening this steam valve wide for an instant has not carried the engine too far, which is highly improbable, and that you get hold of the other valve. Then you have to reach over somewhere and get hold of your exhaust valves and change them, and by this time the engine has either stopped or gone too far. If you have to make more than one revolution you are in a nice mess.

I once knew an erecting man who went home and told his people that he had started and stopped an engine of this character at any point. He had been very careful not to have anyone around when he did it.

W. E. Crane.

Broadalbin, N. Y.

Method of Cutting Nipples

In a recent number, F. E. Fick gives his method of cutting nipples which is all right, but I cut the long thread and screw the coupling on it, and then screw the nipple into that. Then instead of reversing the dies, I select a bushing large enough to take in the coupling. If the bushing is of the adjustable type this is very simple, but in case the bushing is of the ordinary type it may be necessary to wrap the coupling with paper. If a very short nipple is wanted the bushing may sometimes be put on the longer piece of pipe and the coupling will come between the bushing and the dies.

C. E. Howland.

Washington Court House, O.

The "Imperial International Exhibition," which is to be held in London, England, the coming summer, will be held under patronage similar to the recent Franco-British exhibition.

Some Useful Lessons of Limewater

A Series of Interesting Practical Experiments with Oxygen: What an Atmosphere of Pure Oxygen Would Mean to the Animal Kingdom

BY CHARLES S. PALMER

In the last chapter we laid out the ground for making oxygen, planning the apparatus as shown in the various figures, and anticipating as far as possible some of the most important tests which you will make with this gas. You will want at least two jars of the gas—ordinary quart fruit jars—and if you can collect three or four jars of gas so much the better. Here you will want to note that oxygen is a trifle heavier than the air, and the jars of oxygen can be kept for some few moments by covering them with the square pieces of cardboard used to remove them from the water, and which should be put over the mouth of the jar while it is still under water. This is done by grasping the jar firmly with one hand, and with the other slipping the cardboard down into the water over the mouth of the jar, then raising the whole, turning it right side up and setting it down mouth upward, with the cardboard left for a cover.

There is one other point that you should notice, and that is that if you start with your wash-dish pneumatic trough half full of water, the water from the jars, by displacement of the oxygen, will flow out into the wash dish and will fill it an inch or two deeper, and hence the jar will get a little unsteady in the increased depth of water and will tend to float and tip over unless you hold it down or weight it. The gas in the jar sinks to a lower level than that of the open water in the wash dish, as shown in Fig. 1. This caution about steadying the jar will be particularly necessary if you put several jars, full of water, inverted mouth downward in the same wash dish preparatory to filling them with oxygen. Frequently the water escaping from the jars, as the oxygen is led into them, will fill the wash dish to overflowing, a circumstance which does not matter as long as you keep your eye on getting the oxygen into the jars and keeping them from tipping over.

Experiments with the Oxygen

The first experiment you will try will be the testing of the oxygen in one of the jars with one of the splinters of soft pine wood 8 or 10 inches long, which you have got ready. Light the splinter and, removing the cardboard cover from the jar of oxygen, quickly thrust the glowing splinter down into the jar. You will note the increased brilliancy of its burning and you can instantly remove it, replacing the cardboard cover on the jar. Now blow out the flame of the splinter, leaving only a glowing coal at the end, and thrust this again into the jar, when the splinter will burst into a flame as though by magic.

If you do not let the splinter remain burning in the jar too long, you can repeat the experiment a number of times before the oxygen in the jar is exhausted. With a little practice one can easily ignite a glowing splinter in the jar, remove it, blow out the flame, thrust it into the jar again to relight it [illegible] When the jar is exhausted so that it will no longer re-ignite the glowing splinter, cover the jar with cardboard and set it aside [illegible]. However, before you go on to the next jar of oxygen, just note that the splinter burns in the air with a fairly bright but slightly smoky flame, while it burns in the oxygen with a brilliant white and smokeless flame.

The next test will be performed on another jar of oxygen, using instead of a splinter some of the match ends fastened together with a wire handle 8 or 10 inches long. If you use the common "night day" sulphur match, you will note the bright blue flame of the burning sulphur; if you use parlor matches, say not over half a dozen in the bunch, you will note the brilliant burning of the phosphorus, together with some copious white fumes called phosphoric anhydride, that is, the anhydride or water-free residue of phosphoric acid, the acid found in bones in combination with the lime [illegible]

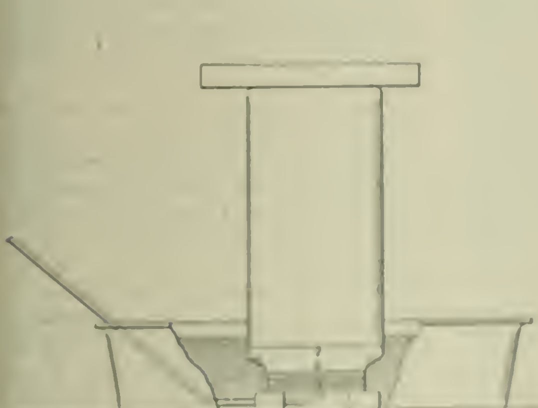


FIG. 1

FIG. 2

FIG. 3

[illegible]

Of course, your common sense will [illegible] glass.

You will also want to [illegible]

it should happen that the iron wire which binds the match ends together, as shown in Fig. 2, should itself take fire, thereby anticipating the next test, do not worry, for all sorts of possibilities may happen; but it is well to anticipate what may happen so that you can understand it.

The next test refers to the burning of the iron picture cord, prepared according to the directions given in the last lesson: heating it. dipping it into flour of sulphur, and wrapping a bit of cotton wool or cotton waste around the sulphur while hot. In this experiment, as shown in Fig. 3, you will have two pasteboard covers, one already on the jar and another perforated with a small hole through which the prepared picture wire extends. This cardboard and wire are grasped in the right hand, holding the cardboard between the thumb and the first finger or fingers, and folding the third and fourth fingers under the cardboard to hold the wire so that it will extend down straight into the jar as you swap covers. The picture wire should extend some 4 or 5 inches below the cardboard when the latter is placed on the mouth of the jar; and, if the experiment succeeds well, you will see the cotton which you lit before thrusting the wire into the jar burn brightly, which will light the sulphur, and this in turn will ignite the iron picture cord.

The picture wire will burn with bright sparks or scintillations thrown off in every direction from the burning tip. Moreover, as the picture wire burns up, you will push the part above down through, feeding it to the flame in the oxygen. Also, you will notice that as the iron burns there will be an accumulation of molten globules at the end of the wire. Some of these molten globules will almost certainly be jarred off the wire by the trembling of your hand, or by the violence of the burning, and will fall to the bottom of the glass jar, cracking the glass unless you had the forethought to protect the bottom of the jar with something like a layer of sand.

Therefore, remember that *before* you start this third experiment with oxygen, you will want to sprinkle into the jar enough clean sand to cover the bottom of the jar evenly, about 1/4 or 1/2 inch deep.

Magnetic Oxide of Iron

You will note, in addition to the black globules, some brownish particles and, of course, you will understand without being told that both the red particles and the black globules are the rust or oxides of iron produced by its burning in the oxygen. This black globule, by the way, is the magnetic oxide of iron, Fe_3O_4 (F-e-3-O-4). This magnetic oxide of iron is naturally magnetic without being put near a magnet; just as water is naturally wet, gold yellow and coal black.

Incidentally, you will find it interesting to gather some of these particles afterward and test them with a magnet, the handiest magnet being the large blade of your jackknife which, of course, you can easily magnetize at any direct-current generator in any power house. You will find this magnetized jackknife very convenient in making many tests which otherwise you might have to neglect.

There are many other experiments which you can try with oxygen, but perhaps those that I have given here will be all that you can handle just at present; but, you do want to be sure to make a spark on a wooden splinter burst into a flame, on the one hand, and on the other hand you want to be sure to get the iron to burn. In a few moments we will go back to examine the contents of each of the used jars of oxygen; but just at present you want to notice that you yourself have answered the question, proposed and discussed in the last lessons, as to what would happen if the nitrogen of the air were removed and its place were taken by oxygen.

The conditions and the results of the burning of the splinter, the matches and the picture wire in the jars of oxygen show that an atmosphere of pure oxygen would be the basis for a very dangerous and destructive conflagration. If we could live safely in an atmosphere of oxygen, and if you should build a fire in your cast-iron stove in an atmosphere of pure oxygen, you would see the stove itself take fire and burn like butter. As to the ability of a man to live in an atmosphere of oxygen, there would be nothing poisonous about it, but the body would be consumed as by a fever, probably faster than he could eat food and digest it to supply material for the good red blood. There used to be an experiment in this line, illustrated by catching a mouse in a trap which does not injure the little animal and letting him loose in a jar of oxygen. If you should try this, you would undoubtedly see the mouse jumping about in a state of great nervous excitement, where he probably is not really suffering pain, but is simply, literally, "burning his candle at both ends." An animal in such a condition would probably not live many hours, but would quickly exhaust the food supply in the blood and tissues by the over-combustion and excessive burning due to the extra supply of oxygen.

In this connection, you will probably begin to get interested in the atmosphere, as you will read about the remarkable way in which animals exhaust the oxygen of the atmosphere, and the equally remarkable way in which green plants replenish the oxygen of the atmosphere by absorbing the carbonic-acid gas of the air, retaining the carbon and giving back a part, at least, of the oxygen to the air.

The Atmosphere Once Held Much Less Oxygen than Now

There probably was a time in the history of our globe when the atmosphere contained very much less oxygen than at present, and the fairly good supply that we now have has been accumulated through long ages by the continuous action of the bright sun shining on green (chlorophyll-bearing) plants. The present condition of the oxygen in the atmosphere, making about one-fifth by volume of the air, is well suited for the support of both plants and animals, and also for the safe burning of the coal under your boiler. If there were very much less oxygen in the atmosphere, the burning would be much more sluggish; and if there were much more oxygen in the atmosphere, the burning, as shown by the experiments you have made with your jars of oxygen, would be much more violent, dangerous and difficult of control.

Before we close this lesson let us go back and examine the first jar of oxygen in which you burnt the wood splinter. Pour in a few teaspoonfuls of limewater, and you will get the same milky precipitate of plain carbonate of calcium that you got in your earlier experiments, and with which you are now getting pretty well acquainted. Of course, you can treat this plain carbonate of calcium in the same way that you did before, namely, by blowing in air from the lungs, and changing it to the soluble extra or bicarbonate of calcium, although there may be carbonic-acid gas enough in the jar from the burning of the wood splinter to do this without any blowing.

The next jar to test is that in which you burned the match ends. In this you will pour a little water, or if you poured water in at first to protect the bottom, that will do. Throw in two pieces of litmus paper, both the red and blue, and you will probably see that the burning of the sulphur or the phosphorus in the oxygen produced the same acid-like substances that you previously got by burning sulphur or phosphorus in the air. If you pour in a little limewater you may get a white milky precipitate, or indeed a mixture of two or three precipitates. These white precipitates are largely the sulphites, the sulphates and the phosphates of calcium; although the wood of the match ends in burning will also have produced some carbonic-acid gas, which again will give you your friend, plain carbonate of calcium.

The test with the jar in which you burned the iron wire will probably not give you very much to note, either with limewater or with litmus, because the sand at the bottom of the jar will interfere with the tests; but at all events you want to collect some of the fused globules of magnetic oxide, which you will notice are really bubbles, not solid shot; and you will also want to preserve the burnt end of the picture wire with its globule of molten magnetite.

This set of experiments will start you still farther on the right road for the examination of the atmosphere, and will give you many things to think of. If there are any questions which you want explained, just write them in a simple inquiry to POWER, and I will answer them to the best of my ability.

We have now studied something about the atmosphere and about oxygen, and this is a very good start in laying the broad foundations of chemistry, for oxygen is found in many substances, and yet it represents only one side of chemical action, namely, that of oxidizers. The other side, contrasted with that of oxidizers, is that of reducers, which are well represented by hydrogen, which we will study next. Hydrogen is found in water, in all acids, and in many other substances; and in the next two lessons we will consider the subject of hydrogen, first the making, and then the testing of it. All of this you can easily do in the homemade laboratory of your boiler room.

Illinois Fuel Conference

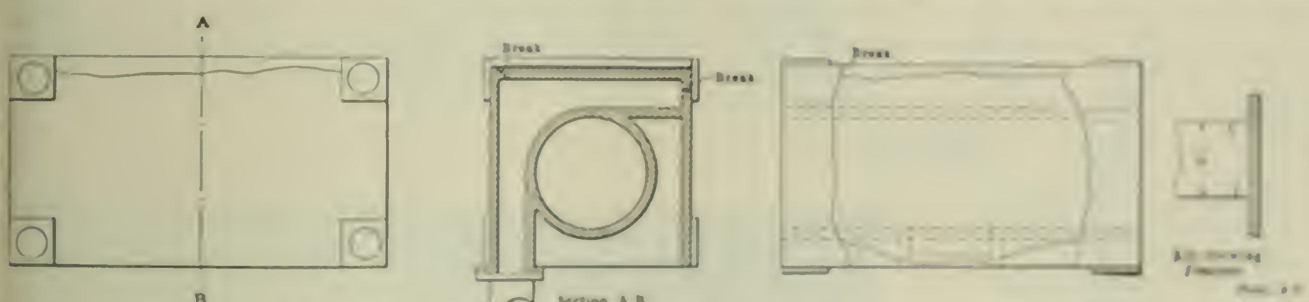
The first Illinois Fuel Conference took place at the University of Illinois, Champaign, March 11, 12 and 13. The conference brought together a varied representation of those interested in coal mining, not only as miners and operators, but also as engineers and geologists. The purpose of the conference was to find means for reducing the dangers incident to coal mining and to conserve the natural resources of the State by improved methods of mining, and to utilize to better advantage the coal after being mined. Many of the ablest men associated with that question, both from the practical and theoretical standpoints, attended the conference and participated freely in the discussions.

The United States Geological Survey, in coöperation with the State Geological Survey, has established at the College of Engineering, University of Illinois, a mine-explosion and rescue station. The purpose of the station is to instruct mine operators and inspectors in the economical value of such modern appliances as oxygen helmets and resuscitation apparatus as adjuncts to the normal equipment of mines. The station will also [illegible] itself with the training of mine bosses and others in the uses of such apparatus. Its service is to be rendered gratuitously and, so far as possible, to all in Illinois, Indiana, Michigan, western Kentucky, Iowa and Missouri who may desire the benefits therefrom. The formal opening of the station constituted part of the proceedings of the conference.

Top of Cylinder Blown Off

A very peculiar accident recently occurred to an 18 and 36 by 36-inch cross-compound Whitehill-Corliss engine at the Poughkeepsie Heat, Light and Power Company's plant, Poughkeepsie, N. Y. The entire top of the low-pressure cylinder between the valve chambers was blown out, part of the casting going through the roof.

The engine was started at 7:20 a.m. in the usual way and had been running until 10 o'clock, when the rupture occurred. No valves had been touched, nor connections interfered with, and all receiver valves and line valves were sealed open.



SHOWING BREAK IN LOW-PRESSURE CYLINDER OF ENGINE AT POUGHKEEPSIE

The engine was running on 125 pounds pressure from a battery of horizontal-tubular boilers, and low receiver pressure, usually 15 pounds, with a 26-inch vacuum showing on the gage board.

Just before the accident the generator was running on about half load, or 200 kilowatts. Part of the flying metal cut the belt, which displaced the gage board and wrecked the governor gear. Aside from this, there was little damage done to either the engine or the building.

Close examination of the metal around the outside of the fracture showed a clean new break, with a minimum thickness of 1¼ inches, but the two ribs [illegible] old breaks, as shown in the sketch. One rib left on one side, which was blown out, showed several cracks in the [illegible] which showed that where the cracks were the metal was stronger than at the other end of the rib. The two ribs shown are of [illegible] [illegible]-inch section.

This engine has been running off and on for 10 years, but a great part of that time was idle. On account of the [illegible] of the year, which made it [illegible] necessary to get some work done by the engine, the high-pressure cylinder was used at 120 pounds boiler pressure, in [illegible] and was run in this way when needed for about a month [illegible] was done to the low-pressure cylinder. The engineer had oiled the engine for the evening run and had started to warm up the cylinder by opening the throttle valve a "crack" to admit steam to the cylinder. A few seconds afterward a loud report was heard and the top of the high-pressure cylinder passed through the roof in the same manner as the low-pressure cylinder. The cause was attributed to water hammer, as the engine had not moved, and it seems very likely that such was the case, as upon dismantling the throttle valve part of the body of the valve was found to have been carried away. Thus, although the valve was closed, had permitted steam to leak into the engine and it is very probable that in starting up the large body of water which had accumulated was not taken into consideration.

As in the case of the low-pressure cylinder, no damage was done to anything outside of the engine with the exception of a lubricator and a few small fittings. The rib in the center of the cylinder and the webs all around showed a clean and new break and there were no flaws or blowholes showing.

A report published in the Provincial Engineer deals with a fatality due to the rupture of a boiler fitting [illegible] [illegible] of a vertical boiler [illegible] [illegible] [illegible] while lying in the [illegible] of [illegible] on [illegible] [illegible] The door, which was made of cast iron and measured [illegible] inches, was secured to the [illegible] [illegible] [illegible] of a stud and dog, but the door was so [illegible] [illegible] which led to its being [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] This led to the [illegible] of the boiler being [illegible] [illegible] [illegible] the [illegible] of the [illegible] [illegible] [illegible] [illegible] up the top of the [illegible] and so [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

The Lee Smokeless Furnace Under a Modified Continental Boiler

Something new in furnace, or rather stoker, construction has been invented by Thomas F. F. Lee, a lawyer of some note in Brooklyn. The stoker consists of two side grates, arranged on the arc of a circle and conforming nearly to the outline of the boiler shell, and also a flat grate immediately beneath the boiler. The element of which the side grates are composed is a bar 14 inches in length and of the cross-section shown in Fig. 1, that is, four fingers with spaces between for the admission of air. The grate bars are mounted in series, usually four, on a square bearing bar running the length of the furnace and projecting through the boiler front, so that by means of a special wrench, or automatically, as indicated at the left of Fig. 1, the bars may be given a slight movement and gradually push the coal toward the bottom grate. The fuel is introduced at the side of the boiler, and as it gradually finds its way toward the bottom of the furnace, disappears as gas through the uptake and in the form of a very fine ash through the bottom grate. There are no clinkers, but fine particles of carbon drop through the small openings in the grate. It is the intention at some future date to arrange a fine sieve below the bottom grate and by means of a conveyer of special design return the coke to the furnace, leaving nothing but the fine white ashes, which are so light that a small proportion of them are carried by the draft through the furnace flue to a pit arranged at the rear of the boiler.

There is provision for admittance of air at two points on the sides of the furnace and also through the fuel at the top. The greater portion of the air passes through the admission at the floor line and a part of the air enters downwardly through the fuel and at the tops of the side grates. This latter admission is necessary to draw the fire up through the columns of fuel. A damper is provided, as shown, to regulate the amount of air passing through the side grates. With this arrangement the coal is coked in the upper part of the side grates, and the volatile gases driven off are carried through and over a bed of incandescent fuel before they can enter the boiler. By the time the coal reaches the active portion of the grate, it is completely dried, so that there is no opportunity for the production of smoke, and almost perfect combustion is obtained. From the top of the stack, which is only 25 feet above the boiler, there is positively no trace of smoke.

FIG. 4. THE OLD AND THE NEW STACK

The boiler itself, which is shown in longitudinal cross-section in Fig. 2, is simply a modification of the Continental boiler, containing a large corrugated flue to carry the gases to the rear, and a few more tubes than is usual in this type of boiler. The gases enter the furnace flue through a narrow neck at the bottom, of the same length as the grate and about 9 inches wide, wind around the large flue to the rear of the boiler and pass out through the tubes to the stack. The boiler is set on the floor line, with a pit in front about 3 feet deep to accommodate the boiler front, giving room for the ashpit and space for the boiler tender or fireman to give the side grates the slight upward movement regulating the feed of the coal, also to remove the ashes from the bottom doors visible in Fig. 2.

An installation of this type of boiler and furnace, Fig. 3, was made at the Dover Boiler Works, Dover, N. J., April 1, 1907, and from September 1, 1907, has been in continual operation, displacing two 48-inch by 16-foot boilers of the locomotive type, rated at 50 and 60 horsepower, respectively. The works contains a Clayton air compressor, 10x16x16x10x10 inches, a second air compressor, 8x12

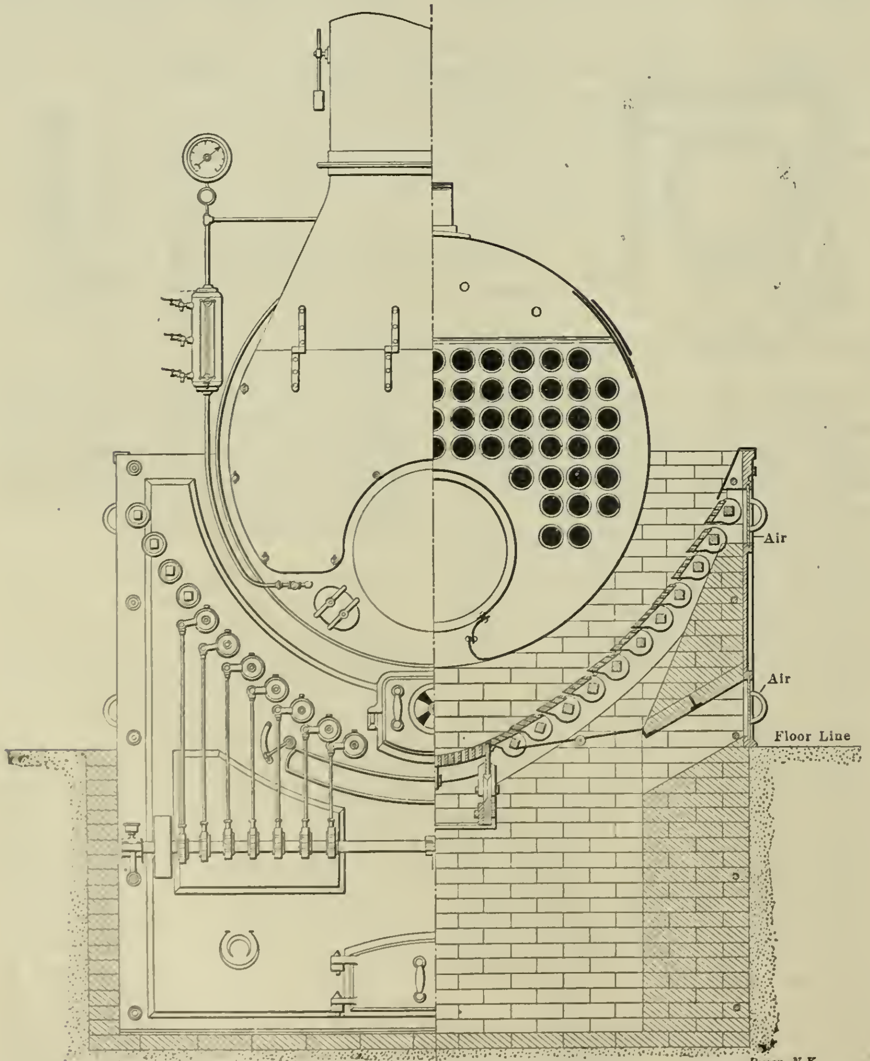


FIG. 1. THE LEE SMOKELESS FURNACE AND BOILER

inches, a 50-horsepower Corliss belted engine and a 25-horsepower engine belted to a dynamo. Frequently this machinery is all running at the same time, and the boiler in operation has handled the load since its installation with no difficulty whatever.

The boiler is 6 feet in diameter and 11 feet 6 inches long; contains eighty-four 3-inch tubes, a 25-inch Morrison furnace flue, and operates on a steam pressure of 110 pounds per square inch. The back is 50 inches long by 9 inches wide, and the [illegible]

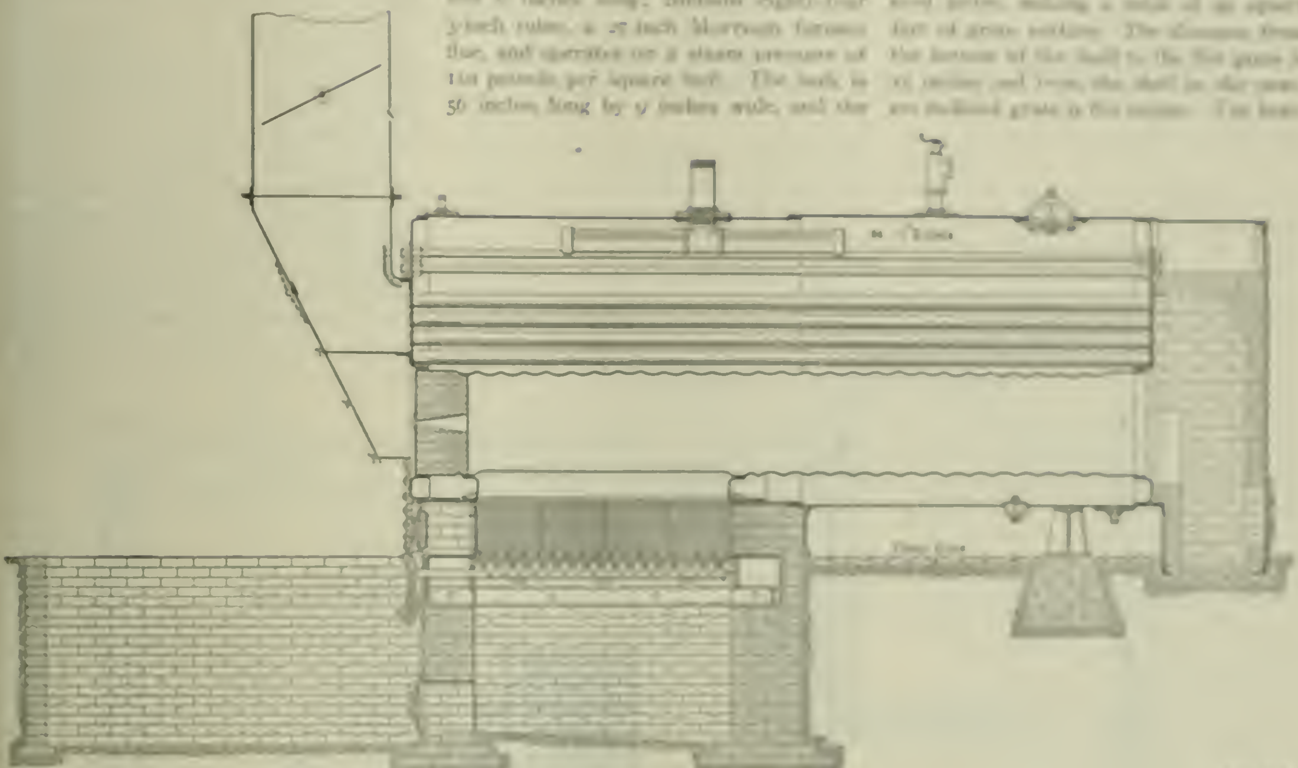


FIG. 2. LONGITUDINAL SECTION THROUGH BOILER AND FURNACE

FIG. 3. INSTALLATION AT [illegible] BOILER WORKS

[illegible]

coal per square foot of grate, or nearly 0.2 pound of coal per square foot of heating surface.

Shortly after the plant was installed at Dover a 10-hour test was made by J. M. Whitham, of Philadelphia, with the following results: Evaporation from and at 212 degrees Fahrenheit, 11.67 per pound of dry combustible; horsepower developed, 98.5; moisture in coal, 8.25 per cent.; dry ash and refuse, 19.38 per cent.; ash by analysis, 13.4 per cent.; draft at damper in stack, 0.038 inch of water; draft in furnace, 0.0651 inch.

Subsequently two tests of 10 hours each with the same coal and under similar conditions were made by Charles W. Scribner, of New York City, and the average result was an evaporation from and at 212 degrees Fahrenheit of 12.8 pounds of water per pound of dry combustible. These figures are extremely high, in fact almost bordering on the theoretical.

It is claimed, however, that they are substantially maintained in ordinary, everyday operation. The appearance of the stack would indicate almost perfect combustion, and the evaporative figure an unusually high efficiency. The absence of smoke and the simplicity of the grate are also points in favor of this construction.

It is also claimed that by regulating the supply of air under the side grates, or in reality varying the active portion of the side grates, the boiler will run just as economically at 40 or 50 horsepower as at its normal rating. The short stack is a feature worthy of note, and is probably allowable on account of the thin fuel bed and the low rate of combustion, although the inventor has some remarkable theories in this regard.

More recent installations of this type of boiler have been made at the plant of the Singleton Silk Mill Manufacturing Company, Luxemburg, N. J., which has installed a 125-horsepower boiler; at the plant of the Buffalo Dredging Company, foot of Porter avenue, Buffalo, N. Y., containing a 100-horsepower boiler, and at the Murray Electric Light and Power Company's plant, Monticello, N. Y., which has installed a 175-horsepower boiler. In all of these plants the side grates are regulated by hand, but it is the intention in future designs to provide the shaft indicated in Fig. 1 and operate the grates by cam movement. It is also planned to in-

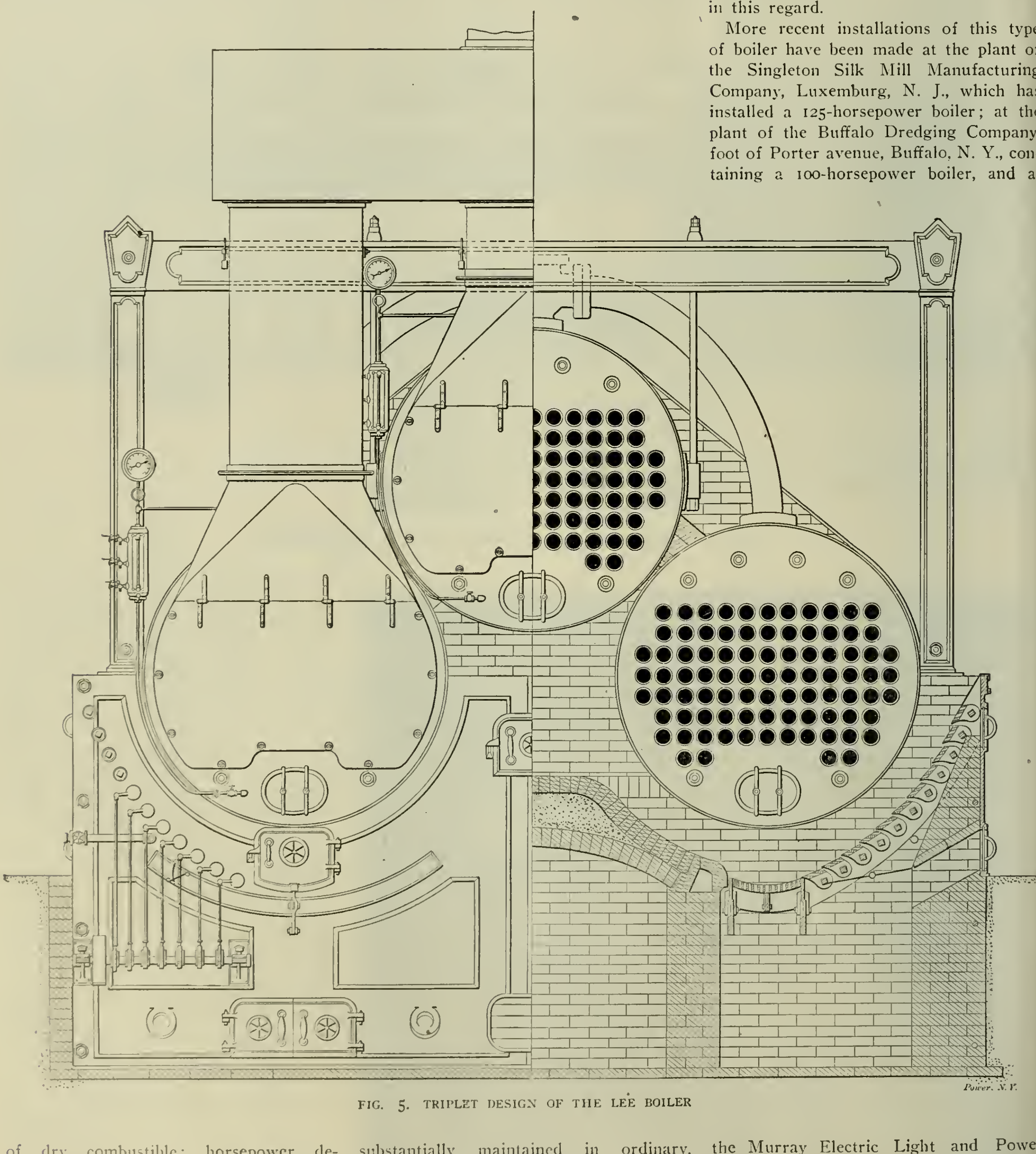


FIG. 5. TRIPLET DESIGN OF THE LEE BOILER

stall the sieve under the flat-bottom grate and the small conveyer previously mentioned. Another innovation is to arrange the boilers in twin or triplet design, a view of the latter arrangement being shown in Fig. 5. For the twin design the two lower boilers are brought closer together and the space occupied by the third boiler in the triplet design is arched over with firebrick. Boilers of the usual design are to be used and the arrangement of the gas passage is indicated in the drawing. The Smokeless Furnace and Boiler Company, 44 Court street, Brooklyn, N. Y., is to control the manufacture of these boilers and stokers, every feature of which is covered by application for patent.

Experience with Gas Power in a Grist Mill

By H. B. Messenger

Following is a presentation of actual results obtained in six months' operation of an 85 horsepower Jacobson producer-gas engine and a ——— suction-gas producer in a flour mill, operated entirely by men who have never had the slightest previous experience with gas engines or producers of any sort. This engine took the place of a good automatic steam engine, rated at 100 horsepower, maximum, and easily capable of delivering 90 horsepower continuously. It was supplied with steam by two horizontal return tubular boilers, one 60 inches and the other 66 inches in diameter, and both 16 feet long and rated respectively at 80 and 100 horsepower. These boilers were kept thoroughly clean inside and the tubes were scraped daily. The feed water entered the boilers at nearly the boiling point and 100 pounds boiler pressure was carried. The main steam pipe to the engine was short, of ample capacity and well jacketed.

At times it took very good firing to keep the engine supplied with steam with both boilers running, and it was impossible to run all the machinery in the mill to its full capacity; the engine would not drive it at full speed. The normal coal consumption, using the best grades of Georges creek soft coal, was in the neighborhood of two tons per day, varying, of course, with the amount of work being done, the condition of the boilers, etc. The gas engine installed to displace the steam engine is rated by the builders at from 75 to 85 horsepower. It is a tandem engine, with cylinders of 14 inches bore and 18 inches stroke. It is very heavy throughout, the engine with flywheels, mounted, weighing in the neighborhood of 14 tons. The shock of the explosion of charges is well absorbed in consequence, and the engine runs very steadily and smoothly. The speed is 220 revolutions per minute.

The engine was started July 22, 1908, on its regular work, beginning that day upon a new carload of pea anthracite. Since then it has run steadily with very few interruptions, and has proved fully capable of driving the entire mill to its capacity and at full speed. Some of the hardest running machinery in the mill, a line taking at least 20 horsepower to operate at full capacity, is thrown in and out without affecting the engine or producer apparently in any way. It is not found necessary or even advisable to notify the operator when this heavy load is to be added, the producer and the engine both taking care of the added load without any attention. The speed regulation is of the best, it being impossible, once the engine is fairly at work, to notice any variation, upon adding the work in large units, without using a speed indicator.

The producer used with this plant was built by the Smith Gas Power Company, Lexington, O. It is 10 feet high and 5 feet in diameter on the outside, lined with firebrick about 8 inches in thickness, making the inside diameter about 4½ feet. The ashpit is about a foot in depth, and the gas-collecting ring in the top occupies very little space. It is only necessary to charge this producer or to work on the fire once each day ordinarily, but if the engine is running heavily loaded it is sometimes advisable to settle the coal down compactly about the middle of the day. From 500 to 1000 pounds of coal is put in once per day, this being sufficient for an 11-hour run and to keep the fire over night. Very little heat is thrown out, the top of the producer feels warm to the hand, but not hot when the fire is in proper order. The water in the seal at the top will last all day without renewal. While the producer will run all day without attention, it has been found that a little attention to the fire about the middle of the day will give better results as to regularity in the quality of the gas; also that a little judicious work in cleaning and poking down the fire about closing time will save work and time in starting in the morning.

The time required to get started in the morning depends almost entirely upon the management of the fire by the operator. We have started on Monday, the fire having been kept over from Saturday night, in fifty minutes from the time of entering the engine room, and it seems probable that with a little more experience and care this time can be still further reduced.

Some few minutes are required after the engine is started before all the load can be thrown on. It is good policy to have the engine and producer in operation for thirty minutes before attempting to carry the full load or to throw parts of the load on and off without variation in the speed, owing to the fact that the production of gas is not fully under way.

More grain has been ground in this mill since the installation of this plant than ever before in the same length of time.

Three cars of coal have been taken in by the use of this producer, the aggregate weight of the three cars being a little under 80½ tons. No other coal has been used in its operation; some coal has been sold and several tons were on hand on January 1, when the stock was first measured. The consumption has been about 80 tons in six months, or a little over 13 tons per month. The mill runs 11 hours per day.

Fire has been kept the entire time, over night and over Sunday. Some coal has been wasted by the inexperience of the operator, and one car of the coal proved to be not suited to the work, requiring the consumption of about one-third more coal per day than the coal in either of the other cars.

The guarantee of 1½ pounds of coal per horsepower-hour has been found to cover a wide margin of safety, and besides the saving in coal, the labor and attention are very much less than were required for the steam power. One man does the work, as he did with the steam plant, but he is able to do a great deal of outside work and has time to spare. He has been known to come to the office in cool weather to get warm, there not being enough heat and work in the engine room to accomplish that result. It is needless to say that in warm weather his position has changed from a very undesirable one to one of the best about the mill.

The miller is also highly pleased with the change. He can now operate any or all of his machinery at any time and the mill never lags, avoiding much trouble by chokeups, etc. The mill runs with much less attention, and does better work and more of it. In short, no one about the plant, from the proprietor down, would contemplate a change back to steam with any degree of pleasure, but all would most heartily oppose such a change.

Lecture on Water Tube Boilers

On Tuesday evening, March 16, F. C. [illegible] delivered an illustrated lecture before the Students' Engineers Club of Brooklyn on the subject of water-tube boilers. Much of the lecture was historical and the earliest forms of water-tube boilers, with boiling water, [illegible] from the time of Watt. After these came illustrations showing the work of the earlier modern designers, beginning with Rumsey in 1788 and taking up in turn the work of Stevens, [illegible]; Perkins and his son, [illegible]; Gurney, [illegible]; Fox, [illegible]; Twibill, [illegible] and Field, [illegible].

The balance of the lecture was given over mainly to showing the development of the water-tube boiler as manufactured by the Babcock & Wilcox Company. Following the lecture an interesting discussion [illegible] took place.

POWER AND THE ENGINEER

DEVOTED TO THE GENERATION AND TRANSMISSION OF POWER

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March 16	37,000
March 23	37,000
March 30	37,000

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Contents

The Boiler Inspector

Sometimes an inspector's report makes absurd demands or recommendations, but this is no more reason why the engineer should condemn the principle of inspection than that he should refuse to consult a physician when some member of his family is sick, simply because some "dub of a doctor" had cut open a friend to remove his appendix and found the trouble to be caused by his kidneys.

With men who are equal as regards the gift of observation and the ability to reason from cause to effect, the boiler inspector has opportunities to perfect himself in diagnosing boiler troubles so far superior to those of the operating engineer that comparison seems absurd. A boiler inspector sees thousands of boilers where the engineer sees one.

Instead of looking forward to the inspector's visit as an unpleasant duty, to be got through with as soon as possible, and with the least trouble, look upon it as an opportunity to add to your store of knowledge, and the possibility of your finding some contemplated change in your equipment which will be worth while.

No one has a corner on ideas, and it is very likely that John Smith, who has a plant almost the same as yours, is a progressive engineer like yourself, and is always scheming to add to the economy of his plant. Possibly some of the same changes have occurred to him as being beneficial that you now have under consideration, and it may be that he has tried some of them with success, while others proved failures. You cannot avail yourself directly of Mr. Smith's experience, because you do not know him, and are not likely to meet him, his plant being located in another State.

Now, the inspector who goes to Smith's plant also comes to yours, and Smith has told him, with pride, of the different improvements he has made, and if he is a real broad-gaged engineer he has also told him of his failures; and if you will only make a friend and confidant of the inspector you will have much of Smith's experience at your command, as well as that of a great many other engineers. You can never gain the inspector's good will by making his duties hard. Boiler inspecting at best is a tiresome and dirty job and you do not gain the inspector's respect or good will by making him crawl through three feet of ashes or drag himself through a lot of mud in the bottom of your boilers to make his inspection.

Make his labors as easy as possible, and what adds as much to his comfort as properly preparing your boilers for inspection is to show him by your manner that you are glad to have him visit your plant, and appreciate the points he can give you regarding the kinks your brother engineers are using. No matter how you regard the inspector's opinion, never try to deceive him regarding the condition of your plant, and do not leave him to find a defect which you know to exist, but tell him of it. By such tactics you at once gain the confidence of the inspector and at the same time disarm him in his position to give you information, regarding your plant, which you as the responsible head should be aware of yourself. The inspector has nothing to gain by making you his enemy, and the chances are, by long odds, that if he turns in a report regarding your plant which you do not consider good, he thoroughly believes he is right and is merely doing his duty to his company and your employer as he sees it.

Never take exception to an inspector's report unless you are prepared to show conclusively that you are right, for if the inspector is right (and in the great majority of cases he *is* right), and he can prove it, your objections merely strengthen his position with your employer, and will greatly injure yours in any future controversy.

Boiler Room Supervision

If you were conducting a chemical works in which some fifty dollars worth of chemicals were converted per hour by a process which, with reasonable care, would yield eighty per cent., but which might easily, through the personal factor, be dropped to fifty, would you go out to the dump and hire the cheapest laborer who could handle a shovel and put him in charge of the department? The burning of coal is a complicated chemical process. The transfering of the heat which is generated by that combustion into water and the production thereby of steam is a process which affords opportunities for economy or waste. The apparatus in which these processes are conducted is usually under high pressure, a source of danger if carelessly or ignorantly handled, however safe and adequate it may be in competent hands, subject to rapid deterioration and costly repairs largely avoidable by skilled and intelligent manipulation.

We do not advocate the placing of the boiler room in charge of a professional chemist, but there are men who are specialists in this line who can save a very considerable proportion of the coal which is fired in the average plant, men who know how much coal a fireman can and ought to handle per shift, and how he ought to fire it; men who are capable of determining the value of the coal which you get, and of the composition of the flue gases; capable of getting the largest amount of steam per dollar's worth of coal, of keeping down leaks and repairs and of forestalling accidents and shutdowns. But this class of man does not work for a dollar and a half a day and would not be content to hang his clothes on a buckstave bolt and wash in a pail.

Firing is dirty work, but there is enough clean money to be saved by doing it right to make it worth while to pay a high-class man, and the physical conditions can be improved to such an extent that they will not repel men of that character.

Coal Consumption and Power Plant Economy

One of the first questions a visiting engineer naturally asks is: "What is your coal consumption per kilowatt or per horsepower hour?" He wishes to find this out so he can compare the work of his plant with that of others.

It is well to remember that the coal consumption per unit of output is, at best, only a partial indication of the efficiency of a power station, although it depends greatly upon the way in which the boilers, auxiliaries and engines are handled, with respect to the load variations. It is far more important to approximate, if possible, the total cost of power production per unit, including the principal items of fuel, labor, water, oil, waste, repairs and, in some cases, sundry items of purely operating equipment or tools. Of course, the total cost cannot be known until the fixed charges are figured.

The total coal consumption per kilowatt-hour may be higher one year than another, and yet the total power cost exclusive of fixed charges may be less. In one case, the coal consumption was 3.45 pounds per kilowatt-hour one year, and 3.26 pounds the next. The cost of power manufactured in the first year, however, was 1.22 cents per kilowatt-hour and the second year 1.24 cents. Thus, quite a noticeable difference in the amount of coal used per unit of output really produced little effect on the plant cost of operation as a whole. This does not mean that the coal consumption was unimportant at any time, however, for it is only by pruning down all excess quantities in plant operation that the total cost runs low enough to make a good showing. The chief reasons why the cost was a little greater in this plant in the year when the coal consumption per kilowatt-hour was the least were an increase of 11 cents per ton in the coal cost at the plant, an increase in the water cost of $900, an increase of $700 in steam-plant repairs and an increase of $1000 in electric-plant repairs. The labor cost was actually a little less per kilowatt-hour during the year when the total expense of production was higher.

During another year in this same station the coal used per kilowatt-hour was the same as in the first year cited, 3.45 pounds, but the total cost of production was 1.32 cents, as compared with 1.22 cents during the first year. The plant turned out 25 per cent. more energy during the year when the cost was lower. [illegible] was certainly an important factor in the decreased expense. The cost of coal per ton in the less expensive year was 10 cents less than in the higher cost year. What made the difference then? Going over the records of the plant in detail we find that the total cost of manufacture was $7000 less in the higher cost year, so that the saving was practically all due to the gain in load.

One of the chief difficulties of economical operation in electric-power plants is due to load variation, making it far from easy to operate the machinery at the capacities for which it was designed. There is scarcely any form of equipment known in power plant engineering which will operate efficiently at low outputs, compared with the results which can be obtained when the machinery is run close to its rating. The steam engine will not do its best work when underloaded. The turbine is less affected by a reduction of load from 75 to 50 per cent. of normal, but when its operation with auxiliaries is taken into account, and this is the only way of actually finding out what a steam-turbine installation will do, it will soon be seen that operation at as near full load as possible is required for the highest economy of power production.

Neither can the gas-engine plant be operated at underloads with any prospect of securing the best results in operating efficiency, and in all plants the larger the output for a given equipment, the less will be the station labor and repair cost per unit.

Is Material or Method Responsible for Lap Joint Cracks?

The memorandum of C. E. Stromeyer, chief engineer of the Manchester Steam Users' Association, for 1907, refers to numerous samples of boiler plate which were tested in an endeavor to ascertain if mild steel possessed aging qualities. Among these samples were three taken from boilers that had cracked or exploded in service, and the history relative to one set of these samples is very interesting as possibly throwing some light on the question of the cause of the so-called lap-joint cracks.

From this report it appears that in 1888 nine boilers were built by one maker and installed in a plant, and although they were built at the same time, four different makes of steel were used in their construction, all four makers being considered of equally high grade. Two of the boilers were constructed of make A, one of make B, one of make C and the remaining two of make D. After about four years of service an inspection revealed two cracks in the [illegible] in different boilers, one being constructed of steel A and one of steel C. Subsequent inspections about a year later revealed the same kind of cracks in two boilers of steels C and D, after which the entire nine boilers were abandoned. Shortly afterward a hydrostatic test developed an additional crack in one boiler constructed of steel B, and all of the rivets in the longitudinal seams of this boiler were removed, but no additional cracks were found and the plate did not appear to be brittle.

It would appear from the facts in this case that the quality of the material was not a factor in the formation of the cracks, for in the five boilers each of the four different makes of steel was represented. This apparently leaves the method of manufacture or manner of laying up the seams to account for the failures. While this case is rather unusual, in that it affords an opportunity for comparison between different makes of steel, in boilers for a single plant, made by one manufacturer at the same time, it must be admitted that the evidence is very good that the quality of the plate was not the cause of the cracks. The evidence in this case also coincides with the experience of an engineer who has gathered considerable data relative to this type of boiler failure in one section of the country.

It was found that while the make of plate concerned in such failures was apparently well distributed among the steel manufacturers, the distribution of the failures among the boiler makers which supplied the sections in question was not uniform, but was confined to a very limited number. This would indicate that the method of manipulation is a more important factor in the formation of such cracks than the quality of the plate used. The real cause or causes of the formation of the lap-joint crack are probably not yet thoroughly understood.

It is evident from the report that Mr. Stromeyer does not regard the use of the lap joint in the same light that it is being viewed by numerous engineers in the United States, for in commenting on the apparent good qualities of the steel found in the three cases of failure that came under his notice he has the following to say:

"It should be mentioned that although lap joints are very common in stationary boilers and give perfect satisfaction, they seem to have been the cause of many locomotive explosions in the past, and the [illegible] [illegible]"

Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

Lagonda Feeding Device

We illustrate herewith a new device that permits the operator to sit in a comfortable position on a platform or scaffold outside the boiler and with very little physical effort feed the turbine tube cleaner into one tube after another. Instead of supporting a heavy weight of hose and cleaner, the hose responds to his will by his merely turning the crank. After a tube is finished, the operator draws the turbine into the funnel shown at the end, and by a new setting of the feeding device the funnel is centered over the next tube to be cleaned. The adjustment requires only a moment and the water need not be turned off until all the tubes are cleaned, thus effecting a great saving of time.

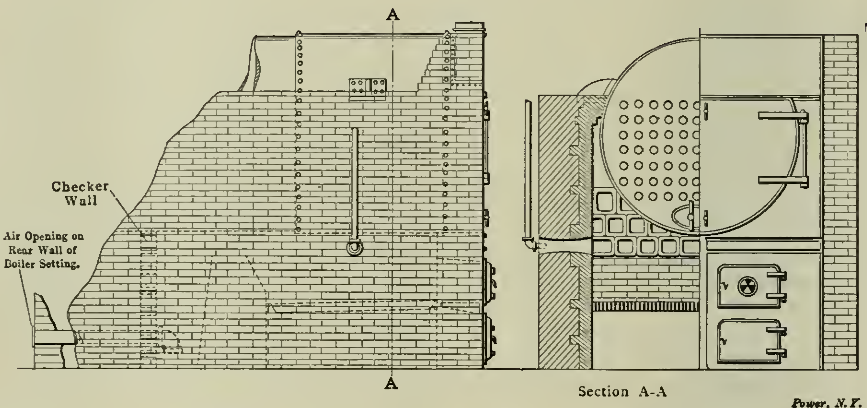
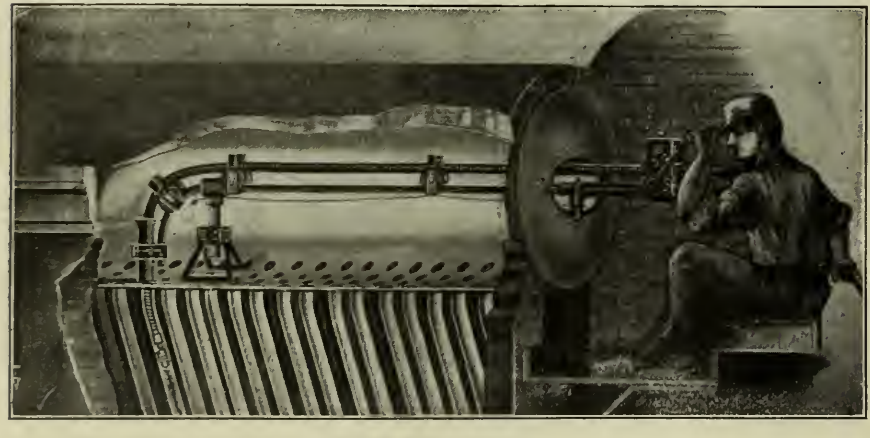


FIG. 1. HOW THE M'GIEHAN DEVICE IS INSTALLED


LAGONDA FEEDING DEVICE

The mechanism of this device consists of a funnel through which the cleaner is guided into the tube, a stand and shafting to support the funnel and hose, and to provide adjustment over the different tubes. The shafting is jointed and snapped together with triggers, so that the sections can easily be handled and used in the limited space between the boilers. On each section of shaft are a spool and rack on which the hose is rolled. The shafting is held in the center of the manhole by a tripod rigidly braced from the edge of the manhole. Extending from this tripod is the feeding device proper for feeding the hose into the tube. There are two capstan-shaped rolls which inclose and grip the hose, and which are geared together so that when one is turned by the crank the other turns.

The Lagonda feeding device may be used with any make of turbine cleaner, and is manufactured by the Lagonda Manufacturing Company, of Springfield, Ohio.

The McGiehan "Smoke Eliminating" Furnace

Another device designed to eliminate smoke when burning bituminous coal, and to increase the efficiency of steam boilers, is illustrated herewith. It is known as the "McGiehan patent smoke-eliminating

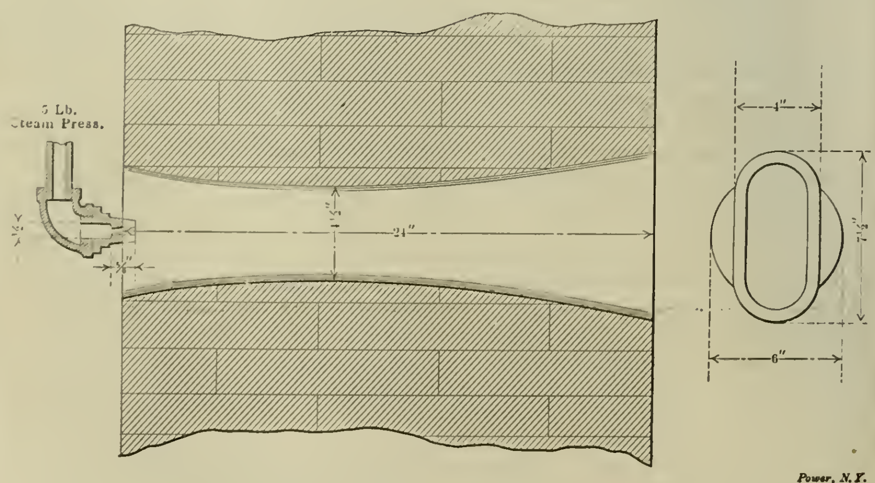


FIG. 2. SHOWING THE STEAM NOZZLE

furnace," designed by P. H. McGehan, Garnerville, N. Y., and handled by W. H. Howard, 90 West street, New York City. The device can be installed with any type of boiler.

Under the boiler, between the bridge-wall and the rear wall of the setting, is a checker wall, as shown in Fig. 1. Extending from the rear end of the boiler, through the combustion chamber and checker wall is a pipe, on the end of which is a tee, turned down as shown, for the purpose of admitting air in a heated state, between the bridgewall and the checker wall, in passing through the combustion chamber. The pipe is covered with firebrick.

To assist in the combustion of the fuel a steam nozzle is introduced on the side of the furnace, constructed as shown in Fig. 2. It is shaped something like a double-ended telephone receiver, the outer end being the larger—about 6 inches in diameter—the inner end being oblong, 4 inches wide and 7½ inches long.

This device can be seen in operation under sixteen 7x18-foot return-tubular boilers at the Rockland Print Works, Garnerville, N. Y. From observations made by the writer it is working satisfactorily,

FIG. 3. RESULTS WITH AND WITHOUT USING THE McGEHAN DEVICE

the mechanical engineer at the plant stating that as high as 170 per cent. of the boiler rating has been obtained and he has been able to evaporate from 11 to 12 pounds of water from and at 212 degrees Fahrenheit per pound of combustible. As a smoke consumer it would seem to be a [illegible] Fig. 3. [illegible]

Personal

Robert Thurston Kent has resigned as engineering editor of the *Iron Trade Review*, Cleveland, Ohio, to become managing editor of *Industrial Engineering*, Pittsburg, Penn., a new paper devoted to mechanical-engineering subjects. Mr. Kent has been with the *Iron Trade Review* since 1905, and prior to that time was associate editor of the *Electrical Review*.

The engineer and another were killed and a laborer injured by the explosion of a boiler at the [illegible] ice houses of the American Ice Company, at Farmingdale, Me., on March 14. The boiler was said to be 30 years old.

SATURDAY, MARCH 6, ON INVITATION OF THE MANAGEMENT, MEMBERS AND FRIENDS OF THE [illegible]

Anniversary and Presentation

The twelfth anniversary of the Engineers' Blue Club of Jersey City, N. J., was celebrated by an entertainment and ball at Columbia hall on Wednesday evening, March 17. An exceptionally good vaudeville program was followed by dancing. During the evening William Cronley called to the stage John J. Callahan and presented him a very handsome badge.

Business Items

The Dakota Gas, Electric Light and Power Company, Wagner, S. D., has purchased from the Minneapolis Steel and Machinery Company an 80-horsepower Muenzel producer-gas engine and suction gas-producer plant. This outfit will be installed in the electric-light plant at Wagner, where there is already one Muenzel unit in operation.

Tripp metallic packing, manufactured by William B. Merrill & Co., Boston, Mass., has recently been applied to the 48-inch plungers at the Dorchester pumping station, City of Boston. Two more sets of the same diameter are now in process of construction for the same station. The large diameters of these plungers demonstrates what this type of packing will do on this class of work.

The first fountain-pen plant in Canada has just been placed in operation by the L. E. Waterman Company, at St. Lambert, Que. The plant is entirely electrically driven, the current being generated on the premises. The generator is a Crocker-Wheeler belt-type three-phase 60-kilovolt-ampere 600-volt 60-cycle machine, running at 1200 revolutions per minute, furnished by the Canadian Crocker-Wheeler Company, Ltd., of Montreal. It is driven by a Bellis & Morcan English vertical engine. This machine was installed for immediate use, and the plant will be doubled before it is completed. The exhaust steam is used for heating the buildings.

Recently the Crocker-Wheeler Company has had a large call for direct-current motors. One of the largest orders of the year in this line is that received from the Sprague-Warner Company, Chicago, for 31 small motors ranging from ½ to 20 horsepower, and aggregating about 150 horsepower. An order for 21 motors for 1-5 to 10 horsepower to drive printing machinery has been placed by Clark & Courts, Galveston, Tex. The Pittsburg Steel Company, Monessen, Penn., has placed an order for two 75-horsepower 500-volt motors to drive draw benches. The American Auto Course Company, Chicago, has ordered 15 small motors of ¾ horsepower each, and the Newton Machine Tool Company has ordered a 22-horsepower adjustable-speed motor, with 1:2 speed ratio. An order for nine crane motors has been received from the King Bridge Company, of Cleveland. A large number of orders for single motors have also been booked.

The new 1909 catalog of the Nelson Valve Company, of Philadelphia, has been issued and contains 220 pages bound in cloth. The catalog shows gate, globe, angle and check valves made in large variety of metals. Among the new features are included the newly patented bronze, swing, check valves and hydraulically and electrically operated gate valves. The listing of steel gate and globe valves for high pressures and superheated steam marks a new era in high-class valve construction. Another new departure of note is the listing of open-hearth steel fittings. The use of engravings showing both inside and outside views is generous; the descriptive articles and dimensioned lists immediately opposite the engravings facilitate easy and critical study of each valve. Test pressures as well as the working pressures are given in each case, so that the valve user has a definite basis for selection of the valve he wants. While this catalog is extensively published, it is offered free on request of any reader.

The Morehead Manufacturing Company, of Detroit, Mich., has sold some of its Morehead vacuum traps for use in connection with steam-turbine service to J. G. White & Co., Inc., engineers and contractors, of New York, who employ this trap for draining the exhaust line between the turbine engines and the condenser at the new power plant of the Delaware & Hudson Company, Mechanicsville, N. Y. Two No. 4 Morehead vacuum traps are used at this plant, the two installations being in duplicate. These traps are used in conjunction with a 2000-kilowatt vertical turbine of the Curtis type. The inside dimension of the exhaust pipe is 7 feet 9 inches wide and 2 feet deep. The vertical distance from center of outlet to center of outlet is 25 feet 7¾ inches. The horizontal distance from face to face of the flanges of the exhaust duct is 9 feet 6 inches. The condenser is of the Worthington barometric-tube type. The approximate vertical fall from the receiver on the exhaust duct to the water line in the trap is about 8 feet. The tray discharges directly into the discharge conduit from condensers. The water of condensation discharged from the trap is thrown away. J. G. White & Co. have just completed a series of exhaustive tests in the working of these Morehead vacuum traps and report satisfactory operation in every respect.

New Equipment

The Philadelphia (Penn.) Warehousing and Cold Storage Company will build an eight-story cold storage and freezing plant as addition to the present plant.

The Toms River (N. J.) Ice Company has been incorporated by J. P. Haines, Chas. B. Mathis and Caleb Falkenbaugh to manufacture ice. Capital, $20,000.

The People's Electric Light and Power Company, Silver Creek, N. Y., is in the market for two gas engines, 60- and 80-horsepower. Henry H. Brand, chief engineer.

The Charleston Light and Power Company, Charleston, Miss., has been incorporated by J. H. Caldwell, W. B. Burke, E. D. Dinkins and others. Capital, $10,000.

The council of the city of Columbus has authorized the issuing of $45,000 bonds to install a 2000 kilowatt turbo-generator. G. H. Gamper is superintendent, department of lighting.

The Berkeley Ice and Storage Company, Martinsburg, W. Va., has been organized by George Showers, H. P. Thorn and others, to establish ice and cold-storage plant. Capital, $50,000

The Elizabeth & Perth Amboy Traction Co. is being formed to construct an electric railway from Elizabeth to Perth Amboy, N. J. Chas. A. Trimble, Elizabeth, N. J., is one of the incorporators.

The City Council, Tacoma, Wash., has authorized the Commission of Public Works to advertise for bids for furnishing two compressors, one air receiver and two electric motors for Station C.

Analysis of Steam and Inertia Forces

Inertia Forces of a Tandem-Compound Engine and Their Combination with the Steam Forces in Each Cylinder Expressed Graphically

BY F. W. HOLLMANN

In engines operating with a high piston speed, it is desirable to know how much the inertia of the moving parts affects the driving effort and the crank- and wrist-pin pressures. If an engine knocks on the centers, it is easily explained, but when a knock occurs in a later period of the stroke, it might cause some guessing. In starting and stopping the piston, with its rod and crosshead, energy is consumed and given up. The amount consumed is theoretically equal to the amount given up, and therefore should not affect the power of the engine, but in some cases the forces caused by the starting and stopping of masses moving at high speeds exceed the useful steam forces and cause parts to be subjected to great stresses. The accompanying diagrams show such a case which, although not very common, is of interest because the heaviest stresses exist when the lightest would be expected. A few words might be said in regard to the way in which diagrams of this sort are plotted.

If the mass of reciprocating weight were concentrated at the crank pin and considered to revolve with it, it would exert a centrifugal force which would be equal to

$$\frac{W v^2}{g R},$$

where

W = Weight in pounds,

v = Velocity of crank pin in feet per second,

g = 32.2, and

R = Radius in feet.

FIG. 1. METHOD OF OBTAINING INERTIA VALUES

Again, if the mass be connected to the crank pin by an infinitely long connecting rod, the mass will be accelerated from the inner center up to the 90-degree position, at which it will have its maximum velocity, and then it will be retarded until the 180-degree position is reached. At the zero and 180-degree points the force exerted by the positive and negative accelerations will be equal to the centrifugal force which would result if the mass revolved in the path of the crank pin. At any intermediate position the value of the force which will be required to give it the necessary acceleration will be equal to this same value times the cosine of the angle which the crank makes with the line through the inner and outer centers.

The length of the connecting rod, however, exerts an influence upon the value of these inertia forces. A formula representing these values can be deduced by the aid of calculus, which will give these values. The formula is

$$Force = \frac{W v^2}{g R}\left(\cos\theta \pm \frac{R}{L}\cos 2\theta\right).$$

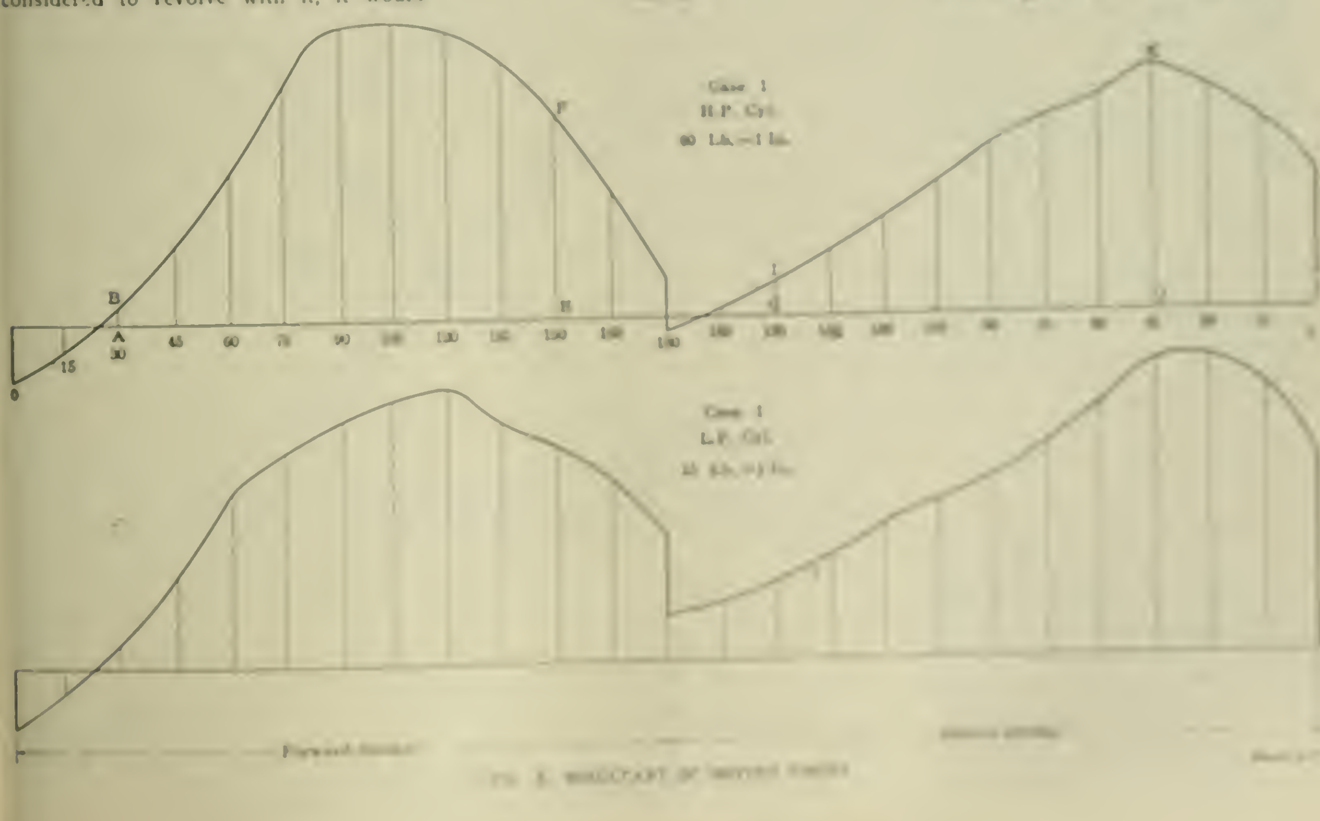


FIG. 2. [illegible] OF INERTIA FORCES

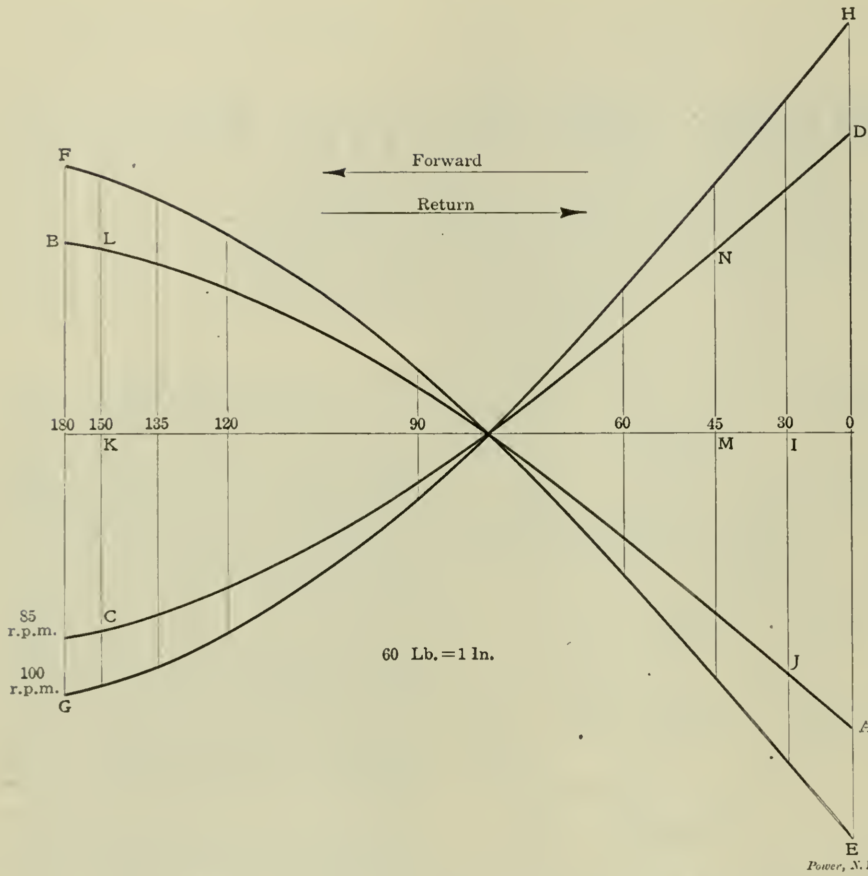


FIG. 2. INERTIA DIAGRAMS OF HIGH-PRESSURE RECIPROCATING WEIGHT

where

$\frac{W v^2}{g R}$ = Centrifugal force mentioned,

θ = Angle which the crank makes with the center line,

$\frac{R}{L}$ = Ratio of crank to connecting rod.

The sign + is used for the forward stroke and — for the return stroke.

Another formula which gives the corresponding piston position for the angle θ is

$$S = R\left[(1 - \cos\theta) \pm \tfrac{1}{2}\frac{R}{L}\sin^2\theta\right],$$

where S is the distance from dead center, + is used when measuring from the inner center and — when measuring from the outer center.

Substituting in formula (1) 0 and 180 degrees for θ gives

$$F = \frac{W v^2}{g R}\left(1 + \frac{R}{L}\right);$$

$$F = \frac{W v^2}{g R}\left(1 - \frac{R}{L}\right).$$

Let $\frac{W v^2}{g R} = F_0$ and in order to express the inertia forces in terms of pressures per square inch of piston area, divide the values by the area of the piston. Then

$$\frac{F}{A} = \frac{F_0}{A}\left(1 + \frac{R}{L}\right).$$

If a radius CA, Fig. 1, were taken equal to the value $\frac{F_0}{A}$ to the same scale as the indicator diagram, and a circle described, then solving equation (1), first dividing both sides by the area of the piston, for various angles of θ and plotting these values from the ends of the radii on lines horizontally as GK, a parabolic curve BOD would result. This will be nearly an arc of a circle, except for very short connecting rods. Having described the circle with radius CA, lay off

$$CO = DE = BF = \frac{R}{L} CA,$$

and through these points draw an arc of a circle DOB. Then for any crank angle GCI the inertia value GK is obtained, and for HCA the inertia value KH. The force GK multiplied by the area of the piston would be required to accelerate the reciprocating mass, and HK multiplied by the area of the piston would be required to retard the mass at its respective velocity, assuming the crank pin to revolve at a uniform rate.

To get the corresponding piston position for the angle θ, describe another circle with a radius equal to half the length of the indicator card, and from the point where the radius CG or CH inter-

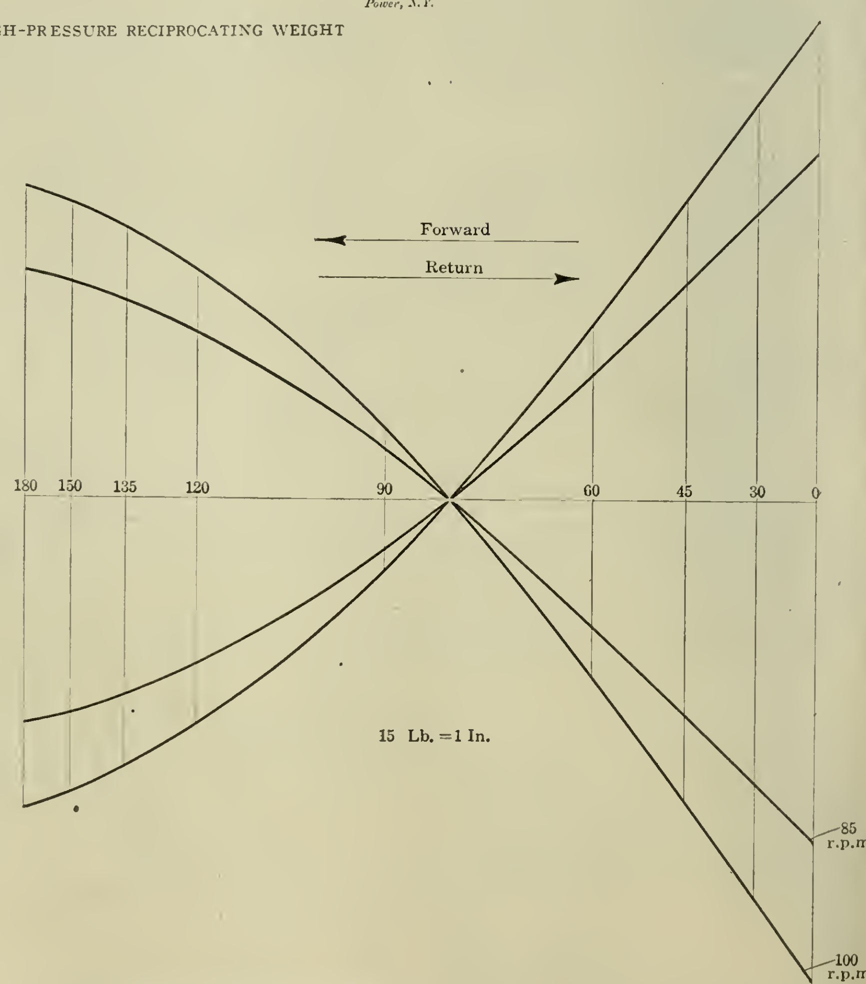


FIG. 3. INERTIA DIAGRAMS OF LOW-PRESSURE RECIPROCATING WEIGHT

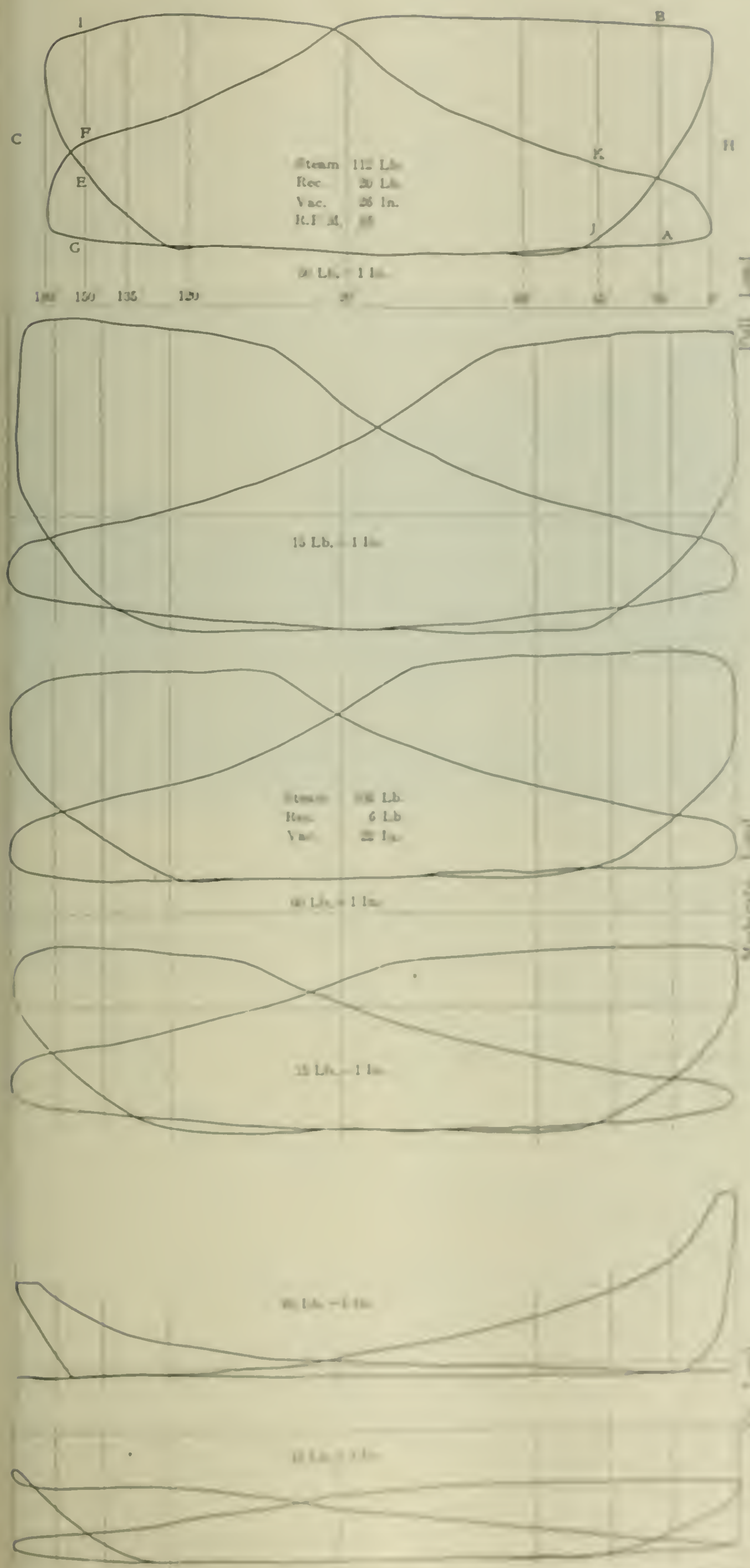


FIG. 4. INDICATOR DIAGRAMS FOR DIFFERENT LOADS

erty in taking the arc [illegible] equal to $\frac{L}{R}$ C N, the [illegible] of the arc being on the line [illegible] N produced. Then N I will give the piston position for the angle I C N and N E will give the piston position for the angle N C P.

Fig. 2 gives the inertia diagrams for the high-pressure reciprocating weights, which includes the piston, piston rod, half the connecting rod, crosshead and half the intermediate crosshead. The curve A B gives the values for the forward stroke and C D for the return stroke at 85 revolutions per minute. Similarly E F and G H give the values for 100 revolutions per minute. The values at the beginning are taken as negative and laid off below the line, because these forces are required to start the piston, while those later on are required to stop the piston, and therefore are considered as positive.

Fig. 3 gives the same diagrams for the low-pressure cylinder, whose reciprocating weight is half the intermediate crosshead, the piston, the rod and the tail-rod crosshead.

Fig. 4 gives the indicator diagrams for three different conditions. The diagrams were not all taken with the same valve settings, but that does not affect the analysis. Fig. 5 gives the forces which result when the steam and inertia diagrams are combined. In this figure the points are laid off in crank angles, while in Fig. 4 the piston positions are taken for corresponding crank angles. The steam force is measured from the back-pressure line of the opposite end and to this is added or subtracted the inertia force, depending upon whether it is positive or negative. Take the high-pressure full-load card in Fig. 4 and the inertia card of Fig. 2. In the forward stroke from the steam force A B the inertia force [illegible] is subtracted and the curve [illegible] in Fig. 5 results. Similarly the steam force [illegible] is added to the inertia force [illegible] and [illegible] in Fig. 5 results. So also in the return stroke [illegible] is subtracted from [illegible] and [illegible] is added as [illegible]. Similarly the low-pressure card is combined with its inertia diagram. The high- and low-pressure diagrams are then combined by adding each corresponding pressure and inertia

MAXIMUM CRANK AND WRIST-PIN [illegible]

Pressures	Crank 1	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

tiplying it by the piston area in each case and adding the resulting values together.

Fig. 6 gives the results of the three cases. The table on page 625 gives the maximum crank- and wrist-pin pressures in the different cases. The wrist-pin pressures are a trifle larger than they should be, because half the connecting-rod weight was taken as the reciprocating weight. The crank-pin pressures are a trifle low, because the centrifugal force due to the revolving weight of the rod was neglected.

Fig. 7 gives diagrams of the points of maximum crank-pin pressures and points at which pressure reversals take place.

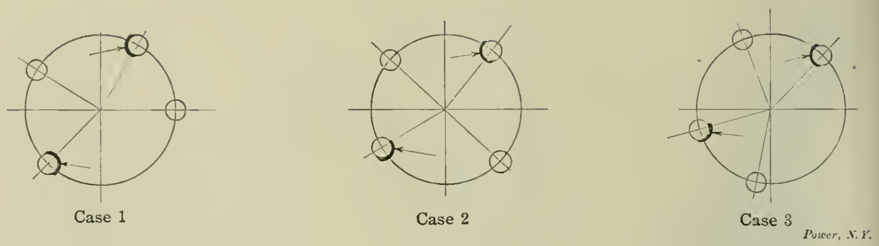


FIG. 7. PRESSURE REVERSALS AND MAXIMUM PRESSURES ON CRANK PIN

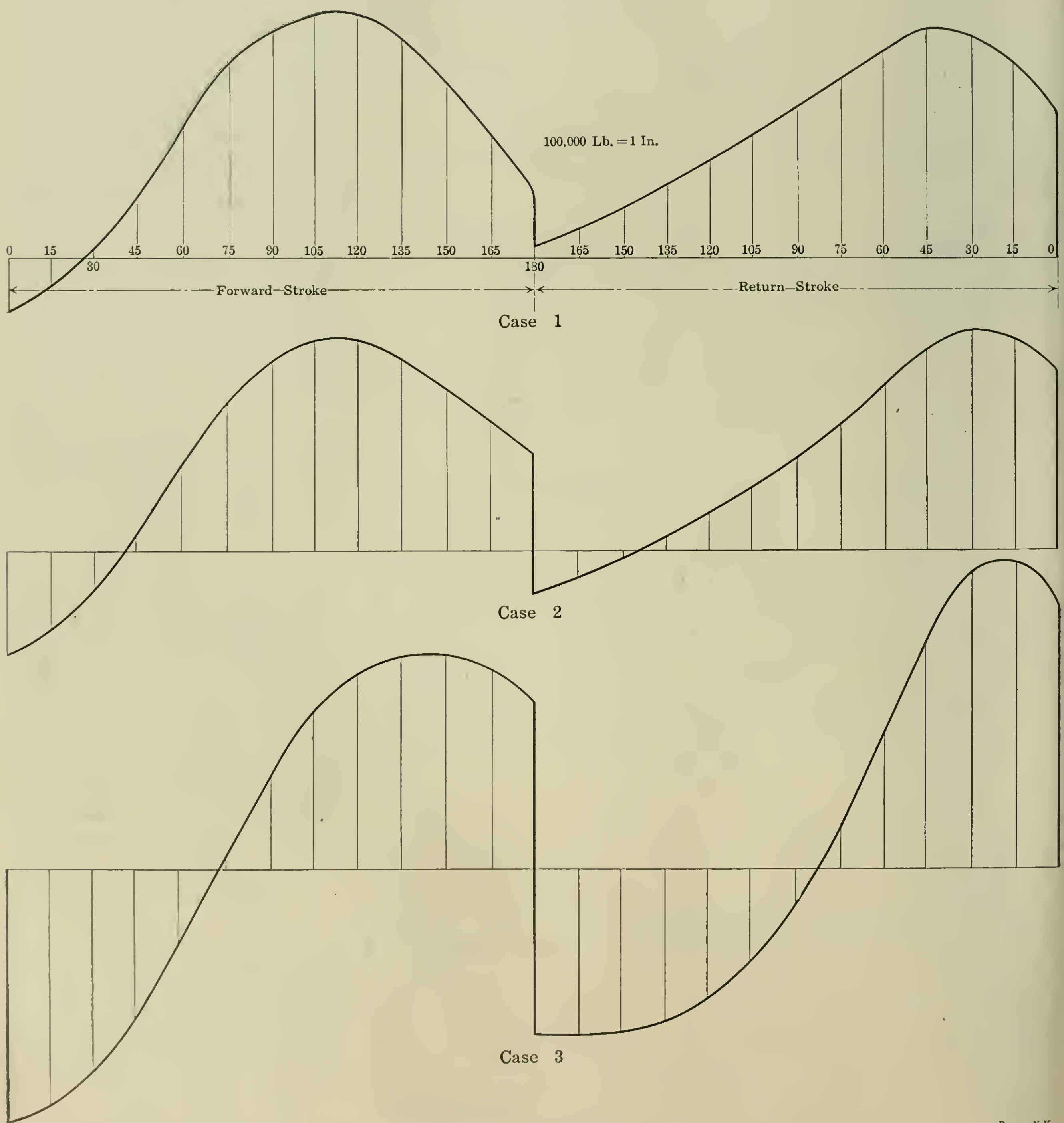


FIG. 6. COMBINED HIGH- AND LOW-PRESSURE FORCES

Standpipes on a Water Power Supply

By W. E. Crane

Several years ago the writer was called upon to solve a problem in hydraulics on a water power plant, which is of sufficient interest to warrant a description.

There were two pipes, each 7½ feet in diameter and 3000 feet long, the total head being 102 feet. Attached to one pipe were two 1000-horsepower wheels and a 45-horsepower exciter wheel; and to the other, a 1000-horsepower wheel, two wheels for lighting, two for direct-current power and another exciter wheel. The wheels were 17 feet above the tail race, so that they were 85 feet below the crest of the dam, and the total head was made up by the draft tubes.

The wheels were all direct-connected to generators and the exciters, the large wheels to alternators and those for railroad work and extreme varying loads to direct-current generators. The pipes were brought to the generator house by a civil engineer and there the writer took them and applied them to the power and it became his duty to take care of the thrust of the water when the regulators closed.

There were but two of the large wheels and one direct-current wheel on variable load running at one time. The point that could be expected would be a velocity in the pipes of 4 feet per second, but usually not over 2 feet per second was obtained. There was none too much water during a portion of the year, and it was important that as little as possible should be wasted.

It was finally decided to erect a standpipe 6 feet in diameter for each pipe. The question was, how much higher than the crest of the dam should be the top of the pipe? With a flow of 2 to 4 feet per second, 85 feet head and 3000 feet of flowing water, ought the draft tubes to be taken into account? It was finally concluded that if the pipes were 10 feet higher than the crest of the dam there would be no [illegible] loss of water and no serious water hammer. At this time the power [illegible] manufacturers objected, saying that if the head was going to change so fast every time one or two gates stopped, he would not guarantee to [illegible] the lighting wheels, so the light was finally compromised on, 10 feet above the crest of the dam. This worked out very well, as the pipe overflowed but two or three times a day and the loss of water was but a small percentage. There was more trouble, however, in cold weather when ice formed on the top of the standpipe and prevented water from overflowing for a week, or until the pressure was great enough to [illegible] out the ice.

It is interesting to note that in recent installations standpipes are becoming general, and that their value has been improved by adding a large tank at the top, which would secure a very [illegible] change in head. [illegible] In the case of the two 7½-foot pipes, an expert recommended [illegible]

FIG. 1. THE TWO 7½-FOOT PIPE LINES

FIG. 3. [illegible]

FIG. 2. LAYOUT OF PIPING FROM DAM TO PLANT

FIG. 4. [illegible]

vents, and these were installed, although the writer advised pipes at least 5 feet in diameter, as the temperature in that locality was liable to be 20 degrees below zero for a month at a time.

One night it was proposed to shut off one of the pipes, and a man going that way volunteered to close the gate at the dam. The chief electrician took it upon himself to open all the gates on that pipe to draw off the water as quickly as possible. It so happened that both vents were frozen up, and about 300 feet of the pipe near the dam, which was ¼ inch thick, collapsed into the form shown in Fig. 3.

Explosion of a Rendering Tank

Herewith are the particulars of an explosion of a rendering tank at the plant of the St. Louis Hide and Tallow Company, St. Louis, Mo.

The explosion occurred at about 4 o'clock in the morning. There were ten tanks, fed from a boiler, the safety valve of which was set at 45 pounds, the tanks being operated at a pressure of about 40 pounds. It was No. 1 tank which exploded, and an examination showed that the tank apparently failed at the vertical seam, as it was found that the metal along this seam was so reduced by corrosion as to be only about 1/16 inch thick. The plate was torn down the seam in question, outside of the calking edge, nearly the full length, from about 3 feet from the top to and around the bottom head, which was blown some distance away. The original thickness of the plate was ⅜ inch. The damage will amount to at least $20,000. Fig. 1 shows the wrecked condition of the plant. Fig. 2 shows the torn condition of a section of shell.

It was arranged to inspect the tanks a week before the accident, but for some unknown reason the tanks could not be given to the inspector. This risk had just been assumed by the Casualty Company of America, and had heretofore been carried by another inspection and insurance company. It is stated that the reports on file at the plant showed that no internal inspection had been made of this particular tank since June, 1908, and it was reported at that time that the shell plates and rivet heads in the tank which exploded were deteriorated.

FIG. 1. THE WRECKED PLANT

FIG. 2. SECTION OF SHELL OF THE EXPLODED TANK

Some Notes on Firing Boilers

By Victor White

The working of boiler fires, while much more a matter of practical experience than theory, is governed by certain rules. The furnace fire acts at the same time as a gas producer, a gas igniter, an air filter and a refuse holder. It is by bearing this in mind that the rules for firing are evolved. Other things being equal, gas is much more readily liberated from coal the smaller the size of the lump. For this reason dust firing, i.e., blowing powdered coal with an air blast into an incandescent chamber, has been recommended. Washed slack, however, forms a good fuel for furnace fires. Large coal, by inclosing the gas until the lump breaks open, acts as a gas retort, and unless the coal cleaves or opens out very evenly, irregular admixture of gas with air and possible smoke is produced. This particularly applies to coking coal. Lump coal is more unwieldy to handle than slack, and extra labor has sometimes to be employed in breaking it up into sizes small enough for convenient firing. On the other hand, the interstices between slack coal are smaller than in lump; the air has more difficulty in passing through; the use of small coal necessitates the reduction of the spaces between the firebars to keep the coal from falling into the ashpit; too strong a draft is not permissible for fear of carrying the smaller particles into the flues; hence a very thin "filter bed" of coal to obstruct the air must be maintained.

Thin Fire Essential with Small Coal

Since the fires must be kept thin with slack coal, more skilful firing is required than with thick fires of lump coal; any irregularity of firing produces weak places in the fire, which later develop into holes under the action of the draft, letting colder air (which will obviously pass in greater quantity through the weakest resistance) pass the fire without penetrating the incandescent material. A thin, even fire is essential in using small coal. The thickness varies with the intensity of draft and quality and size of coal used (not with load on the boiler), but after being experimentally determined should be strictly adhered to. With a draft of 1/2 inch and good anthracite slack, a depth of about 4 inches of fire is necessary. Increasing the depth by injudiciously heavy firing chokes the fire and is a sure method of dropping the pressure. In hand firing the correct method of stoking small coal is to distribute it in light sprinkles, by slightly twisting the wrist of the hand holding the shovel handle at the moment of firing, over the grate in an even shower. Eight or ten shovelfuls are sufficient at each firing over a grate area of 30 or 36 square feet, the firings succeeding each other at intervals necessary to keep steam and therefore varying with the load. Firemen must be carefully watched on this point; their tendency, particularly when from the navy, is to fire heavily and then take a quarter of an hour's spell, producing in this way much smoke and waste.

Close Grids on Firing Doors

Another practice in frequent use which leads to inefficiency is that of opening the grids on the firing doors of the furnace front, allowing cold air to draw in over the fire, with the object of mixing this air with unburnt gas and avoiding smoke. The diminution of smoke, where effected, is gained at the sacrifice of furnace temperature unless the grate area is too small to allow a sufficient quantity of air to pass through; the proper way to produce smokeless combustion is to keep the correct thinness of fire all over the grate, and to fire lightly and often. Where the furnace is divided into two grates, alternately firing one grate and then the other gives the best results, one fire being incandescent when the other is emitting unconsumed gas, and causing its ignition, and water circulation in the boiler also appears to be improved. The admission of air during hand firing cannot be avoided; it is seen that quick handling of shovels tends to economy.

Avoid Frequent Changes in Variety of Coal

The behavior of the coal in the fire should be carefully studied. Bituminous coking coal is apt first to form slabs of semi-molten material, and then to break into fissures allowing cold air to pass through. It therefore requires slicing or mixing occasionally; still more does a coal having a heavy proportion of clinker. On the other hand, anthracite gives a good clean ash and little clinker, needs very little slicing; disturbance of the fire would send unburnt fuel through the firebars. Coking coal is sometimes pierced with the poker.

In using fuel giving intense local heat, such as coke or hard anthracite, it is well to have the ashpit supplied with a water tray, the downward heat of the fire slowly evaporating this water. The steam passing up through the firebars will keep them from overheating, especially if they are thin and deep. Long flaming coals, whose heat is developed to a large degree away from the fire, do not need this precaution, and if possible it should be done without, as heat is wasted in superheating the steam so generated.

In considering the claims of those furnaces which induce a strong draft of air through the fire by means of steam blowers, it must be borne in mind that the advantage of increased circulation of air is to some extent neutralized both by the waste of high-pressure steam and the loss of fuel energy in dissociating that steam. It is worth noticing in passing that to mix two different qualities of coal is not usually satisfactory. Anthracite and bituminous slack do not, for example, burn well together, as they require different treatment.

Frequently changing from one variety of coal to another should be avoided; it is always found that a particular coal will burn best in a certain type of furnace. Boilers having cramped space above the grate, for example, give their best performance with coal giving intense local heat and little flame, such as anthracite, while boilers having ample combustion space go best with long flaming coals. Change of coal probably means alteration of the furnace, at the very least as regards pitch of the firebars, and in the writer's opinion the difficulty of getting a fireman to alter his method of stoking with one class of coal given to him, and the ensuing waste until he has learned how to handle it, is often underestimated by boiler managers.

Cleaning Fires

The dampers and the air doors together provide an efficient means of following the load with the fires by means of draft, combined with intelligent firing. The dampers should be the rough adjustment, the air doors the fine. The firing performance must always be judged in relation to the steam pressure and water level. A good steam line should be kept on the pressure chart without blowing off at the safety valves or undue checking and shutting of boiler-feed valves. When the coal clinkers on fixed grates the disposal of this incombustible is sometimes difficult. The top layer of burning material must first be removed, either by pushing back or "winging" the fire. The first method consists of piling up the burning coal at the back of the grate, exposing the clinker; the latter is pushing the fuel to one side and then the other of the grate, leaving the clinker of each half uncovered. This clinker is then pulled out through the front doors of the furnace by means of the rake, when it is quenched with water. In the pushing-back method the clinker under the coal must be dislodged and dragged out as well as possible by the slice and rake.

Before cleaning a fire it should be burned down as much as possible, the bulk of the firing being done on the other boilers. In any case the damper and bottom air doors should be shut while the fires are laid bare. It is obvious that quickness in this work is of first importance. In the writer's experience two men were able to clean 114 square feet of grate area in ten minutes, heavy fires having been carried previously. This included turning the fires back and removing the "bars." No attempt was made to clean the clinker off the furnace bricks, and the coal used was fairly clean. In case the clinker sticks to the firebars and bricks of the furnace, the slice must be used to detach it. Care must be taken not to bring down any of the brickwork, which may have become loose through alternate expansion and contraction, in this operation. A fire whose waste material is almost pure ash will not require much disturbance, the ash, if small, mostly clearing itself through the firebars, especially if helped occasionally with the poker.

The intervals required between cleanings are gaged by experience, being dependent on the class of coal used and the loads carried by the boiler. As the time for cleaning approaches the fireman will experience more and more difficulty in keeping his steam without excessive slicing and poking of the fires. Not more than one grate in a twin boiler, or bank of boilers, should be cleaned at one time.

Banking Fires

When a boiler is taken out of action the fires are slackened until the coal on them is consumed, the dampers being gradually closed. If the boiler is not required again, the ash and clinker are drawn and quenched, the air and firing doors being then closed up. If the boiler is shortly wanted for work again the fires should be banked. After cleaning and closing the damper the fire should be completely covered with a layer of fresh coal about 3 inches deep, the front doors being then closed. The fire is sometimes drawn together into a heap. This will then smolder, and, with the addition of a few shovelfuls of [illegible] every few hours, will keep the furnace warm until a fire is again required. The man in charge of the boilers should [illegible] determine for himself the number of hours that a fire can be banked [illegible] without undue [illegible]. He must take care to ensure that a fire that has been banked [illegible] is not closed too long [illegible]. The danger of [illegible] acute when the damper doors are perfectly air-tight—a condition unfortunately not often realized owing to the warping action of the heat on sheet metal. Should such danger be apprehended, however, a small hole may be drilled in the damper, and the air holes in the firing doors be left a little open, to sweep away all gases generated.

Mechanical Stokers

These are divided into two classes according to their method of working, "sprinkling" and "coking" stokers. The former attempt to imitate the light sprinkle of coal given equally to all parts of a fire by a skilled fireman. The general method of regulation is the same as for hand firing, the only difference being the substitution of machine for hand labor. The second type of stoker adopts the more scientific method of dividing the gas production from the gas ignition. The coal is fed steadily into the furnace from the front of the firebars, being deposited on a dead plate, and is then gradually carried backward by a movement of the bars, until the unconsumed remainder falls over the back end of the bars into the pit.

On first entering the red-hot furnace the coal is heated and its volatile gases given off, the fixed carbon and incombustibles remaining. These gases sweep backward along the fire and upward to the heating surfaces, and the portion of the coal which has been for some time in the furnace, and which is now coked and incandescent, ignites the gases, the sheet of flame spreading up against the heating surfaces. By this gradual and systematic ignition the full heat value of the coal is realized. The main duty of the attendant on a coking stoker, when it is in good order, is to proportion the rate of feed of coal onto the bar and the rate of travel of fuel to the ashpit to the load carried by the boiler; to see that no unconsumed fuel is carried over to the ashpit by too quick a travel, and to make sure that the coal on falling onto the dead plate really does ignite. For this latter purpose inspection doors are provided in the front or side walls of the furnace.

The saving of labor may be roughly gaged by the fact that whereas a skilled fireman could not well dispose of more than two tons of slack coal per hour on a peak load, doing nothing else but firing, and would be exhausted if worked at this rate for eight hours, a man working with mechanical stokers in good order can continuously dispose of seven to eight tons per hour, his duties including the disposal of ash and clinker (if the ash heap is not far distant) and the regulation of feed water.

The method of starting fires in a mechanically stoked boiler is the same as for a hand-fired plant. With dampers a quarter open several shovelfuls of brightly burning coal are fed equally over the bars, or kindlings of wood, oily waste and paraffin may be used, and the furnace lightly hand fired, the dampers being opened a little as the fire increases. The automatic gear is then put into operation. Mechanical stokers, though not so flexible as hand firing, can with proper supervision be made to follow sharply varying loads, such as are met in electric-light and power stations, with entire satisfaction.

Catechism of Electricity

1010. *What is the test for voltage in the supply wires?*

Connect a voltmeter across them and see if there is a deflection of the pointer. If a voltmeter is not at hand and the current is normally supplied at 220 volts, connect two ordinary incandescent lamps in series and then connect them temporarily across the supply wires. If they light, the current supply is all right; if they do not light and their filaments are not broken, there is no current in the supply wires or the voltage is much too low. On a 500-volt circuit five lamps must be used in series instead of two.

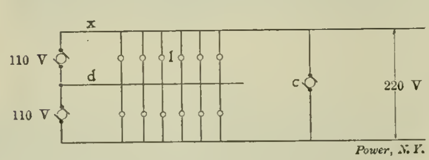


FIG. 285. DIAGRAM SHOWING HOW A MOTOR MAY OPERATE UNDER MISLEADING CONDITIONS ON A THREE-WIRE SYSTEM

1011. *What is the method of procedure in case the motor is improperly connected?*

If the motor fails to start by reason of being improperly connected, its armature can be freely turned by hand; the connections, however, may all be secure and there may be current in the supply wires. If the field circuit of a shunt-wound motor is properly connected, the pole pieces should be strongly magnetic when the main switch is closed. Farther than this no definite rules can be given that will apply in every case. Unless the attendant is perfectly familiar with the wiring of the particular motor giving trouble he should consult the diagram of connections accompanying the machine and from it learn if the connections are as they should be.

1012. *On a three-wire system is it not possible for lamps to burn properly but the conditions of the circuit to be such as to prevent the running of a motor?*

Yes. If one of the two generators supplying the system becomes reversed, both the outside wires of the supply circuit will be of the same polarity. Although lamps connected between either outside wire and the center wire of the system will light, a motor connected to the outside wires of the system will not run.

1013. *Are there any other misleading conditions of a similar nature on a three-wire system?*

Yes. One of the outside wires of a three-wire system, Fig. 285, may be open at *x* and yet a motor *c* connected beyond the break may get current at 110 volts through the lamps *l* connected between the outside wire on the same side as the break and the center wire. A 220-volt motor operating in this way will not be able to run anywhere near full speed owing to the supply voltage being 110 instead of 220, and the resistance of the lamps *l* being in series with it.

The center wire *d* of a three-wire system may be open and yet not affect the operation of a motor at *c* because the motor is connected to the outside wires only.

1014. *If it is suspected that friction trouble is preventing the motor from starting, what should be done?*

The cause of the friction should be ascertained and removed as previously instructed, before an attempt is made to run the motor. In starting up a motor after a trouble of this kind, it is advisable to switch on the current just long enough to see if the trouble has been entirely removed before leaving it on permanently.

1015. *What are the indications that the motor will not start on account of too heavy a load?*

The fuses melt or the circuit-breaker operates; an ammeter connected in circuit with the motor indicates a larger current than that required by the motor at full load; the insulation on the armature begins to smoke. An overload on a series-wound motor does no harm, as the motor will start up as soon as the load is reduced. On a shunt-wound motor, however, an overload is a more serious matter because the armature is liable to burn out.

1016. *What should be done when it is found that the motor will not start by reason of too much load?*

The main switch should be opened at once and the load reduced. If the fuses have melted they must be replaced with new ones, or if the circuit-breaker has opened it must be closed, before closing the main switch preparatory to starting up under a smaller load.

Tube Tiles Used to Form Furnace Roofs

Encircling the Lower Row of Tubes in a Water-tube Boiler with Refractory Firebrick Tiles to Increase Efficiency and Prevent Smoke

B Y   A .   B E M E N T

When the fire is located directly under the exposed tubes of a water tube boiler, the volatile gases arise immediately among the tubes, with the result that the temperature of the gases is so quickly reduced that no further combustion takes place. In this way a large amount of smoke is produced, especially if high volatile coal is used, and at the same time a considerable heat loss results from the failure to burn all of the gas. This fact is one that has been recognized for many years, but it is only within the last five or six that a systematic attempt has been made to correct the condition by better furnace construction. A scheme now extensively employed for this purpose consists in encircling the lower row of tubes in the boiler with refractory firebrick tiles, which produces a furnace roof equivalent for all practical purposes to that of a firebrick arch, under which combustion of the gases takes place, so when the fuel is fed at a reasonably uniform rate, the volatile gas is entirely burned. Thus not only is the full realization of heat secured, but there is no production of smoke.

The tiles employed are usually 1 foot in length and of a width sufficient to cover one-half of a tube; thus two tiles are required to inclose the tube for each foot of its length and, joining together back to back, fill the space across the boiler, while additional rows give the requisite length to the roof, a space being left at the back end of the roof, so that the gases, after having passed underneath, may enter among the tubes of the boiler at its rear. This scheme of employing tiles applied in this manner, originated in Chicago some six or seven years ago with W. L. Abbott, the operating engineer of the Commonwealth Edison Company. The initial application was to Heine boilers, shown by longitudinal section, Fig. 1, and cross-section, Fig. 2, wherein the tile roof supported by the lower row of boiler tubes is clearly indicated. Another feature not found in the regular Heine boiler is a gas baffle which rests upon the lower row of tubes from the tile roof as shown. While this gas baffle had no connection with the tile roof, its purpose [illegible] in the illustration [illegible]. It was first inserted by Mr. Abbott with the object of improving the efficiency of the boiler, or in other words [illegible] capacity [illegible] increase of efficiency obtained of about 10 per cent., while at the same time the capacity was increased about 5 per cent. over what had been obtained before that gas baffle was inserted.

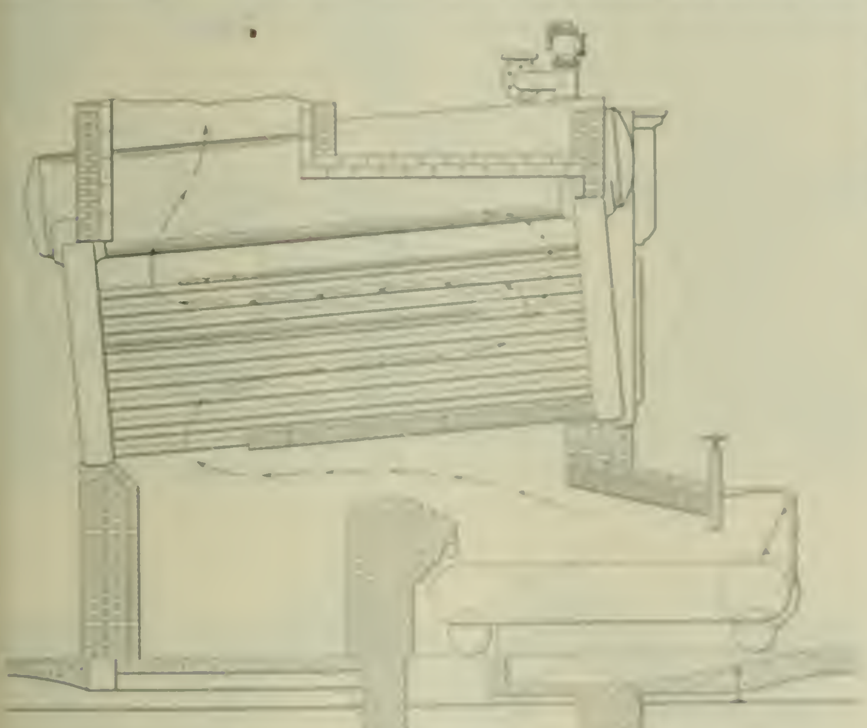


FIG. 1. ORIGINAL APPLICATION OF TILE FURNACE ROOF TO WATER-TUBE BOILER

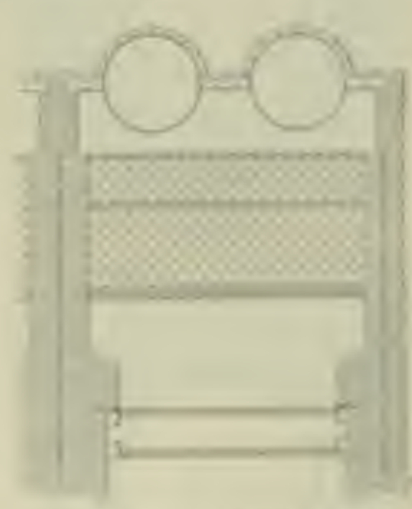


FIG. 2. TRANSVERSE SECTION OF BOILER

The original design for tiles is shown by Fig. 3. The trouble attendant upon the employment of these tiles, not only as affecting combustion and lessening smoke, however, but protection afforded the tubes of the boiler, caused the makers of the boiler to design, adopt and install a tile shown in Fig. 4, which has been extensively employed and called a C tile. The small amount of stock used in the lower part resulted, however, in a section so thin as to cause the tile to soon fail by breakage, as illustrated by Fig. 5. This led the writer to make the design shown in Figs. 6 and 7, designated as an encircling tile, which has come to be extensively used.

The wear of these roof tiles is not uniform, some of them being exposed to higher temperature and greater strength than others, which results in an irregular wearing away, and [illegible]

8, 9, 10, 11 and 12. It is semicircular in shape, in order that it may be put in place of a single pair of encircling tiles. Thus if the roof fails at one point, the damaged encircling tiles may be removed with no other disturbance, and the round repair tile substituted. The first operation after the encircling tile has been broken out and removed is shown by Fig. 8, one of the tiles being set in place below the tube. It is then turned around until it rests on the top of the tube as shown in Fig. 9, after which the lower part is added as shown by Fig. 10, then both tiles are revolved into the position shown by Fig. 11, which also shows the repair as it would appear in the roof in series with the encircling tile.

Many other designs of roof tile have been made by various people for application to different boilers. Fig. 12 illustrates one reported to have been used on boilers, it consisting of blocks supported by an iron stem molded therein and held in place by a rod, passing through a hole in the stem and hanging across from one tube to another. To the writer's knowledge, however, this scheme has never been permanently employed. The tile which the Babcock & Wilcox Company has recently adopted for use on its boilers is the writer's design, shown by Figs. 6 and 7. The Babcock & Wilcox and the Heine boilers, having a tube spacing of 7-inch centers, with tubes of 3.5- and 4-inch diameter, allows the use of the designs of tile previously mentioned. There are boilers, however, where the tubes are spaced more closely together, for which some different form of tile is required, and Fig. 13 illustrates the form employed by the Lyons Boiler Works, consisting of a tile of the cross-section shown and about 1 foot long, having a thin section extending up between the tubes, held in place by an iron rod which is passed through a hole in the upper part of the tile and resting across the tubes.

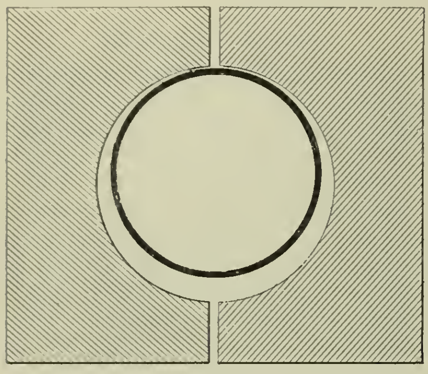


FIG. 3. SECTION OF ORIGINAL TILE

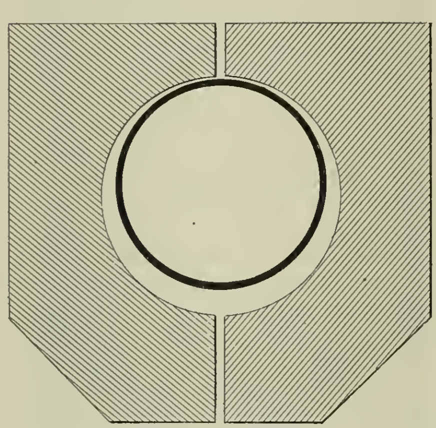


FIG. 6. SECTION OF ENCIRCLING TILE

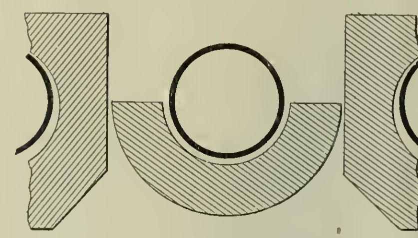


FIG. 8. FIRST POSITION OF REPAIR TILE

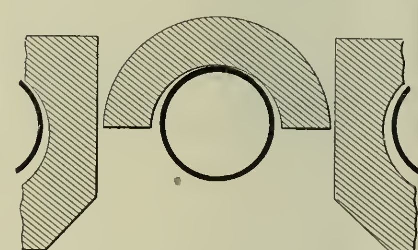


FIG. 9. SECOND POSITION OF REPAIR TILE

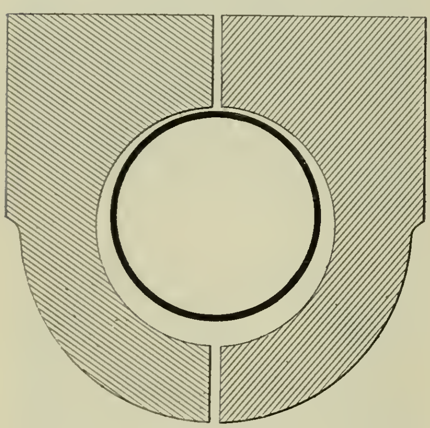


FIG. 4. C TILE USED IN FORMATION OF FURNACE ROOF

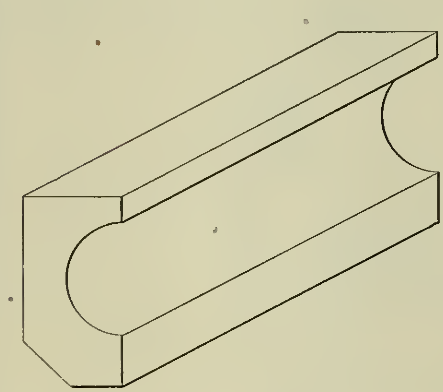


FIG. 7. DESIGN OF ENCIRCLING TILE

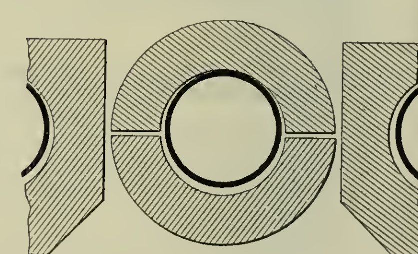


FIG. 10. SHOWING ADDITION OF SECOND PORTION OF REPAIR TILE

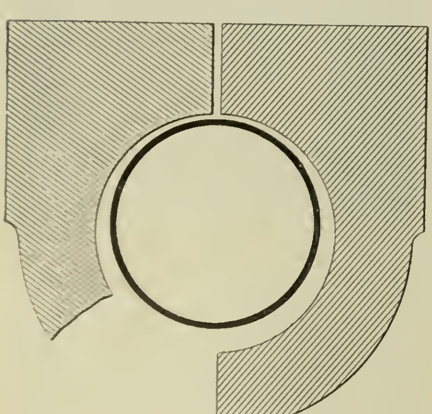


FIG. 5. COMMON FORM OF BREAKAGE OCCURRING WITH C TILE

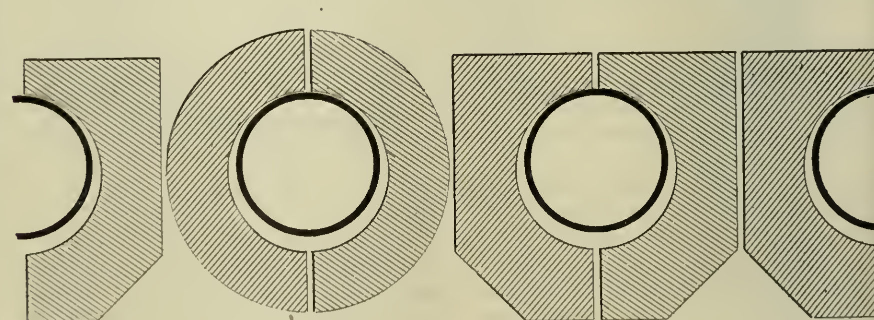


FIG. 11. ENCIRCLING TILE ASSEMBLED IN POSITION IN FURNACE ROOF

The form used by the S. Freeman & Sons Manufacturing Company, in Racine, Wis., is illustrated by Fig. 14, which shows a design requiring only one tile for completely covering the tube. Fig. 15 is a design made by George L. Dieterich, of the Chicago Retort and Fire Brick Company, which shows a tile suspended by a hook-shaped upper section, which hangs from the tube. In the formation of furnace roofs with these tiles, they are first applied individually to the tube at the rear, and then moved forward into place. Experience has shown that when made from good material of the proper shape they have a long life, and their use is attended with satisfaction. It is necessary, however, to call special attention to the fact that it is requisite to specify a clay which is of high grade and not easily fusible. It is also [illegible] that care be taken by the maker to prevent the shape of the tiles being distorted in handling between the molds and the kiln, so as in this way good tiles may be easily ensured. With these forms of setting used for water-tube boilers in which the gases pass [illegible] tubes of the boiler at the front [illegible] necessary to [illegible] [illegible] [illegible]

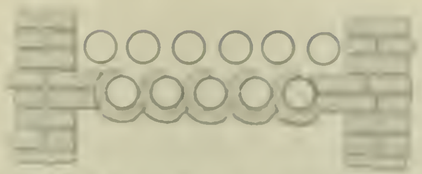


FIG. 14. TILE AND FURNACE ROOF APPLIED TO [illegible] WATER-TUBE BOILER

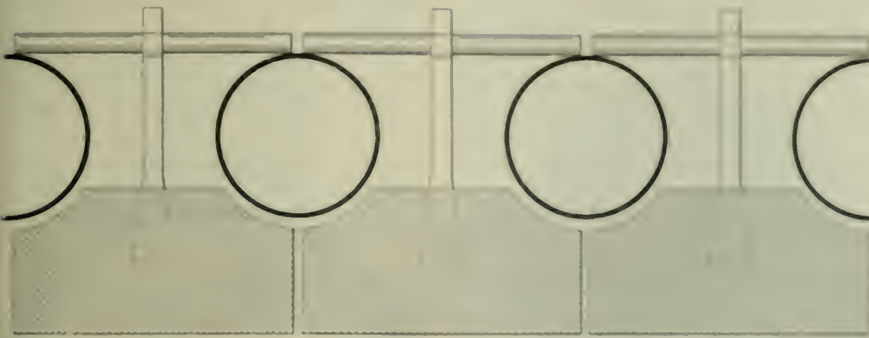


FIG. 12. FURNACE ROOF SUPPORTED BY ATTACHMENTS MOLDED INTO BLOCKS

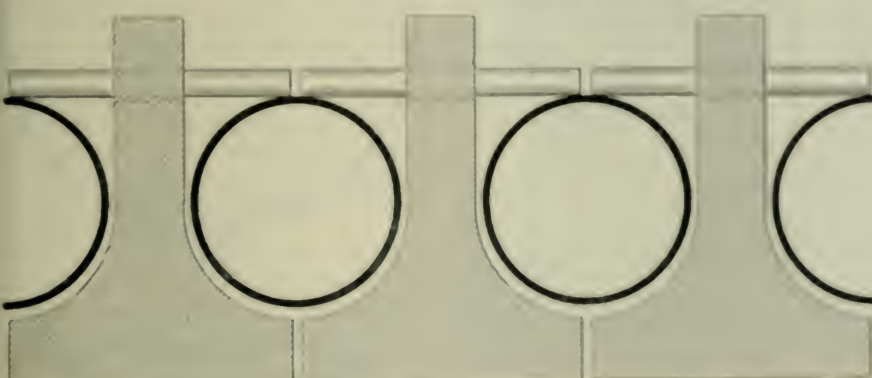


FIG. 13. FORM OF TILE ROOF USED IN [illegible] BOILERS

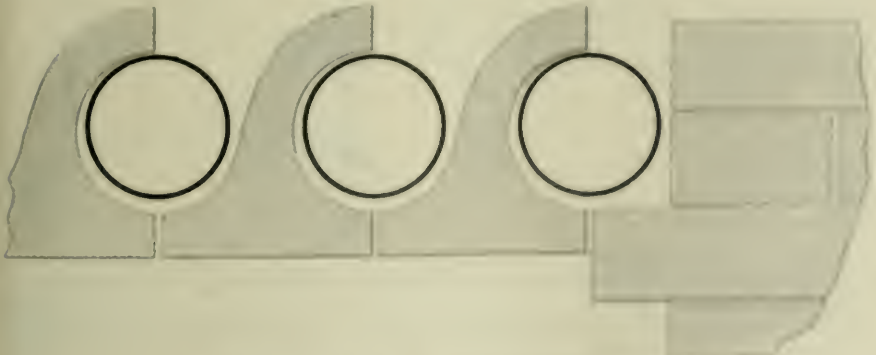


FIG. 15. SUSPENDED AND [illegible] ROOF TILE

Bracing Dome Heads

By [illegible]

While the steam dome is considered by [illegible] as a [illegible] to a steam boiler, [illegible] it is still [illegible]. When a flat head is used the bracing of the head

FIG. 1

is almost invariably as illustrated in Fig. 1. This type of bracing has been advocated by practically all authors on the

FIG. 2

subject of boiler construction, and the writer is not aware of any who have advised attaching the braces to the portion

FIG. 3

of the shell inclosed by the dome, as illustrated in Fig. 3. This portion of the shell [illegible] attached to this portion of the shell, they should be considered valueless. The writer believes that the above views on this form of bracing have been the result of following the lead of someone who was considered an authority on the subject, without any attempt at analysis of the stresses that are actually present in this form of construction. It is also believed that head braces attached to the neutral surface, as in Fig. 8, are actually an improvement over the customary method of attaching them to the shell of the dome.

In the first place, domes are relatively short compared to their diameter, mak-

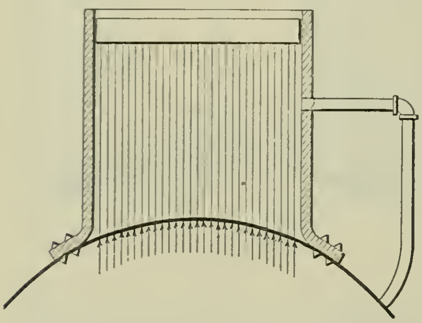


FIG. 4

ing the use of short braces necessary. The feet of the braces are required to be located well in toward the center of the head to get proper distribution, and the resulting angularity of the braces detracts considerably from their holding power. Again, there is a decided tendency to leak at the joint where the dome is attached to the shell, due to distortion of the shell at this point, and after a leak has once started it is extremely difficult to stop

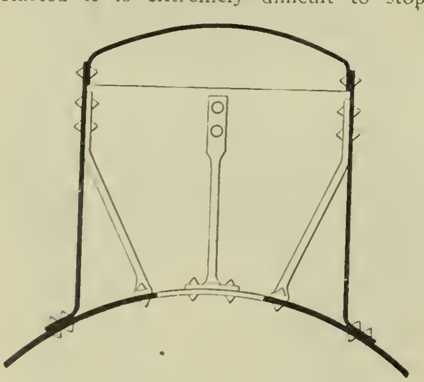


FIG. 5

owing to the continual working of the surfaces. One of the principal causes for distortion at this seam is the lack of support of the neutral surface to keep it of true cylindrical form, the stresses in the shell at the sides of the dome, as may be seen from Fig. 2, tending to pull the neutral surface out flat as indicated by the dotted lines. This causes a bending action along the flange of the dome where it is riveted to the shell. That flexure at this point is the cause of leaking is also indicated by the great superiority of a double-riveted seam over a single-riveted seam for tightness, the double row of rivets adding to the stiffness of the construction considerably.

If the neutral surface could be supported so that it would retain its cylindrical form, as effectually as the pressure supports the other portions of the shell, there would be no tendency for the connecting seam to be distorted and the only weakening effect introduced would be the removal of the metal for the rivet holes, or the conditions would be identical with those which would exist if a circular patch the same size as the dome had been riveted on at this point.

To illustrate how head braces attached to the neutral surface may approximate this condition, assume a shell, as illustrated in Fig. 3, with a cylinder similar to a dome riveted to the top of the shell but with no communication from the shell of the boiler to the dome space. If the inside of this cylinder was bored out, it could be fitted with a piston free to move up and down. Assume that each square inch of piston area is connected with each square inch of the projected area of the neutral surface by a rod screwed through

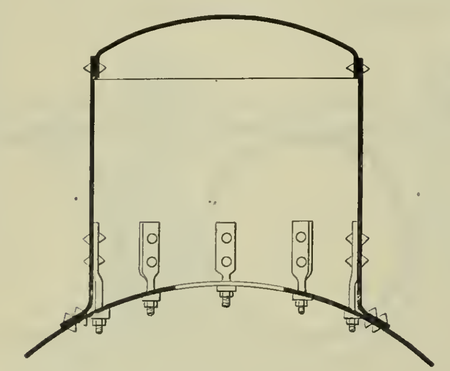


FIG. 6

the shell and into the piston. If it is now assumed that the boiler is under 100 pounds pressure, but with no pressure in the dome space, the portion of the shell under the dome would be pushed outwardly with a pressure of 100 pounds on each square inch of area, as indicated by the arrows, the same as the other portions of the shell, and there would be no tendency to deform if the shell was a true cylinder at the start.

Suppose now that the valve on the pipe communicating with the dome space were opened and pressure admitted. The conditions as regards the portion of the shell beneath the dome will remain unchanged, as long as the stay rods care for the pressure admitted to this space, for no matter whether the pressure is in excess of, or less than the pressure in the boiler, it will place only a tensile strain on the rods, and the neutral surface will be in equilibrium as regards the pressure in the dome, and there will be no tendency for it to assume any other shape than its original form.

If it is now considered that instead of the pressure in the dome coming from some external source, it is connected with the boiler shell as shown in Fig. 4, conditions would be obtained similar to boiler practice, except that the opening instead of being through a pipe connection is cut in the shell directly into the dome. It is seen that the surface of the shell inclosed by the dome, instead of being neutral, is actually forced out with the same pressure that any other portion of the shell of similar size is, and the tendency to deform is therefore eliminated. Of course the head of a dome does not offer the same flexibility as the piston head con-

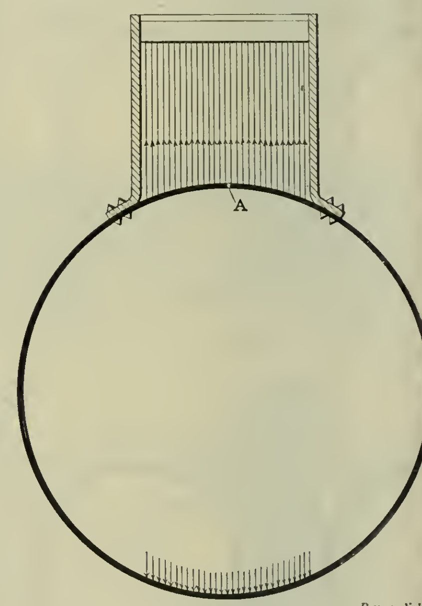


FIG. 7

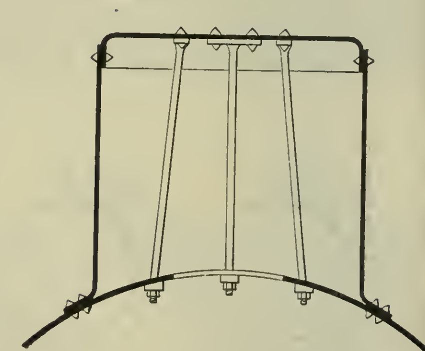


FIG. 8

sidered, and the dome shell must transmit a large portion of the pull due to pressure on the dome head to the shell of the boiler. However, the writer believes that if the braces required on the head were attached directly to the so-called neutral surface of the shell, the tendency for the shell to deform and produce leaking at the dome flange would be greatly lessened. A form of bracing that would accomplish the same result as regards the neutral surface, where it is desired to use a bumped dome head which is not braced, is shown in Fig. 5.

The method of bracing shown in Fig.

6 is often met with in high-pressure boilers which are equipped with domes. These braces accomplish in a very limited way what the braces shown in Fig. 5 are intended to do, but it is evident that they are not used with this purpose in view.

Another way of looking at the problem of the stresses involved in this construction is illustrated in Fig. 7. Here *A* is a hole drilled through the shell and communicating with the dome space, and although the pressure on each side of the neutral surface is equal, there is a pull on the rods of 100 pounds per square inch of piston surface (assuming the pressure in the shell to be 100 pounds), which produces the same effect in retaining the cylindrical form of the neutral surface as a like amount of pressure beneath the surface would. The pressure on the piston is balanced by the pressure on a similar area on the other side of the shell, as indicated by the lower arrows.

A new engineers' organization was formed on January 25 last at Baltimore, Md., known as the Engineers' Exchange, its home being at 413 Fayette street. The present membership is 150, with applications constantly coming in. The aim of the Exchange is to bring engineers of all of the associations into closer relations. The first floor of the building has been fitted up as a reading room, in which spaces are rented to various manufacturers and supply houses as a permanent exhibit.

On the evening of March 22 the Exchange was formally opened, with an appropriate social session. The officers are George L. Sleight, president; James Gardner, first vice-president; D. J. Murray, second vice-president; H. A. Phillips, secretary; H. A. Kries, treasurer.

The Elektra Steam Turbine

By Frank C. Perkins

A new type of German steam turbine has recently been constructed for operating direct- and alternating-current generators, ventilators and pumps, as well as for boat service, which is of more than passing interest. The accompanying drawing, Fig. 1, shows a single-casing steam turbine of this type, designed to work with a condenser, while Fig. 2 shows a double-casing compound turbine for operation with condensers. The details of construction of the single-casing turbine are shown in Fig. 3. This turbine was designed and constructed at Karlsruhe, in Baden, Germany, by the Gesellschaft Fur Elektrische Industrie. The Elektra turbine is essentially a high-speed steam turbine and means for reducing the speed is frequently necessary for boat service, and for the operation of machinery in [illegible], while for driving dynamos the maximum

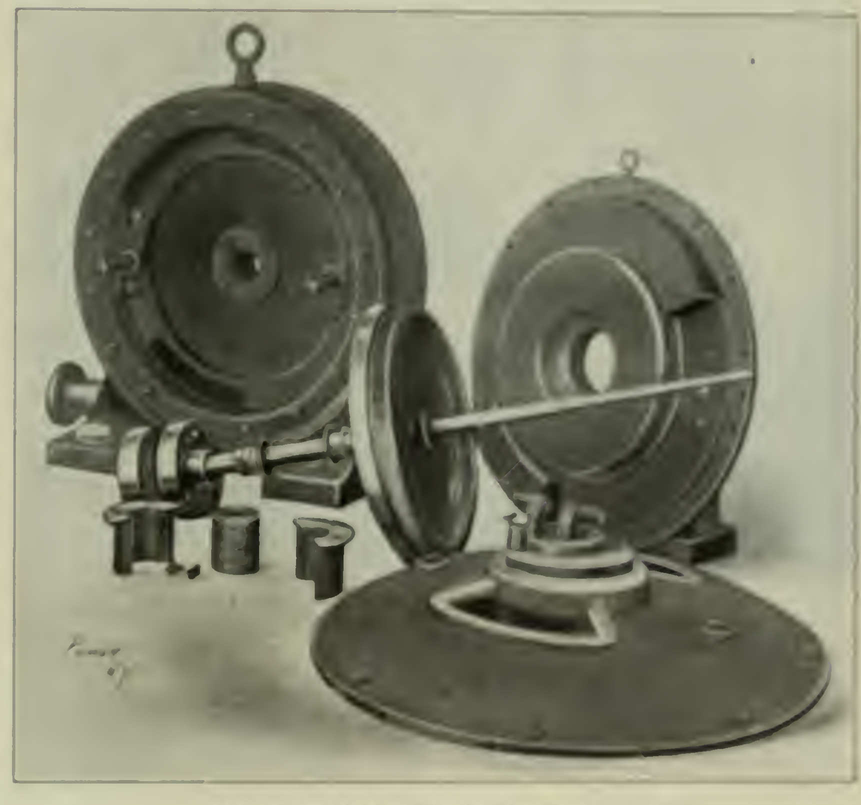


FIG. 3. DETAILS OF SINGLE-CASING TURBINE

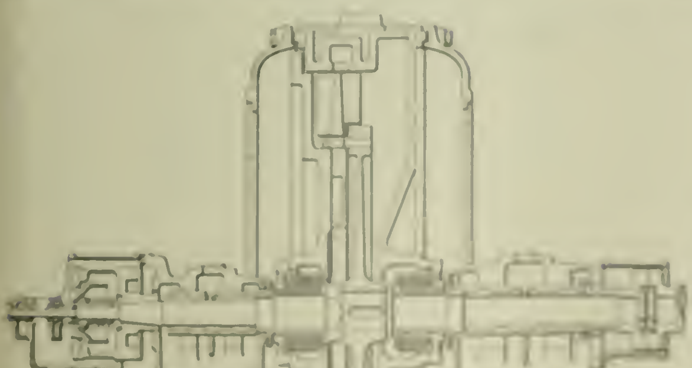


FIG. 1. SINGLE-CASING TURBINE

FIG. 2. [illegible] TURBINE WITH TWO CASINGS

may be directly coupled and operate successfully at the high speeds required.

The two turbines shown in Fig. 4 are of the compound type, each having a capacity of 100 horsepower. These turbines are directly coupled to three-phase alternators driven at a speed of 3000 revolutions per minute. Similar turbines have been built of 300 horsepower capacity, directly coupled to Drehstrom dynamos rated at 200 kilowatts and supplying a three-phase current of 2000 volts pressure. These units occupy a floor space of 3.3x8.6 feet, the total hight measuring 4.16 feet.

For operating boats, these turbines are said to have given excellent satisfaction, a special design having been provided for reversing. One of these units of 35 horsepower capacity operating at a steam pressure of nine atmospheres and at a speed of 3000 revolutions per minute, with reducing gear for lowering the speed to 500 revolutions per minute required for the propeller, occupies a floor space of 2.67x4.83 feet, with a total hight of 3.67 feet. The Elektra turbine is handled in America by the Alberger Condenser Company.

The Canadian Government has appropriated £3000 for the erection in Ottawa of a fuel-testing plant. It will deal chiefly with peat, with the object of solving the problem of utilizing the peat bogs by converting peat into producer gas from which electricity can in turn be generated. A peat bog will also be secured and a plant laid down to demonstrate the best methods of converting the raw material into fuel. Peat occurs in immense quantities in Ontario and Quebec.

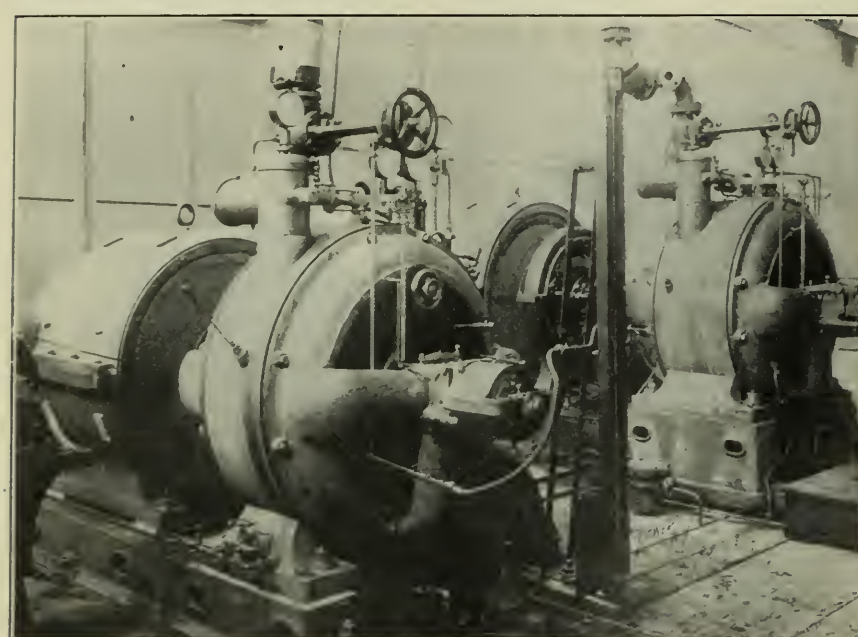


FIG. 4. COMPOUND TURBINES WITH CAPACITY OF 100 HORSEPOWER EACH

Test of a Vertical Gas Engine

The accompanying chart, Fig. 1, presents the principal items of a test, made a few months ago, of a Rathbun two-cylinder vertical gas engine. The test was not run for the purpose of obtaining complete data for the heat-balance sheet, but merely to determine the regulation and fuel rate.

The engine was the standard single-acting type built by the Rathbun-Jones Engineering Company, of Toledo, Ohio, with cylinders of 12½ inches bore and 13 inches stroke, rated at 100 horsepower on natural gas and designed to run at 290 revolutions per minute. The governor controlled the speed by throttling the mixture and also adjusted the timing of the ignition, advancing the firing point when it reduced the quantity of mixture admitted and *vice versa*. It is largely due to this feature that the engine shows ability to carry overloads without being underrated at normal full load; another potent factor which contributes to this result is the relatively high compression used—about 145 pounds absolute at full rated load. For the engine under consideration this is the most efficient compression pressure; consequently, any increase in compression tends to decrease the efficiency.

It will be noted by reference to the chart that the gas consumption at full load was 7.85 cubic feet per brake horsepower-hour and 7.95 cubic feet at 10 per cent. overload. The speed was a trifle high at rated load, coming down to the designed rate only at the maximum overload; or, to express it more fairly, the engine yielded 10 per cent. more than its rated power at its rated speed. The regulation was obviously about 4¼ per cent. between 35 horsepower and rated load; the test was not carried below 35 horsepower.

The gas averaged about 1100 B.t.u. per cubic foot at the temperature at which it

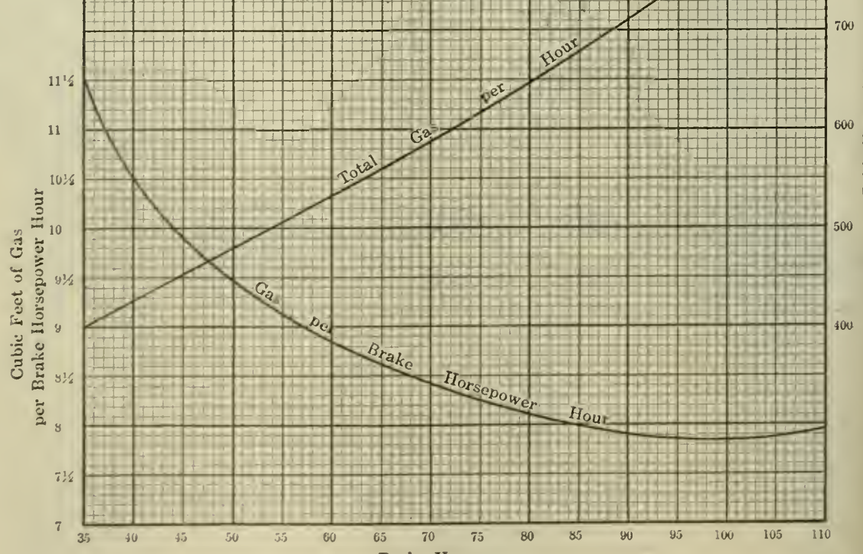


FIG. 1. PRINCIPAL RESULTS OF A TEST OF A RATHBUN TWO-CYLINDER VERTICAL GAS ENGINE

passed the meter, so that the thermal efficiency of actual output was practically 30 per cent.

The cooling of this engine is unusually effective and well distributed, which makes for overload ability by facilitating the extra compression thereby entailed.

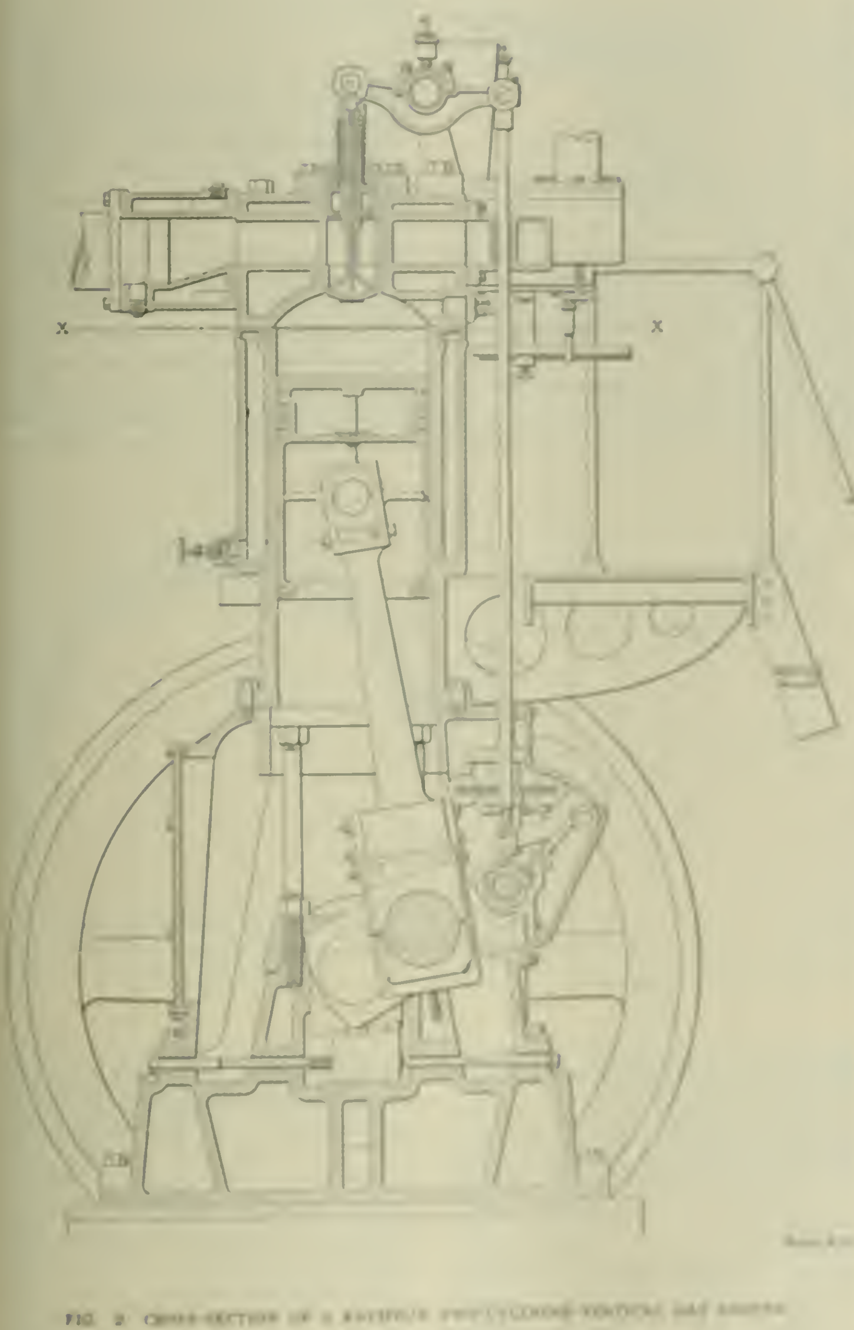


FIG. 2. CROSS-SECTION OF A RATHBUN TWO-CYLINDER VERTICAL GAS ENGINE

This and the automatic adjustment of the ignition timing combine to prevent back pressure by too early combustion at the high compressions. The exhaust valve is water-cooled, as indicated in the sectional view, Fig. 2, and the cylinder head and barrel are separately jacketed. In the latter drawing the section below the line X — X is taken through the center of the cylinder, while the section above that line is taken through the center of the exhaust valve, which is in a vertical plane a trifle nearer the observer than the center of the cylinder.

An interesting constructional feature of this engine is the fixing of the upper part of the crank case to the main journal housings. Stud or bolts extend from each side of each journal box [illegible] of the crank case, allowing [illegible] the crank case of the [illegible] the thrust of the cylinder [illegible] during the power stroke.

The Chief Engineer and the Ventriloquist

The following is a brief account of the terrible fate of a practical joker:

Sunday—Chief engineer's log book reads: Visit of a stranger. A severe squeak in engine No. 1 was remedied by a liberal application of oil.

Monday—Report shows that stranger again called and stayed some time, during which engine No. 2 developed an annoying squeak.

Tuesday—Stranger proves to be brother-in-law of the assistant engineer. Called again today, but could not pay much attention to him, as engine No. 3 had to be oiled to stop a severe squeak.

Wednesday—Everything O. K. No callers and no squeak.

Thursday—Stranger called. Engine No. 1 had to have all the lubricators speeded up in order to stop squeaking. Stranger seems a loafer.

Friday—That confounded stranger called again and I used up three pints of oil to stop the noise. I wonder why he and the squeaks seem to call at the same time. Looks queer.

Saturday—Last night assistant engineer told me his brother-in-law was a ventriloquist. I guess I was pretty easy.

Saturday afternoon—Stranger called. Squeak at last definitely located. Two quarts of dirty oil were poured upon the squeak. The cause of the squeak walked out of the engine room to buy a new suit of clothes. He said he would fix me. That's what they all say.

Work Begun on the Grand Falls Development

Two carloads of plant, consisting of engines, boilers, steam drills, derricks and other machinery, have arrived at Grand Falls, New Brunswick, and are now being set up for the beginning of operations. William Aitken (formerly of Nova Scotia and afterward of Boston) and Clarence A. Conrad (formerly of St. John), representing the Frank B. Gilbreth organization of New York, have already arrived and taken charge of the preliminary work.

W. B. Lowe, general manager for the Frank B. Gilbreth organization, has already placed large orders for supplies in St. John. All compressors and much of the electrical machinery for the temporary power plant will have to be made to order. The development of hydro-electric power at Grand Falls is of great importance to the Province of New Brunswick.

There is in British Guiana the Kaieteur fall, a waterfall [illegible] feet high [illegible] Niagara [illegible]

Hot Bearings; Some Causes and Remedies

An Old-time Topic in a New Dress, Giving the Reader the Full Benefit of Knowledge Gained by a Veteran of Many Years' Experience

BY H. S. BROWN

There are few troubles in the engine room that give the engineer more anxiety than hot bearings, and particularly the crank pin, as it is difficult of examination while the engine is running. An engine may run for years with no sign of heating, when suddenly without any apparent cause the sense of smell detects hot oil, and the man in charge is on the anxious seat at once. A case of shutdown stares him in the face, the thing of all others he strives to avoid. Where is the engineer who does not take the greatest pride in a year's run without a shutdown during working hours? A shutdown once from hot bearings is likely to be repeated, and perhaps many times. This is particularly the case with large powers, as in railway power houses, steamships, etc.

From many years' practical experience in the drawing room, in the shop and as erector of steam machinery, I am free to say that there are numerous cases of hot bearings for which the engineer is not responsible, even though he may be held liable. Conditions beyond his control or foresight will arise when least expected. On the other hand, there are more cases, even, when he is not guiltless. The man who is continually tinkering with his bearings may expect trouble at any moment.

The cases are legion in which engines have run for months without a wrench or hammer being put near the keys or wedges. This is well illustrated in the long runs of marine engines. Twelve to twenty days has in the past been no uncommon experience.

With proper lead and compression on the valves the extremes of light and heavy pressures on the bearings will be so much relieved that the wear will be reduced accordingly. My opinion is that due credit is not given to the proper amount of compression for the even and minimum wear on both pin and main bearing. If we plot a diagram with one line showing the pressure on these bearings with a good liberal compression and another with no compression, we shall see one cause for the heating of bearings in the no-compression treatment. If we take a cold rod of horseshoe-nail iron and draw it to a point, under a rapid-running trip hammer, the metal will be red with heat at the finish. Or, if we heat a steel billet, say 6 inches square, to a red color, and draw it under the blows of a steam hammer, the color of the billet will brighten under the rapid and severe shocks delivered. This shows how much heat is generated from severe shock applied suddenly to metals.

Poor Oil a Cause of Heating

Poor oil is another cause of heating. A new brand of oil should never be introduced until its quality has been established. With an oil of good quality, with body, the shaft practically rides on it; a thin film covers the surface of the bearing; but it should be fed regularly, and just enough. Not a flood at one time, and then the bearing allowed to run dry. With a poor lubricant, the surface of the shaft or pin comes in close contact with the surface of the boxes, and friction, with heat, is the result.

Clean oil is also a very important element. If an engineer will carefully filter his oil before using he will be surprised at the amount of grit extracted. After filtering, the oil should be kept in a closed can until used. A very small amount of grit will sometimes start a rough surface on a pin or bearing and cause heating.

Keying up is an exceedingly delicate operation at times, as what would be a good running condition of the boxes on one engine would start another to warm up. And if the adjustment of the boxes is close a slight raise in temperature will expand the metal and a rapid increase of heat will follow.

I have known cases where the rod had been keyed up at noon and, after starting up, there was no sign of heat for a time; but suddenly the smell of hot oil was noticed, and a shutdown followed. In such cases the bearings should be run as loosely as permissible without knocking.

Another important feature is a regular inspection of the bearings, at stated intervals, depending on the amount of wear in the boxes. To illustrate, in my early days I was employed in the roundhouse of a railroad company where we met with all sorts of conditions of heating. We found many cases in which the boxes had worn until the bearing had extended over the entire surface, always resulting in heat so intense at times that boxes would turn blue. As a never-failing cure,

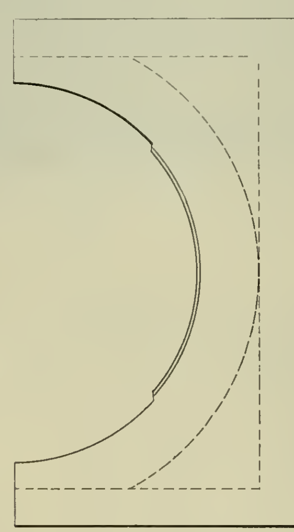


FIG. 1

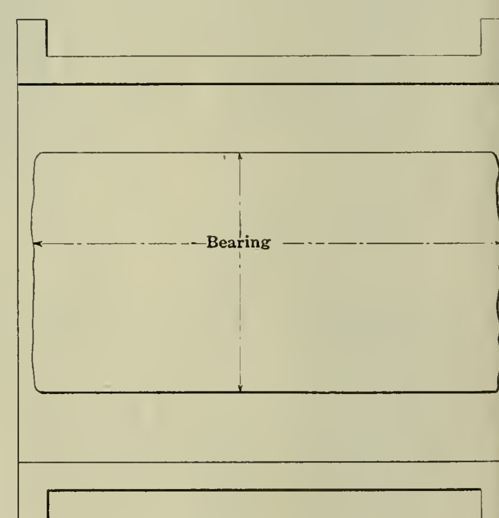


FIG. 2

we would take a half-round coarse file and remove the bearing surface, as shown in Figs. 1 and 2, leaving the bearing in the crown of the box. By this means the oil was carried around on the surface of the pin to the section of bearing where it was required, and the open space that had been formed by filing would form a storage for oil.

When the bearing is extended over the entire box, the oil is not evenly distributed, and the sections not supplied will cause slight friction, with resultant heat. The oil becomes thin and passes off very rapidly. A good result will follow the use of a heavy grease, with just enough oil to keep the grease spread over the entire bearing.

Another evil effect from excessive bearing surfaces with most boxes of hard composition or bronze is that there is a tendency toward a closing-in of the boxes, as shown at *a a*, Fig 3, and even with a slight raise in temperature. Then as the box begins to pinch on the pins heat is generated very fast.

In fitting up new boxes for the connecting rod, it is a good plan to cut away the bearing surface, as shown at *a a*, Figs 4 and 5, to the depth of from 1/16 to ⅛ inch, according to the size of the box. The narrow sections *b b*, Fig 5, should be filed away so as to clear the pin and leave the bearing from *c* to *d* in the crown of the box.

The tendency to close in as shown in Fig 3 is more likely in the round type of box, and to prevent this liners should be fitted, as shown at *a a*, Fig. 6, with freedom enough in the bearing to set up tight on the adjusting bolts. This holds the boxes firmly against the rod and cap, a practice that I think should be followed on all crank-pin boxes.

The liners should be cut as follows: Eight from 1/64-inch sheet brass, four from 1/32-inch, two from 1/16-inch and one from ⅛-inch. This allows of adjustment of the boxes for a long time without filing.

Defects in Crank-pin Box Design

One of the defects in crank-pin box design is in having too little metal at the edges X, Fig 4. The metal is so thin that they will not hold their shape and soon become loose in the strap. Thus, at the first increase of temperature heat will develop very rapidly, as there is no body of metal to carry it off. Also, as the boxes are a loose fit in the strap, that tends to destroy the conduction of heat, which throws a larger portion of it onto the pin. It is also a mistake to cut away the metal from the corner of the box, as shown at *b c d*, Fig. 4. It breaks up the path for heat travel, with very little saving in the cost of metal.

While the designer will cut out the post, he will core chambers in the body of main bearings and circulate water to carry off heat in the second case. The circulation of water in the bearings has been the practice for many years on marine engines, and latterly on heavy stationary engines.

I have seen cases in which a bearing would start to run hot, with a [illegible] supply of cold water, would cut a path in the bearing and go on (with a good supply of oil). On the other hand, I have seen a main bearing (composition) start to cut and, with a free hand for the time that the engine down, the metal of the box cutting and scoring the shaft. There have been cases where no [illegible] [illegible] [illegible] forged on a connecting rod with additional metal and water for larger [illegible] at these points as soon as the [illegible] boxes to absorb heat, and it has proved a success.

On account of a small bearing, a new pin has often been put in, and in some cases an entire new shaft, with increased surface on the bearings to overcome the troublesome heating. I recall cases in which I have been on watch for weeks beside hot bearings, applying every remedy that was suggested, without reducing the heat, a change of metal being the only remedy. In one case the entire shaft was changed. After analyzing the metal in the pin, which was found too low in carbon. It contained only [illegible] per cent. A new pin was fitted with [illegible] per cent. carbon and there was no more trouble. The following will give good results:

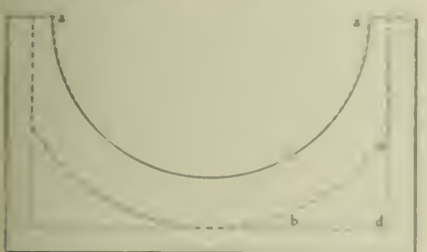


FIG. 3

FIG. 4

FIG. 5

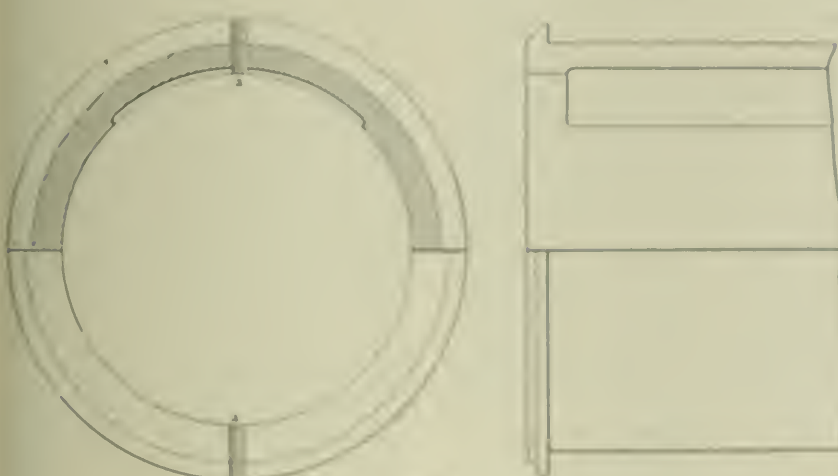


FIG. 6

FIG. 7

Crank Pins

[illegible] per cent.	carbon,
[illegible]	silicon,
[illegible]	sulphur,
[illegible]	phosphorus,
[illegible]	manganese.

For the crankshaft pin the carbon should be increased to [illegible] per cent.

Crank Shafts

[illegible] per cent.	carbon,
[illegible]	silicon,
[illegible]	sulphur,
[illegible]	phosphorus,
[illegible]	manganese,
[illegible]	nickel.

PISTON RACKS

0.43 per cent. carbon,
0.11 " silicon,
0.036 " sulphur,
0.039 " phosphorus,
0.52 " manganese.

VALVE STEMS

0.33 per cent. carbon,
0.10 " silicon,
0.047 " sulphur,
0.049 " phosphorus
1.03 " manganese.

CARE IN SELECTION OF MATERIALS REQUISITE

Too much care cannot be taken in the selection of material for pins and shafts. The analysis should always be specified in ordering and tested after receiving. With poor material in the pin and shaft, after long service the metal will wear away and uncover the open grain and streaks of gritty matter, which will often start heating, the cause of which seems a mystery. In cases where the bearing of the pin

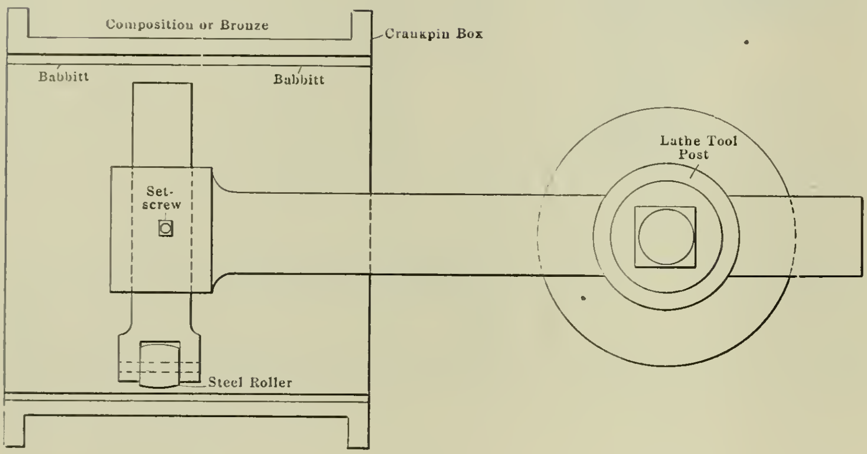


FIG. 8

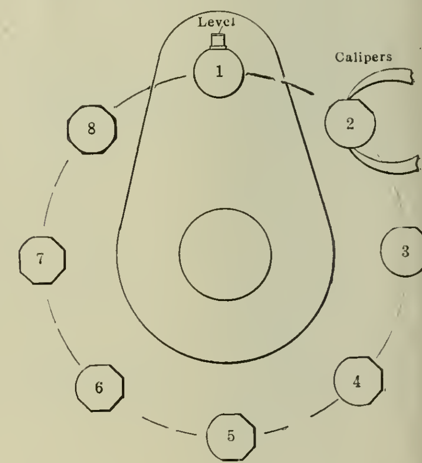


FIG. 9

This gives a hard surface and will wear well in the stuffing box.

All of these are taken from practice and have proved very successful.

A case of crank-pin wear and cutting away is shown in Fig. 7. The engine had run about four weeks and was pounding on the pin so that it could be run no

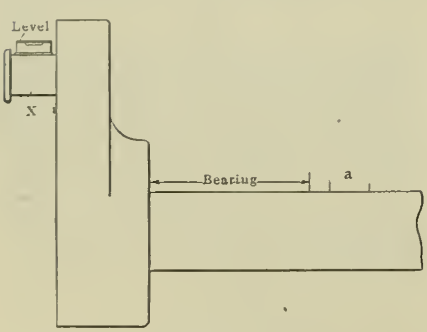


FIG. 10

longer. The wear on the boxes (composition) was about 1/16 inch, while on the pin it was ½ inch, on one side only. The steel in the pin was of poor quality, and there were streaks of dark grit on the surface. This came from the amount of metal removed, as the pin was made from a bar. Crank pins should be forged in dies under a hammer, if the collar is to be solid with the pin. This densifies the surface metal, closing all openness of grain. Not over ⅛ inch should be turned off the bearing in finishing, as the deeper the cut in the bar the more open it shows.

heats, and the boxes are of hard composition, or bronze, with a soft-steel pin, babbitt of a good quality will prove effective. But great care should be taken in putting the babbitt in. Bore about ¼ to ⅜ inch out of the box, leaving a rough surface from the cutting of the tool, then heat the boxes, and thoroughly tin them on this rough surface. Put in the babbitt, leaving about 3/16 inch to bore out. Take a rough cut, leaving 1/16 inch for finish. Then with a small roller in a bar, as shown in Fig. 8, roll the babbitt out against the composition, run the roller back and forth a number of times in the lathe, and then with the boring tool take the finish cut to size, which should be about 1/64 inch larger than the pin. *Never hammer babbitt in the boxes*; rolling is far better.

The following mixture of babbitt has proved very satisfactory for crank pins: Tin, 88; copper, 5; lead, 10. For heavy main bearings: Tin, 85; copper, 4; antimony, 9.5. For light, slow-running main bearings: Tin, 5; lead, 80; antimony, 15.

The different metals should be melted separately and mixed while in the fluid state. This is very important and should be strictly adhered to.

Crank pins that are out of line with the shaft, or when worn out of round, are often very troublesome in heating, and to true them up is a very delicate job. The writer has found the following very successful: Place the pin in position *1*, Fig. 9, and file a flat section true to a very sensitive level, the same level as the shaft but not the main bearing on the shaft, as that may have worn taper. Place the level at *a*, Fig. 10, but caliper the shaft at that point to be sure it is parallel.

After the flat place is filed at *1*, turn the pin to position *2* and file another section. Repeat the operation until all of the flats have been filed as shown, around to *8*. But after the position *2* is reached, caliper the pin (at one point only, preferably in the center as at *X* Fig. 10), to be sure that when *8* is reached it will be round. After all of the flats have been filed, take a cast-iron box, Fig. 11, and bore it to the small diameter of the flats as at position *8*. The casting should be thick enough so as not to spring out of true. Then with lampblack or red lead in the bore of this box to mark the high spots on the pin, finish filing. The last of the filing should be with a dead smooth file, with the corners ground off so as not to mark the pin. If care is used in this operation the pin will be perfectly true and round.

It is often stated that a crank pin out of line with the cylinder will heat, but such is not always the case. In overhauling a large horizontal engine some years ago, it was found that a line through the cylinder was nearly ¼ inch one side of the center of the pin; still, that engine had run for years with no sign of heating.

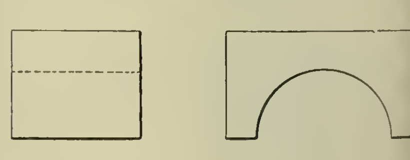


FIG. 11

It is stated that the oil used on railways in the United States as fuel amounted in 1907 to 18,855,691 barrels. It is estimated that 13,593 miles of railway were operated by oil-fired locomotives making some 74,000,000 engine-miles in the year.

Belting Compared with Chain Transmission *

By Harrington Emerson

"For power transmissions, as met with in ordinary shop practice, no means has as yet been devised which can compare in economy of first cost and ease of handling with belting, especially with regard to unskilled labor."—"Power Transmission by Chain," *Cassier's Magazine*, May, 1908.

The writer of the article, Edward J. Flax, is a recognized authority on chain transmissions and was supplied with fullest information by leading European chain manufacturers.

Chain transmission is not thought of for general shop use, although for advertising purposes a shop has in one instance been so equipped. There are, however, installations where chains are best, in spite of their many drawbacks. Chains are, mechanically, merely a form of gearing, and as such are suitable for positive transmissions of very heavy power at slow speed. They are widely and properly used for conveying ashes, sand, chemicals and liquids which would corrode or destroy belting. Chains of this kind are generally made of malleable iron. Even for conveyers for clean substances, flour, wheat and other grains, belts are preferable, and in the best installations leather is preferred to cotton or rubber, being more durable. Transmission chains have to be carefully made. If the chain is to run smoothly, noiselessly, and without considerable friction, both the links and the sprockets must be mathematically correct. This perfection of design is found only in the highest and best makes of steel chain.

The Ordinary Chain

The makers of the best chains are those who know most about the troubles with chains. The American manufacturer of the Renold silent chain thus describes the ordinary chain: "As soon as the chain is started up, it stretches and immediately all the strain falls on one tooth. This condition gets worse as the strain increases. As the wheel turns the working tooth goes out of mesh, then the wheel slips back until the next tooth comes into contact with the next link in the chain. Obviously this jar brings an abnormal strain on the chain and sprockets. Consider how many times a minute this jar occurs at even moderate speeds. It is no large that all ordinary chains stretch rapidly."

This deterioration starts in with the beginning of service. Even in such light and flexible duty as bicycle transmission, a chain is subjected to sudden, severe strains, which either stretch the chain or distort the bearing surfaces. Either mishap is fatal to smooth frictionless running service.

If the transmission is positive, as from motor or shaft to a machine tool, sudden variations in strain become hammer blows, sledge-hammer blows, and the chain must either break or the parts yield. To avoid the evils arising from the stretching of the chain, self-adjusting forms of teeth have been invented, of which the Renold silent chain gear is one of the best.

Distortion

The adjustment of the teeth to wear, however, does not obviate the distortion on the bearing and meshing surface due to blows. The chain being a positive transmitter there is no slip or give under a sudden increase in load, as when a tool sticks in a casting, and even if the tool breaks, the chain has sustained a severe and hammer-like blow. Chains even of the best make are often hopelessly distorted in as little as three months' time. To palliate this evil, spring sprocket wheels are not rigidly mounted on their shafts, but a spring is interposed between rim and hub, so that when the shock or blow comes it is softened by the spring. This added complication and expense has proved a very great betterment, prolonging the useful life of the chain, but wear and jar still exist and the date of renewal is merely postponed. There comes a time when chain and sprocket wheel must both be replaced.

The makers of the Renold silent chain claim that it is superior to leather belting because:

(1) It cannot slip.

(2) It can be used in a hot or damp place.

(3) It can be run on shorter centers than belting.

In all the above respects the chain is good, especially where the work must register exactly, as in the color-printing process. It is very useful for dishwashers, etc., or for other forms of transmission where there is oil or high heat.

The short-center claim is perhaps not quite so sound. The big tools of a planing mill have not found anything to replace belting, yet the centers are very close, the pulleys very small. This is one of the most severe of shaft-transmission problems, and experience has proved that only the finest quality of single leather belting will run these machines successfully.

Short Centers

[illegible] Smith, [illegible] president of the American Society of Mechanical Engineers, at a recent meeting of the society spoke as follows on the subject of short centers:

"In driving the new and extra powerful tools for using high-speed steel, much attention has been paid to trains of gearing and sprocket chains for getting sufficient torque, the good old-fashioned belt being neglected as being too weak and of no account. The trouble with the old-time belt drive was that the belts were run much too slow. Some did not have the capacity to transmit much power. I have found, however, that the cheapest and most practical method to drive a shaft from a motor is with a short belt running at high speed and endless. A small belt running at [illegible] feet a minute will transmit an enormous amount of power and can be kept so loose as not to be strained up to its working limit, thus being very durable. Because it runs loosely the shafts are not pulled together, so that there is very little journal friction and wear. There need not be any fear of its being too short between pulley centers if it is strong, thin, endless and runs at high speed."

The makers of the Morse rocker chain, also a very excellent chain, recommend it for use under the following conditions:

(1) Where room is lacking for the proper sized pulleys for belts.

(2) Where the centers between shafts are too short for belts.

(3) Where a positive speed ratio is needed.

(4) Where there is moisture, heat or dust that would prevent a belt working properly.

(5) Where a maximum power per inch of width is desired.

The Renold silent chain and the Morse rocker chain need springs [illegible] in the sprocket wheel. [illegible] the belt naturally possesses, and where transmitting power is [illegible] of a low speed under the severe conditions of moisture and dirt, as in automobile transmission, the belt will be cheaper to install, cheaper to maintain, cheaper to repair in case of breakdown and more efficient than any chain. A leather belt will run on very short centers and transmit very high powers, but it should be run on [illegible] than a long belt.

[illegible]

One of the most difficult transmissions in engineering practice is from the axle of a moving train to the dynamo which charges a storage battery for train lighting. The transmission must run without attention over a distance of many miles; must stand up under excessive heat and exposure, cold, rain or snow; it must run covered with the sand and grit from the roadway [illegible]. For this very difficult service belts are used because other forms of transmission have failed.

A good belt and a good pulley [illegible]

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*Paper presented to Leather Belting Manufacturers Association, February 3, 1909.

Selection of Coal for Boiler Furnaces

General Consideration of Types of Furnace and the Selection of Coals, with Recommendations as to Most Desirable Specifications

BY D. T. RANDALL*

It is well known that certain coals are especially suited for locomotive use, others for metallurgical use, for illuminating gas, or for the manufacture of coke, etc., but all coals are considered as possible fuel for boiler plants. This being so, it is important to know about the design of furnaces and the influence of certain characteristics of coal in order that the best results may be obtained.

Furnaces

An ideal furnace would, of course, be one in which all coals, no matter what the character of their composition, could be burned with equal efficiency. Furnaces may be generally classified as follows:

(1) The hand-fired grate set in a chamber inclosed by the iron surfaces of the boiler, as in the internally fired boilers of marine type, in the locomotive type used for stationary purposes, house boilers and small vertical boilers. These boilers cool the gases from the coal and are not suited for use with coals containing more than a small percentage of volatile matter. Where bituminous coal is burned in such boilers there is a considerable loss of unburned gases as is evidenced by the smoke given off.

(2) Hand-fired grates set in a chamber partially inclosed by brick and with the boiler surfaces just above or near the surface of the fire. This includes the usual setting for horizontal return-tubular and water-tube boilers. These are not suited for burning bituminous coal.

(3) Hand-fired grates set in a brick chamber with a considerable space for combustion to take place before the gases reach the surfaces of the boiler. This may be accomplished by brick arches, tiles, etc., and, in addition, piers, baffle walls and other devices are used to assist in mixing the gases and air while within the combustion space. With these may be included down-draft furnaces and coking furnaces fired by hand.

Many of the foregoing, when carefully fired, give good results and with certain sizes and kinds of coal they may be operated without dense black smoke, but usually not without some smoke. Often a special coal is required to secure good results. This creates a demand for coals low in ash and of large size. Screenings are seldom burned in such furnaces with good results.

(4) Automatic stokers partially inclosed in brick, with a small combustion chamber and a short distance from the grates to the boiler furnace. Such settings usually give good results except at high capacities, or when the load is changed suddenly. They give off more or less smoke, depending on the size and character of coal used. Coals high in fixed carbon may be used with good results.

(5) Automatic stokers inclosed in brick settings, with a large combustion chamber and a considerable distance from the grates to the boiler surfaces. Such settings will burn almost any size or kind of coal with economy and without smoke within reasonable ranges of load.

Time is required for the air and gases to burn and any means that will facilitate the ultimate mixture of the air and gases will reduce the size of the combustion chamber necessary for good results. In general, then, for most coals, and especially for those which have high percentage of volatile matter, it has been found more satisfactory to install some kind of device which will feed the coal regularly in small quantities, allowing it to become heated gradually, driving off a practically uniform amount of gas to which a proper amount of air can be admitted and burned in a combustion chamber which is sufficiently large to allow of complete combustion in the furnace.

Draft

In considering any type of furnace, one should keep in mind the necessity of having a strong draft available. This may be provided by a stack or a fan. A stack may be supplemented by a forced-draft fan, or an induced-draft fan may be used alone or in connection with a forced-draft fan. Most plants do not have sufficient draft at times when boilers are overloaded.

The amount of draft required depends upon the kind of coal used, the size of the coal and on the load to be carried. Stacks should seldom be less than 120 feet high. In many cases they must be higher, or a fan used with them. For most bituminous coals a draft or difference of pressure of 1/4 inch of water between the top and the bottom of the fuel bed will be sufficient. For small sizes of bituminous coals and for the various small sizes of anthracite, the draft required is greater. For buckwheat sizes of anthracite, a draft of 1 inch of water is frequently necessary.

Choice of Coals

Because a coal is sold at a low price per ton does not of necessity make it the cheapest coal to buy. In choosing a coal when the furnace equipment and other conditions are favorable, the one giving one million heat units for the lowest cost will prove to be the most economical to purchase. As a rule, coals mined near the point of consumption and bearing only a small freight charge will be the cheapest coals to purchase and, in most cases, it will pay to install a suitable furnace to burn them. An engineer having full information before him may then decide whether his furnaces are suitable for burning the cheapest coal, or whether it will be profitable to change the furnaces.

It often happens that, for some good reason, it is impossible to change the equipment and in this case it is, of course, necessary to choose a grade of coal which will make it possible to generate the steam required, even though it be more expensive. These conditions arise especially in plants belonging to Government or State institutions and in plants which are rented.

In considering coals for boiler plants, one must be familiar with the kinds and grades of coal available, their chemical characteristics and the prices, together with the furnace equipment to be used.

Certain characteristics of coal determine the method of firing or the design of furnace required to burn them most efficiently. Among these are the tendency to clinker and to cake in burning. The amount and character of the volatile matter, ash and moisture are also important.

How to Select Coal

In choosing coal for a boiler plant, it is probable that the chemical comparison is the more reliable, if based upon a representative sample of the coal, than a boiler test. The possibility of doing accurate work in a laboratory is greater than in a boiler room, where the fireman may unintentionally influence results by his method of handling a fire. Usually it requires a few days for a fireman to become accustomed to a new coal, and even an expert fireman has difficulty to burn the same coal two days in succession and supply the same amount of air per pound of coal each time. A boiler test is only a rough

*Engineer in charge of tests at the United States Geological Survey Experimental Station, Pittsburg, Penn. Paper read at Illinois Coal Conference, March 10, 11 and 12.

determination, and two tests, one on each of two coals, are seldom sufficient for comparison. If several tests can be run and the averages of the results of these taken, they will compare pretty closely with the chemical valuation of the coal, provided the coals are of the same general character. Coals high in fixed carbon and low in moisture give better results than those high in volatile matter and moisture. This is true in nearly all furnaces and especially true of those not provided with firebrick furnaces.

Size

In the perfect furnace which has been mentioned, the value of the coal should depend entirely upon the *heat units which are available* in the coal. This being so, the heat value would be the true basis for the purchase of coal. Unfortunately, as has just been mentioned, the size of the coal, even though it is otherwise equally high in B.t.u., is an important element in burning the coal on most kinds of equipment. Usually the smaller sizes are more difficult to burn on account of the difficulty of drawing air through the fuel bed and in many kinds of coal the smaller sizes contain a greater percentage of ash than do the larger sizes.

Owing to the difficulty of burning the smaller sizes of coal, they are usually much cheaper than the larger coals. Improved furnaces with strong drafts have been provided in so many plants that very little coal is being wasted today on account of its size. The culm banks of the anthracite region are being put through washeries and the good portion sold for fuel. Many coals break up badly in handling. This is especially true of some of the high grade Eastern coals. Some of them are delivered with 20 per cent. fine coal which will pass through a screen with round holes ¼ inch in diameter. If the coals cake in burning, this is not as serious as with noncaking coals. With fine coal a much stronger draft is required which, in some cases, carries a considerable quantity of the very fine fuel off the grate before it is burned, and in case it does not cake there is also a considerable loss due to sifting through the ashpit.

Chemical Characteristics

The results of more than 600 steaming tests conducted at the fuel-testing plant of the United States Geological Survey show that with the equipment used coals from Illinois, Indiana, Kentucky, Iowa, Missouri and Kansas may all be burned with practically the same efficiency, even though the heating value varies from 6000 to 13,000 B.t.u. per pound of coal, the ash varies from 8 to 25 per cent., the moisture varies from 3 to 20 per cent. and the volatile matter varies from 30 to more than 40 per cent. in these coals.

Influence of Heating Value

The results of these tests indicate that for coals of the same general character the performance of a boiler depends, for the most part, upon the B.t.u. available in the coal; that moisture, volatile matter, sulphur and ash have more or less influence on the capacity and efficiency. It is difficult to separate the effects due to any one of these items, except when they occur in large percentages. Coals of the same character may be compared directly on the basis of the B.t.u. in the coal *as delivered* without serious error. It is important to note that the heating value should be considered on the basis of the moist coal "as delivered" and not on the dry coal (see Table 2). Coals of different character may be compared on the basis of their B.t.u. values, but account must also be taken of the percentage and character of volatile matter, the percentage of ash and the percentage of moisture. An allowance for these must be made, depending on the conditions under which the coal will be used.

Influence of Moisture

The loss due to moisture in the coal when present in small percentages is comparatively small. Stated roughly, this loss amounts to about 1 per cent. for each [illegible] per cent. of moisture based on the "combustible" in the coal. It will, therefore, be seen that an increase of 1 or 2 per cent. of moisture in the coal has but little effect on the efficiency of the boiler. However, when moisture occurs in large amounts, as it does in some coals, there is a serious loss due to the heat required to evaporate this moisture from the coal and to the reduction in temperature of the furnace gases. This loss is not accounted for in chemical reports on B.t.u. in coal, and an allowance should be made if a coal is high in moisture. This would correspond to the so-called low B.t.u. value of gas and liquid fuels used in internal-combustion engines (see last column, Table 2).

In order to make clear the relation between the different forms of reporting coal analyses and to show the influence of moisture in coal when both moisture and ash are present in varying amounts, the accompanying tables have been prepared.

Influence of Ash

It is difficult to determine just what effect the presence of ash may have on the efficiency of the boiler. Apparently it is small. Ash has, however, a decided influence on the capacity at which a given equipment may be operated. It reduces the effective grate area and introduces an added resistance to the flow of air through the fuel bed. There are also losses of efficiency and capacity due to the necessity of cleaning fires more frequently. This becomes of less importance in types of furnaces where the ash is discharged by dumping or other automatic discharging devices.

Influence of Volatile Matter

The volatile matter in the coal is also an important element, as it is more difficult to burn than the fixed carbon. The percentage of volatile matter as shown by the proximate analysis is not a direct measure of the difficulty of burning the coal with good efficiency and without smoke. Different coals having practically the same percentage of volatile matter vary in the amount of tarry and heavy hydrocarbon gases [illegible] which they are heated.

TABLE 1

PROXIMATE ANALYSES OF COALS FROM DIFFERENT PARTS OF THE UNITED STATES
(See Prof. Paper 48, U. S. Geological Survey.)

Coal		Proximate Analyses of Coal as Fired				
		Fixed Carbon	Volatile Matter	Moisture	Ash	B.t.u.
West Virginia	8	60.68	31.19	1.26	6.87	13,877
Illinois	1	38.21	38.91	9.69	13.19	10,708
Missouri	3	29.08	26.18	18.43	26.31	7,738
North Dakota	1	25.40	28.13	35.84	10.63	6,874

TABLE 2

THE INFLUENCE OF MOISTURE AND ASH IN COAL ON THE B.T.U. VALUES AND ON THE HEAT UNITS AVAILABLE TO THE BOILER. SAME COALS AS IN TABLE 1

Coal		Comparison of B.t.u. Values			Comparison of Ash			Moisture		
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
West Virginia	8	13,677	14,408	15,084	6.87	[illegible]	[illegible]	1.26	[illegible]	[illegible]
Illinois	1	10,708	11,862	14,202	13.19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Missouri	3	7,738	9,593	13,847	26.31	[illegible]	[illegible]	18.43	[illegible]	[illegible]
North Dakota	1	6,874	10,442	12,666	10.63	[illegible]	[illegible]	35.84	[illegible]	[illegible]

In addition to the foregoing, it must be remembered that the volatile matter is not all combustible material and the variation in this respect is very great when all the coals in the country are compared. Coals having a high percentage of volatile matter which is nearly all combustible are found to be the most difficult to burn properly. The results obtained from tests on an iron inclosed furnace show a drop in efficiency as great as 10 or 12 per cent. in burning coals ranging from 18 down to 45 per cent. of volatile matter in the "combustible." A well-designed furnace reduced this loss in efficiency when burning such coals to about 5 per cent. A perfect furnace would, of course, obtain the same efficiency from all coals.

Influence of Sulphur

Sulphur is considered an undesirable element in coal. It usually gives trouble from clinker and is sometimes destructive to the grate bars. Its effect depends upon the form in which it occurs in the coal; on the percentage of ash in the coal. Coals having sulphur varying from ½ to 6 per cent. or more are successfully burned under boilers and, in many cases, no difficulty is experienced.

Purchase of Coal for the Government

The United States Government is a large user of coal. Its fuel bill amounts to nearly ten million dollars annually. Much of the coal purchased is tested and analyzed. One single contract for this year was for 400,000 tons of coal to contain 14,600 B.t.u. per pound.

In order to compare the cost of coals used by the Government in the larger cities of the country, it has been customary to calculate the cost on the basis of the number of cents per 1,000,000 B.t.u. It is interesting to note that for last year's contracts the cheapest coal was delivered in Louisville, costing only 7.1 cents per million B.t.u. The cost in Boston for similar coal was 16.3 cents and in St. Paul the price was 17.1 cents. Anthracite was delivered in Eastern cities at prices ranging from 8½ cents per million B.t.u. for buckwheat coal to 14 cents for pea coal, and as much as 20 cents in some cases for egg and broken coal.

Specifications

Having decided upon a kind of coal to be used for a plant, the purchaser naturally desires to have some assurance that he may be able to secure the coal in question, or one of practically the same composition, for a given period. This has led to the use of specifications for the purchase of coal. If the size of the contract and other conditions warrant the use of a specification, then the proposal for coal to be of value should contain at least two general statements regarding the kind and character of coal:

Proposals for Coal

The bidder should state in his proposal (1) the commercial name and size of the coal to be furnished, the size to be specified within certain limits in order to avoid disputes when coal is delivered, and (2) the character of the coal to be furnished, in the following form:

PROXIMATE ANALYSIS.

	As Received.	Dry Coal.	Free from Moisture and Ash.
Moisture....	....		
Volatile matter.......	....		....
Fixed carbon	....		
Ash........	....	....	
	....		

Sulphur separately determined................ %.
B.t.u. in coal as received (not dry)...

The price per ton should be stated for coal of the specified quality. The price to be paid on coal delivered should vary directly with the B.t.u. in the coal "as delivered;" this value to be modified further, if advisable, by corrections:

(1) For more or less ash in the dry coal;

(2) For more or less volatile matter in the "combustible," allowing in all cases 2 or 3 per cent. variation without premium or penalty. A limiting value may be placed on the percentage of sulphur in the coal which will be accepted. Corrections for ash and volatile matter are best expressed in the form of a table. In making corrections for variations in the quality of the coal delivered, it may in some cases be more convenient to make all changes in the price on the basis of change of the B.t.u.

The reasons for basing the contract on the items mentioned are as follows:

(1) "B.t.u. in coal as received" corrects for changes in heating value due to changes in both ash and moisture.

The B.t.u. in the coal as delivered being the most direct measure of its value to the consumer, it is reasonable that the contract should be based principally upon this value. This value may be determined and reported directly by the chemist. This results in a premium for better coal and a penalty for coal not up to the standard.

As has been shown, as far as is now known the presence of small amounts of moisture in the coal has but little effect on the efficiency of the boiler, and as coals from the same mine or group of mines do not usually vary more than 3 or 4 per cent. in moisture, it hardly seems worth while to correct for the small amount of heat lost in evaporating it. By basing the value of coal on the B.t.u. as received (moist), the variations in heating value as otherwise affected by the moisture are provided for.

(2) "Ash in the dry coal" is independent of changes in moisture in the coal, this figure always being the same no matter what the moisture content may be. Coal delivered from the same mines may vary considerably in the percentage of ash. A reasonable allowance, such as 1 or 2 per cent. from the average, would seem to be desirable, as such a variation is almost unavoidable in commercial products. Inasmuch as the heating value is taken care of by the B.t.u. determinations, the only remaining correction to be made for the ash is the extra trouble in handling the coal and ashes and the possible reduction of the capacity of the equipment. When the ash greatly exceeds the amount for which the furnace was designed the reduction in capacity may become a serious matter and would justify a rapidly increasing penalty. For the first 3 or 4 per cent. increase or decrease in the ash it is only necessary to provide for the difference in the cost of the handling, which is between ½ cent to 1 cent per ton for each 1 per cent. of ash in the coal. If corrections other than for B.t.u. are to be made, and the ash is a factor, the specifications should be based upon the percentage of ash in the dry coal for reasons which are explained elsewhere.

(3) If volatile matter is to be corrected for, then "volatile matter in 'combustible'" is preferable to "volatile matter in coal." It should be the same, or nearly the same, regardless of variations in moisture and ash in the coal, and it is more properly a measure of the difficulty to be experienced in burning coal, as it is the direct ratio of the volatile matter to that part of the coal which is actually burned. It is reasonable to have a penalty for great variations in the volatile matter from the standard specified, for the reason that furnaces are not all equally well designed to burn coals high in volatile matter. This should not in any way affect the dealer or operator, provided the coal is furnished from the same mine, as the volatile matter should remain practically constant and a reasonable limit should be established within which no change in the price would be made. This variation could well be 3 per cent. either way from the standard established. The value for volatile matter should be based on volatile matter in the "combustible" (coal free from moisture and ash), as this value remains nearly constant in the same coal. Premiums or penalties for lower or higher volatile matter may properly vary according to local conditions.

(4) *Sulphur.* Sufficient information is not available on which to base a reasonable rate for correction for this element.

A forest products' laboratory is to be established at the University of Wisconsin, at Madison, by the United States Forest Service, where all lines of the experimental investigations of the Government looking to closer and better utilization of timber and the checking of wood waste will be concentrated in the near future.

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Air Receivers

The uses of compressed air are so varied that no definite rules can be laid down to cover all requirements of the receiver. That a receiver is desirable seems to be generally conceded, but the reasons for its use seem to be rather confused.

The most important functions of a receiver can be divided under four heads: To act as a temporary reservoir; to collect the water and grease and insure dry air; to reduce the loss caused by friction in the pipes, and to equalize the pulsations and steady the flow of air to the place of use.

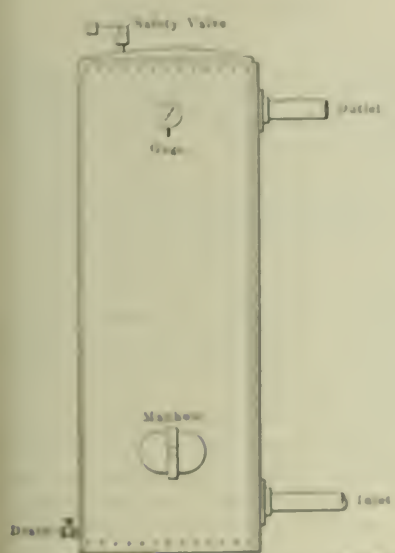


FIG. 1. VERTICAL RECEIVER

The first function of a receiver that occurs to most people is that it will act as a reservoir of power. This is true, to a certain extent, if the receiver is made large enough, but in most cases this would require a receiver so large as to be prohibitory. For this reason the plan of using the receiver as a reservoir will never be satisfactory, and the extra money spent for the reservoir would be better used if expended in the purchase of a compressor of sufficient capacity to supply the greatest demand put upon it.

An idea of the size of receiver necessary to act as a reservoir can be had from the following example of a [illegible] compressor, running at [illegible] revolutions per minute at a working pressure of 100 pounds. It would require a receiver 5 feet in diameter and 60 feet long to keep up the work of the compressor one minute after it had been stopped and not allow the pressure to drop more than 15 pounds. While if the compressor was at work and the demand for air was 25 per cent. greater than the capacity of the compressor in four minutes it would lower the pressure 15 pounds. The real value of the receiver is when the demand for air is very irregular, the advantage being due to the fact that the compressor stores energy in the receiver without any great change in pressure when the demand for air is less. This saves the compressor from the hard usage caused by a varying change in the load, and avoids the loss caused by free expansion, which would result if no receiver were used. When the variation in the quantity of air used is very great, and a uniform pressure is required, an unloader is often used.

FIG. 2. HORIZONTAL RECEIVER

The receiver when properly connected serves as a means for removing the water and grease from the air. The inlet to the receiver should be at the bottom, and the outlet at the top. This applies to both the vertical and horizontal types. See Figs. 1 and 2. To each receiver should be fitted a pressure gage, safety valve and drain. The water and grease are drained from the air by allowing it to pause in its flow, to cool and to drop the water and grease which would otherwise be carried along by the current of air. If the receiver is too close to the compressor the air will not have time to cool sufficiently. The general practice is to place the receiver about 50 feet from the compressor. If the air is not sufficiently dry to prevent freezing after having passed through the receiver, it can be further dried by placing a separator in the pipe line, made as shown in Fig. 3. The shell is made from a [illegible] pipe nipple, according to the size of the line, with caps screwed over the ends. The bottom cap is drilled and tapped for the drain and the top cap for the inlet and outlet pipes. This separator should be placed at the end of the air line, and at the lowest point in the pipe system.

The air may also be dried by placing a second receiver at the end of the air line. This also is useful in reducing the loss by friction of the air in the pipe system. When air is quickly withdrawn from the pipe the pressure will momentarily drop below the average. If a receiver is placed as near the point of action as possible the loss of pressure and momentary fluctuations will, to a large extent, be prevented. Also, by keeping a uniform pressure at each end of the air line, the flow of air will be more uniform, and the pipe friction will then become a constant quantity, due to the average consumption of air and the difference in pressure at the two ends of each end of the pipe. Since the friction loss varies as the square of the velocity, it is [illegible] [illegible] than the loss [illegible] when the velocity is [illegible] due to the [illegible] air consumption.

The fourth function, the equalizing of the pulsations and steadying the flow of air at the place of use, is [illegible] [illegible] the [illegible] [illegible]

FIG. 3. SEPARATOR OR TRAP

comes from the compressor into the pipe, the pressure will run up momentarily far in excess of the average pressure used, unless there is sufficient space for its immediate accommodation. This will throw unnecessary strain on the compressor, and also consume power. By placing a receiver in the air line this difficulty is relieved and a steady flow of air is sent into the pipe leading to the work.

The size of receiver required depends upon the rapidity at which the air is drawn from it, and the drop in pressure permissible. The size also depends upon the working pressure, and in general it can be said that the greater the working pressure, the smaller the size of receiver that can be used for a given number of cubic feet of free air per minute. Fig. 4 is a diagram showing the general practice in selecting the size of receiver under ordinary conditions. For example, to find the size of receiver necessary for an 1100 cubic-foot machine at 110 pounds working pressure, project across to the 110-pound curve, and then down to the lower margin, where the size is found to be 140 cubic feet. From this the dimensions of the receiver can be computed.

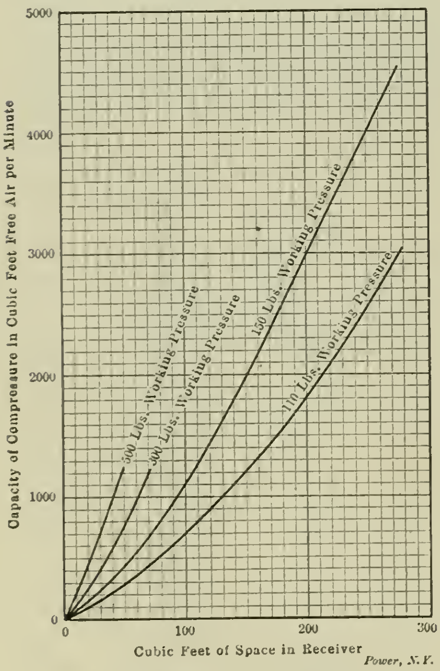


FIG. 4. CAPACITY OF AIR RECEIVERS

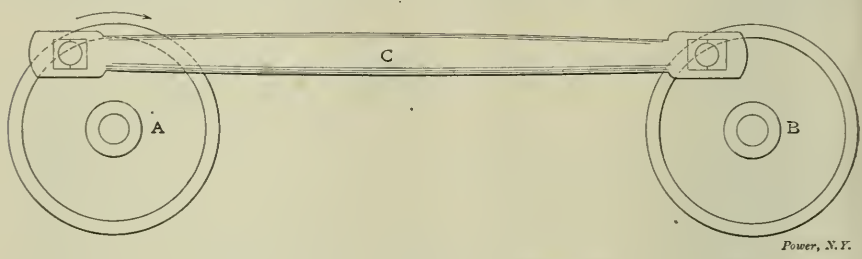
Receivers should be made of the best 60,000-tensile-strength steel. The side seams should be double-riveted, and strongly made with dished heads, and tested at a pressure 50 per cent. greater than the maximum pressure used. The larger sizes should be provided with manholes. To prevent too great an accumulation of water and grease, the drains of the receiver should be opened frequently.

John B. Sperry.

Aurora, Ill.

A Problem in Power Transmission

The accompanying sketch represents an end view of two countershafts connected, as shown, by means of two crank disks and a rod C. The countershaft A is belt-driven from the main shaft and runs at from 40 to 50 revolutions per minute, while B is supposed to drive a belt conveyer.



CRANK CIRCLE, 12 INCHES IN DIAMETER; R.P.M., 40 TO 50

The problem is to drive B by means of the rod C, without the use of gears, belt, friction, flywheel or counterbalance. Or, to state it another way, the transmission of power must be made through the two crank pins.

J. A. Carruthers.

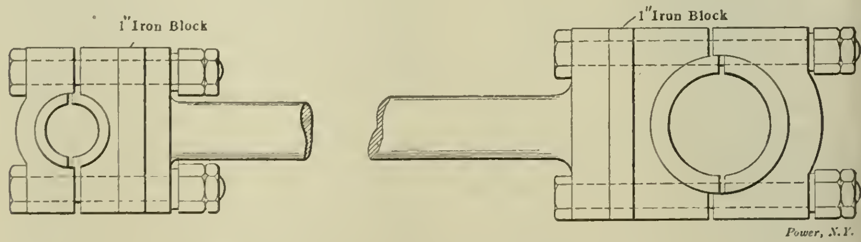
Bankhead, Alberta.

Curing a Balky Gasolene Engine

A short time ago the writer received a commission from a mining company to move a gasolene engine from an old working to a new shaft, and erect and belt it to an air compressor for supplying compressed air to rock drills. A machinist was sent to do the job, with instructions to get everything in first-class order and see that the engine and compressor had at least five days' work under full-load conditions before leaving them.

Within a few days a communication was received from the machinist saying that the gasolene engine would not pull the load, and he could not get more than 30 pounds pressure in the air receiver before the engine began to slow down and finally stop, when the pressure reached 40 pounds; it would work all right when running light, but could not be made to carry the load, and it was impossible to get an explosion oftener than once in every four revolutions.

All of the usual remedies for balky gasolene engines were tried without avail, and it was finally decided that the engine needed more compression, which was given it by inserting an iron block, 1 inch thick, at each end of the connecting rod, between the end of the rod and the brass box (see sketch), thus lengthening the connecting rod 2 inches, which gave about 33⅓ per cent. more compression, with the result that no more trouble was experienced in getting the engine to carry its full load with ease. The 1-inch blocks were only put in as a temporary makeshift until a new piston could be made.



WHERE BLOCKS WERE INSERTED IN CONNECTING ROD

J. A. Smith.

Monterey, Mex.

Transformer Connections

Concerning the transformer problem presented by R. S. Carroll, it makes no difference which way the connections are made. Since the motors are not in use when the lights are on, and *vice versa*, the unbalancing of the system, due to the load on the lighting transformer, will not affect the motors. Even if both were in use at the same time it would make no difference, assuming the motor load to balance as the lighting load unbalanced the system, regardless of the phase it might be on.

Such an arrangement for lights is bad, especially if many lights are to be supplied, as the unbalanced condition will cause uneven voltages across the phases.

A two-phase system is much better where both lights and power are to be supplied, as a reasonable unbalancing of the two phases does not make so much difference as in the three-phase system.

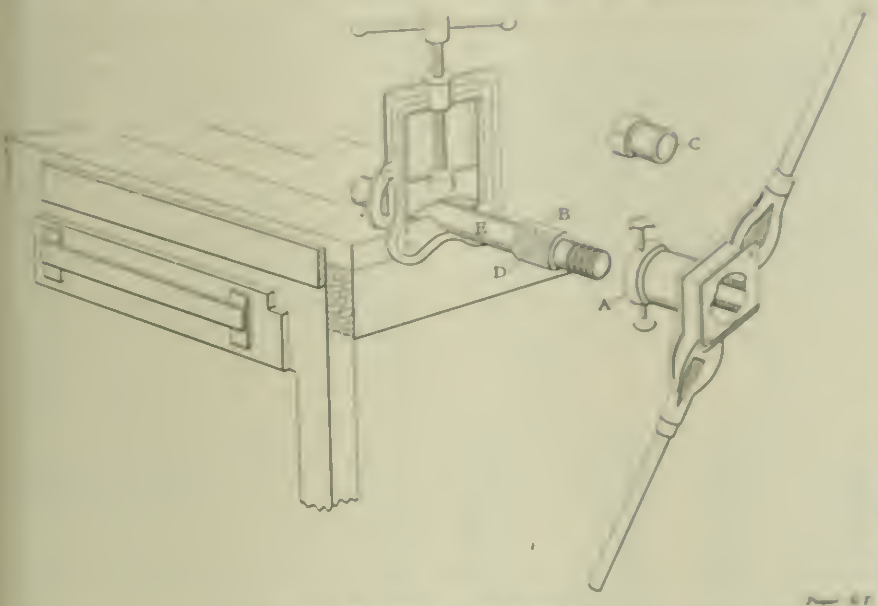
Where lights are supplied from a three-phase system, part of the light load should be on each phase, keeping the system as nearly balanced as possible.

C. L. Greer.

Handley, Tex.

Cutting Close Nipples

The accompanying illustration shows the way I make close nipples. By leaving out the thimble *C* the die stock *A* will fit over the coupling *B*, thus threading a



HOW TO CUT CLOSE NIPPLES

close nipple, the nipple being screwed into the coupling to meet the pipe *E* at *D*.

T. A. KNOWLTON.

Conway, N. H.

Drainage of Steam Piping

From time to time there have appeared communications relating to the erection and drainage of high-pressure steam piping. I have, however, never seen this subject fully and adequately treated, although I have long looked for such an article. What brings this to my attention now is the letter by T. J. Bloss in the issue of February 9.

Mr. Bloss is undoubtedly correct in stating that steam piping should drain in the direction of the flow of steam, and that the steam should enter the engine through a steam separator of ample proportions from which the water of condensation is led away through a trap. A good separator is a valuable addition to the steam line under these conditions, but like every other piece of apparatus, it has its limitations.

I have in mind a 75-horsepower Corliss engine belted from the flywheel to an electric generator. The flywheel is far too light for the service that is expected of the engine, and consequently the regulation is very poor. The steam line is 200 feet long, or more, but is well planned and erected with ample small drip pipes tapped in at intervals, and the water thus removed from the main header is taken off through a trap. Just above the throttle is a large separator of undisputed excellence. Apparently very adequate means of preventing water in the cylinder have been employed, but in several instances water has passed all of these safeguards in such quantities that the engine was stalled. The lightness of the flywheel is, undoubtedly, all that saved the engine from being wrecked on these occasions and no effect more serious than forcing the engine out of alinement was apparent.

I have often wondered whether small pipes tapped into the bottom of a main steam line, as explained, were really of much action as water removers. A jet of steam will not only carry a stream of water over a wide opening in the bottom of the pipe, but it will carry considerable water with it up a long vertical pipe as well. It is reasonable to suppose that, under some conditions at least, the drip pipe may become a more or less perfect condenser, thus supplying considerable water for the trap to remove, and making the engineer in charge think that his drainage system was doing excellent work, when, in fact, little or none of the water came from the steam header.

Meyer, in his "Steam Power Plants," suggests that the steam main be made large enough for the velocity of steam flow to be low, to permit this system of drainage to be used, but the first cost would have been too high in the present case, so the question remains: what is the best and surest way to get the water out of the main?

C. H. PANCK.

Syracuse, N. Y.

A Piston Made of Junk

The steam piston head of one of our small pumps became broken in two, the rod was badly bent. We had no casting for the piston and, therefore, set about to devise some means of making a temporary repair. There were found on the scrap pile, however, the following materials from which the piston was built up: Two disks, each 12 1/4 inches, and a piece of an old cast iron bushing 1 5/8x3 1/4 inches. First the bushing was chucked and bored for a 4-inch pipe thread, next the disks were turned down as per sketch, leaving a flange, and both were screwed up tight. Then the whole was chucked and the taper hole bored to take the piston rod. The rod was then turned and fitted to the taper hole and the head was turned and grooved out for the rings.

A PISTON MADE OF JUNK

This piston has run for 3 months, [illegible] without trouble, although it was [illegible].

J. E. [illegible]

[illegible]

Armature Clearance

In all plants, large or small, measuring the armature clearance of the dynamos and motors once every month will prevent a great deal of future trouble. A very convenient method is to turn out on a lathe a set of steel rods of 1/8 inch to 3/8 inch diameter and make smaller sizes of drawn wire from 1/64 inch up to 1/8 inch; a little brass tag should be secured to the end of each, and the diameter of the rod stamped on the tag. These steel rods are to be used in watching the clearance, by passing them between the armature and face of each field-magnet pole, keeping a record of the largest size that passes freely each time. It will be found advisable to test the clearance also after a machine has run on a hot bearing for any length of time.

Motors are operated with smaller clearances than generators, as a rule, because of the difference in size, the smallest generator used in any ordinary plant being considerably larger than the largest motor in the plant.

MALCOLM C. SAEGER.

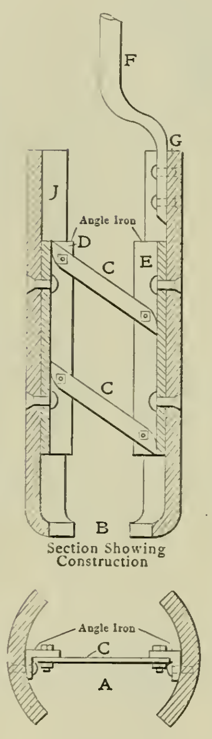
New York City.

Device for Removing Well Pipe

Sometimes when taking out or putting in pipe for an artesian or other small-bore well the pipe slips and falls to the bottom of the bore. This occasions great delay and a new well may have to be dug. By using the device herewith described, pipe can easily be pulled out. Take a piece of pipe the size of the piece in the well, and cut off a piece about twice as long as its diameter. That is, for a 6-inch pipe use a piece 12 inches long. Cut this piece into halves lengthwise and then halve one of the halves lengthwise, making two quarters, as shown in the sketch at *A*. Turn in the lower ends, as at *B*. Take two pieces of angle iron, of suitable size, about two-thirds the length of the pieces of pipe and rivet one piece to the inside of each quarter, in the positions shown at *C C*. Drill two holes in the upright of each angle iron for bolts to go through to hold the links. Drill the holes in the piece *D*, making the upper one one-fifth the length of the piece from its upper end and the lower hole three-fifths the length of the piece from the upper end.

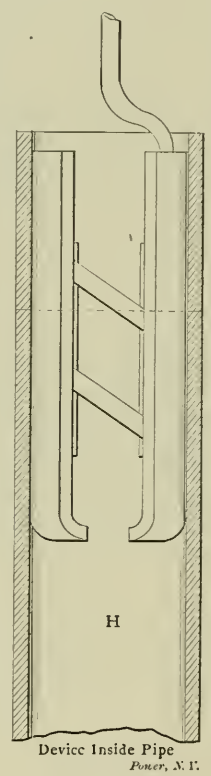
In the angle iron *E* make the upper hole two-fifths the length of the piece from its upper end and the lower hole four-fifths the length of the piece from its upper end. Then make the two links of such length that when they are held straight across at right angles from the angle iron *D* to the angle iron *E* they will hold the two pieces of pipe apart to the original diameter. Forge the ends of these pieces to the shape shown and drill a hole in each end the same size as those drilled in uprights of the angle irons, and at such a distance from the ends that when the bolts are passed through them and through the holes in the angle irons the pieces will not be prevented from coming to position.

After these holes are drilled the links can be bolted to the angle irons with machine bolts, the bolts being loose enough to allow the pieces to swing upward easily. A piece of square iron *F*, of suitable size, is then obtained and one end flattened and riveted to the upper end of the quarter *G*. Then it is bent in and up as shown. To the upper end a rod or rope can be fastened. If these instructions have been followed the device will look like the sectional view. When it is held up by *F*, gripping a pipe, the outside will look like *H*.



Section Showing Construction

FIG. I



Device Inside Pipe

FIG. 2

Secure a rod or rope to the upper end of *F*, and lower the device into the well in which the pipe is. When it touches the pipe the piece *J* will swing in toward *E*, and allow the device to slip into the pipe. When an attempt is made to pull the device out of the pipe it will cause the side *E* to slide up in the pipe, while the side *J* remains stationary, thus causing the links to approach a position at right angles to the angle irons, consequently spreading the two sides of the device and gripping the side of the pipe to be raised. By continuing to pull up on the rope or rod the pipe can soon be raised to the surface.

F. E. FICK.

Govans, Md.

Receiver Pressure

The relation between cylinder ratio and point of cutoff, in the low-pressure cylinder, and consequently the receiver pressure, are not well understood by many engineers. It is self-evident that if the cutoff in the low-pressure cylinder corresponds to the cylinder ratio, the receiver pressure at all times will be at the point of efficiency; that is, the receiver pressure will follow the high-pressure terminal, giving as nearly perfect expansion as it is possible to secure in a reciprocating engine, the low-pressure cylinder taking steam at approximate pressure and temperature corresponding to the high-pressure terminal.

To make this clear, we will assume a case with a cylinder ratio of 1 to 4. It is perfectly clear that one cylinderful of steam from the high-pressure cylinder will fill the low-pressure cylinder one-quarter full, neglecting the influence of the clearance at the same pressure, and the loss due to condensation and without reheat in the receiver.

With engines where the low-pressure cutoff is controlled by the governor, it is not possible to secure a cutoff that will correspond to the cylinder ratios for all loads. In such, the low-pressure cutoff should be so adjusted as to give a cutoff corresponding to the cylinder ratio for the average load.

If the cutoff in the low-pressure cylinder of a compound engine with a ratio of 1 to 4 takes place before one-quarter stroke, it will cause a negative load on the high-pressure diagram, the size of the load being in proportion to the shortness of the low-pressure cutoff; that is, the shorter the cutoff the larger the load. Also, if cutoff takes place later than one-quarter stroke, it will cause a drop in pressure between the high-pressure terminal and the receiver, the amount of the drop being proportioned to the length of the cutoff, i.e., the longer the cutoff the greater the drop.

This drop represents a loss due to free expansion, all of which goes to show, I believe, that there is just one proper joint of cutoff in the low-pressure cylinder for maximum efficiency, as explained above. A further conclusion would be that the cutoff on the low-pressure cylinder should be hand-controlled for the best results.

It is understood that with a low-pressure cutoff set corresponding to the cylinder ratios the greater the load the larger proportion of load carried by the low-pressure cylinder and, in event of an overlooked engine, it might be necessary to lengthen the cutoff on the low-pressure cylinder in order to distribute the load between the cylinders, and also to prevent injury to the low-pressure cylinder by reason of excess pressure.

The point at which it would be necessary to lengthen cutoff would be when the receiver pressure reached the highest allowable point consistent with safety.

It is not possible to say what should be the highest allowable receiver pressure, as that would be owing to the design of the cylinder and receiver and engine as a whole; but as a general thing, builders place relief valves on receivers set for what, I suppose, they calculate is the safe maximum pressure, and engineers, by adjusting the cutoff so as to keep just under pressure for which the relief valves are set, may feel perfectly safe.

F. J. DE WITT

Auburn, N. Y.

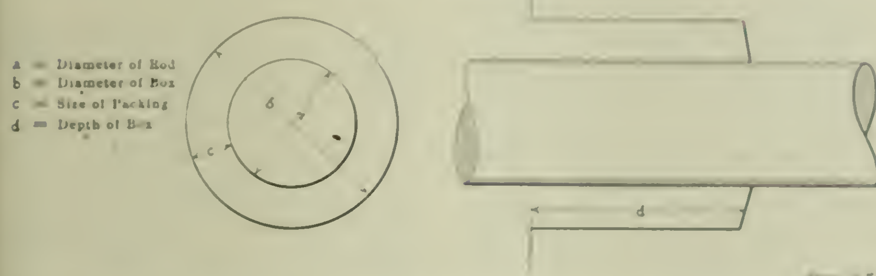
Packing Chart

The accompanying style sheet for packing may be modified to suit different plants or departments. It hardly requires any explanation.

GEORGE T. MUNDAY

Waxahachie, Tex.

STYLE SHEET FOR PACKING



[illegible]		a	b	c	d	Remarks
1	Air compressor valve stem	¾	1¼	3/16	1¼	Duo
2	Air compressor piston rods	1¾	2¾	½	2½	Duo (or air end)
1	Engine piston rods	2¼	4 1/16	1	5½	Daniels PPP
4	Engine valve stems	1½	2½	½	1½	Coil rings
1	Boiler-feed pump	1	1¾	⅜	2	Rawhide water end
2	Boiler-feed valve stems	⅝	[illegible]	½	1	Asbestos wick
1	Boiler-feed water plunger	4	6	[illegible]	1½	Rock hard

Compound Engines

Having noticed a great difference of opinion in regard to the economy and the amount of power obtainable from compound engines, as compared with simple engines, the following discussion may be of some interest.

It is a fact, determined by tests and experiments, that the best economy in an engine is obtained by a moderately short cutoff, so restricted that it shall not come earlier than one-third stroke. This is due to the fact that the condensation of steam and the amount of heat absorbed by the walls of the cylinder during admission, increase as the cutoff is lengthened, and as this water of condensation is revaporized during the exhaust, the heat is removed from the walls and must be again supplied by the incoming steam at the next admission. This action of the cylinder walls is thus seen to place a limit on the number of expansions that can be profitably used for a simple engine, and while increasing the steam pressure will give greater power, there is no gain in economy by raising the steam pressure beyond a very moderate limit unless the expansion can also be increased at the same time.

This leads at once to the compound and multiple-expansion engines, as they have proved to be the best means for increasing the expansion of steam and at the same time avoiding excessive cylinder condensation. It should be borne in mind, however, that compounding is not always advisable, and it is necessary to determine the conditions under which it should be resorted to and the gain in economy to be expected. In the first place it is obviously unfair to compare a simple engine and a compound engine running under the same steam pressure, for the primary object of compounding is to use high pressures and a large number of expansions. The only true comparison would seem to be between two engines each of which is working under its best conditions of operation.

Experience seems to indicate that for simple condensing engines 80 pounds steam pressure is about the maximum point for best economy, while compound engines may profitably employ from 150 to 170 pounds. With a steady full load the latter engines will show from 20 to 30 per cent. better economy than the former, but it must not be forgotten that when running under a reduced load a compound engine will generally suffer more loss of economy than a simple engine. This is evident when we consider that as the power of a compound engine is reduced by shortening the cutoff on the high-pressure cylinder, the load is in general thrown more and more onto that cylinder, this being universally true if the cutoff on the low-pressure side is fixed. At light loads the low-pressure cylinder may even act as a drag, the high-pressure cylinder performing all of the work and being subjected to the greater temperature fluctuations which the engine was designed to eliminate.

Under maximum load and with the cutoff of the many determined by the ratio of the cylinders, a compound engine will show a good gain in economy over a simple engine of the same power, and has the additional advantages of a more even distribution of work on the crank shaft and smaller strains on the pins.

However, the actual power developed by a compound engine is the same as that of a simple engine which has a cylinder the same size as the low-pressure cylinder of the compound engine, and which takes at each stroke the same volume of steam as the high-pressure cylinder and at the same pressure.

H. L. DEAN

Hyde Park, Mass.

Cleaning Water Tube Boilers

I am pleased to note that during the past year some space has been devoted to the subject of cleaning water-tube boilers. Many a boiler has been entirely ruined by neglect of cleaning, although I appreciate that many forms of water-tube boiler are so inaccessible as to require considerable time for cleaning, which has caused them to be neglected. The types which cannot be quickly cleaned necessitate the investment of considerable money in extra idle boilers, which are not even earning the interest on the money invested in them, because they are in operation but a few days at a time.

I have charge of four [illegible] water-tube boilers and run three of them continually every day in the year for twenty-four hours per day to carry our load, and most of the time the four boilers are required. Therefore, only one boiler can be cut out for cleaning at a time, and it must be cleaned when the load will permit, and sometimes it must be cleaned quickly and cut in for service again.

Our water is quite bad, carrying several grains of impurities per gallon, and I clean each boiler after fourteen days' running. We can clean one boiler in one day, thus cutting out each boiler twenty-six days each year.

My plan for cleaning is as follows: At 8 p.m. after the peak load has dropped off, I cut out the boiler I wish to clean, draw the fires and blow the soot from the tubes. The boiler and setting is then allowed to cool down, the draft doors being opened slightly to allow a little air to flow over heating surfaces. After the boiler has stood two or three hours the steam pressure is allowed to reduce through a valve and pipe suitably arranged for the purpose. As soon as the pressure gets down very the manhead in the steam drum is taken out. At about 4 a.m. the night engineer has a hose placed with its nozzle just inside the manhole, and starts feeding cold water into the steam drum, and at the same time opens the blowoff cock slightly so that the water will flow from the boiler at the same rate at which it is entering. This plan gradually cools the water in the boiler, rapidly draws the heat from the brickwork and safely hurries cooling. When the boiler is drained it is ready for internal inspection and cleaning, the furnace, ashpit and combustion chamber being cleaned while the boiler is draining.

Before starting internal cleaning I send a man into the mud drum with an incandescent lamp on an extension cord. He holds this light at every tube and I, from inside the steam drum, examine the condition of every tube and direct the passing of the turbine through them, if need be.

Scraping and washing complete, I again inspect the tubes and if satisfactory, the two manheads are put in, and the blowoff cock is taken apart and examined for signs of leaks or cutting. If in order, it is put back, packed and adjusted with the set screw until freely working and then locked with a jam nut. If it is leaking it is ground and made tight, after which it is put back and adjusted as described.

The total time required in following out my plan of cleaning this boiler is, using two men, 7 hours and 15 minutes. Therefore, starting to clean at 7 a.m., the boiler is being filled with water again at 3:15 p.m. The filling of the boiler requires approximately ½ hour, and as soon as water appears in the glass a fire is kindled and fired slowly for 1¼ hours, and the pressure brought up to the working pressure. The boiler is then cut into the header at 5 p.m., just in time to help with the peak load. At 8 p.m. the next boiler in turn is cut out and cleaned, so that all four boilers can be cleaned in four days' time, if necessary.

F. P. OHMER.

South Bend, Ind.

Results of a Pump Test

As there has been considerable controversy about the power required to operate a centrifugal pump with the discharge valve closed or partly so, I submit the following data of a test made with a No. 6 centrifugal pump, driven by a 35-horsepower induction motor:

Conditions.	Power Required.
Valve closed	12.6 kilowatts per hour.
Valve quarter open	15.0 kilowatts per hour.
Valve half open	16.4 kilowatts per hour.
Valve wide open	16.6 kilowatts per hour.

All other conditions were the same throughout the test.

W. N. GULICK.

Tustin, Cal.

Valve Stem Broke

The man in charge of a large cross-compound engine noticed that the high-pressure cylinder was not developing its share of power. He removed the valve and found the stem broken close to the valve. The engine ran as it did because there was a piece broken out of the valve and steam was blowing through the hole, thus supplying some steam for that end of the cylinder.

J. M. SEWELL.

Hyde Park, Mass.

Reducing Fuel Expenses

Some time ago an engineer took charge of a certain plant which was in bad shape. It had been permitted to run down to such a degree that the fuel expenses were exorbitant. In an attempt to reduce the amount of coal used, the first things the engineer tackled were the valves located on top of the boilers. These valves had been allowed to run so long without packing that the stems were badly grooved and it was almost impossible to make them tight with new packing. As new valve stems could not be readily obtained, it was decided to pack the old stuffing boxes, as the valves were seldom used. In doing the work the valves were left wide open and some heavy lead washers were driven into the stuffing boxes and were calked around the fluted stems. The remainder of the box was filled with a good fibrous packing.

As the safety valves leaked badly, they were ground in and properly adjusted. It was then decided to clean the tubes,

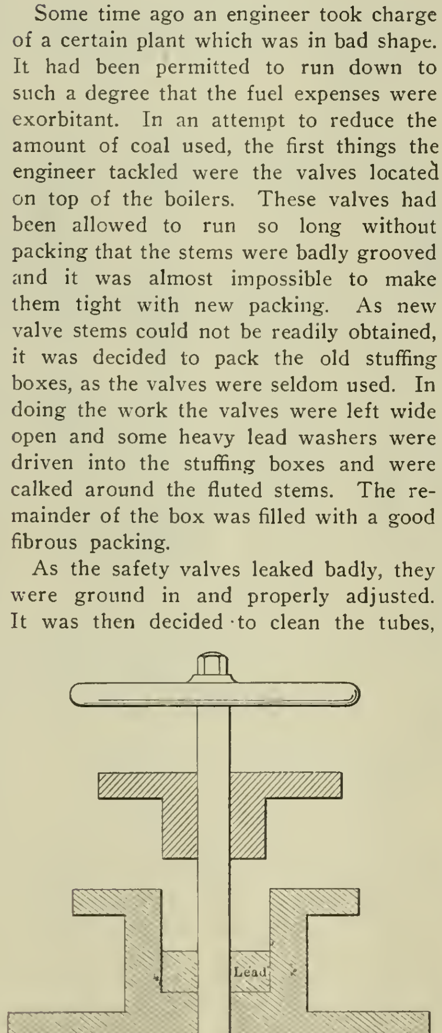


FIG. 1. REPACKING VALVE

and at the first opportunity it was found that it was impossible to force a flue brush through any of the tubes. A length of steam pipe having the largest possible outside diameter that would enter the boiler tubes was secured and forced through each tube by means of a sledge hammer. The flue brush was then used, and after steam was raised, it no longer required the forced-draft fan to hold the steam at the required pressure.

Upon investigation, the feed-water heater appeared as though it had never been blown or opened up for cleaning since it was erected. The amount of scale taken from the heater filled more than three ash cans. During the cleaning of the heater the fire linings of the furnaces

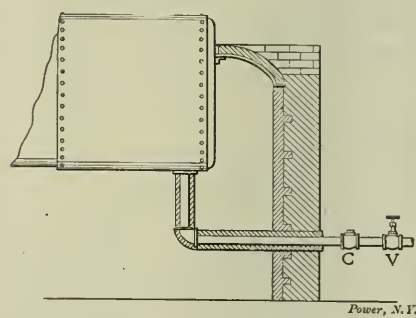


FIG. 2. INSTALLING BLOWOFF VALVE

were put in good shape, and next day when the plant was running the fireman was jubilant, and naturally so, as his work had been greatly reduced.

Next in order to receive attention was the blowoff valve. The asbestos-packed cock at *C*, Fig. 2, received a new lining, and an auxiliary blowoff valve was connected in the line at *V*, the improvement being that valve *V* could always be repaired without shutting down or interfering with the regular operation of the plant.

The engineer noticed that the fireman had to run the boiler-feed pump very fast in order to keep the water at the proper level. The pump was opened for inspection and found to need some packing around the water plungers and a few discharge valves. The packing and valves were promptly inserted, and when the pump was started, it was found that about one-quarter of the original speed was sufficient. All leaking flanges received new gaskets, and the pipe covering was either repaired or renewed wherever it was found necessary.

The next thing to receive attention was the engine. It being found that steam blew past the packing rings rather freely, it was decided to expand them and insure a steam-tight piston. When the rings were adjusted with the piston at the end of the cylinder, great difficulty was experienced in trying to get the piston to pass the center of the cylinder. Hence, the engineer lessened the labor by expanding the packing rings to fit the smallest part of the cylinder. After the rings were adjusted and the piston tested for tightness, the cylinder was closed and the engine started doing its regular work. The application of the indicator showed the valves needed adjustment, which was promptly made.

An account was kept of the amount of coal burned after these repairs were made, and when compared with the amount of coal burned previous to the repairs and the horsepower developed in both cases, the amount of coal saved was nearly 30 per cent.

WILLIAM KAVANAGH.

New York City.

Interesting Indicator Diagrams

The two sets of diagrams herewith were taken from the same engine under the same conditions of working, but with different valve setting. The engine was

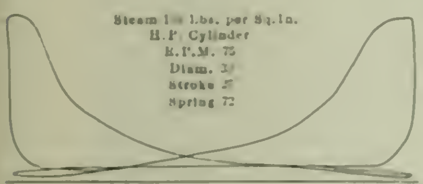


FIG. 1

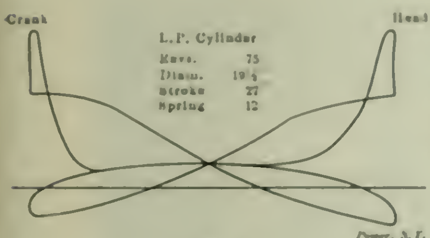


FIG. 2

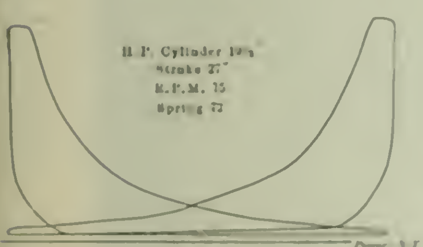


FIG. 3

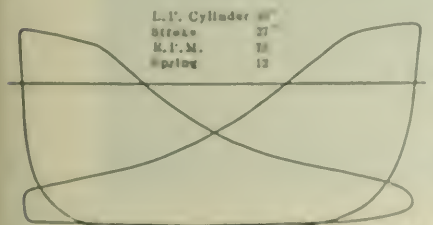


FIG. 4

a 250-horsepower, and was supposed to run condensing.

The first set was taken from the engine as it had been running for two years. The setting had been done by one of the graduates of a continental polytechnic, and represented three weeks work for a man who had done well in his term. On taking over the works the writer was convinced that the engine was not running evenly, and considerable heat was being developed and running on the oil hill.

After indicating, the trouble was shown by diagrams Nos. 1 and 2. There were several men interested in the running of the engine, and in spite of the diagrams they were as convinced as ever that the result was all that could be desired. The condenser was not in use, and the weight of opinion was that it was not worth while, although there was a lake of some miles in area at the engine-room door. It was thought that the pumping of the water would more than balance the gain, so the engine ran noncondensing on a condensing valve setting.

The condenser was dug out and in three weeks was ready for a trial run, and the result of this is shown in Figs. 3 and 4. The pressure at the boiler house was 140 pounds steam superheated to 250 degrees Fahrenheit.

F. L. BRAY.

Sheffield, England.

Wants Hydraulic Information

We have a stream of water delivering 360 inches under a 12-inch pressure. By going 500 feet from the estimated location of the plant a fall of 1.40 feet can be obtained. What size and grade of pipe, and what class and size of wheel would be most applicable, and how many 16-candlepower lamps can be carried?

WILLIAM F. P[illegible]

Stine, Nev.

Foot Valves and Suction Pipe Repairs

My first experience was with pumping out ditches for laying sewer pipe. The ditches were narrow and the strainers gave considerable trouble, as splinters, etc., would close up the holes and stop the flow of water. To remedy this, I made a drum of 3/16-inch iron, about 13 inches in diameter by 10 inches long, and drilled the circumference full of ½-inch holes. The bottom, however, was not drilled. This was attached to the top of the old foot valve, as shown in Fig. 1, and was a success as a strainer, as it would rest on the bottom of the ditch and sink no deeper, and the sand could not get through the bottom.

Another experience was with a salt-water pump used to fill a tank for flushing purposes. A cast-iron strainer on a 3-inch suction pipe was originally used but, due to corrosion, barnacles, [illegible] and seaweed, it was soon "down and out." As the lift was not very great, the foot valve was discarded and a large strainer made from a piece of [illegible] sheet brass, bent to form a cylinder [illegible] inches in diameter and drilled with [illegible]-inch holes, as shown in Fig. 2.

The suction pipe of 3 pump began to leak at an underground joint which [illegible] pulled apart and was repaired as shown in Fig. 3. Two half rings were cut out of 1-inch boards, about 10 inches outside diameter, the inside hole being cut to fit the pipe. Over these rings tin was nailed, making a half cylinder about 18 inches long. Then an open box without a bottom or top was made to fit on top of the cylinder. A piece of thin tin was wrapped around the pipe and wired in place. The half cylinder was worked under the pipe and all the sand cleaned out. The box was put on top and the whole filled with portland-cement mortar. This stopped

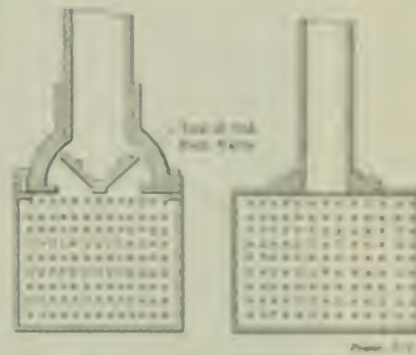


FIG. 1 FIG. 2

the sand from getting in and as there is no pressure on the pipe it gives satisfactory results. I think, however, it would have been better to have wrapped the pipe with cloth first, instead of tin.

The discharge pipe on our salt-water system began to leak. To cut out the piece, cut threads with a ratchet stock and put in a new piece would have been the proper way to do, but the pipe was badly corroded and too thin to cut threads. We

FIG. 3

FIG. 4

therefore adopted the following plan: We [illegible] the pipe each with a pipe [illegible]. Then a piece of [illegible]-inch pipe, about [illegible] inches long, was [illegible]. Cement was then [illegible] as shown in Fig. 4.

[illegible]

[illegible]

Vandergrift Low-Pressure Turbine Plant

A Rateau Regenerator, and a Rateau-Smoot 600-Kilowatt Direct-current 250-Volt Turbo-generator Set Said to be the First of Its Type Here

The Ball & Wood Company, of Elizabethport, N. J., recently built a low-pressure turbo-generator outfit which is in successful operation at the Vandergrift plant of the American Sheet and Tin Plate Company, Vandergrift, Penn. The outfit consists of a Rateau steam regenerator, a Rateau-Smoot low-pressure turbine and a Smoot generator. It utilizes the exhaust steam from reversible blooming-mill engines, which work intermittently and at widely varying loads, thus having a supply constantly differing in volume. In order to overcome this variation and to supply the turbine with a steady flow of steam the regenerator was installed. The Rateau Steam Regenerator Company, of New York City, received the contract for this plant, and the turbine was built in the Ball & Wood Company's shops.

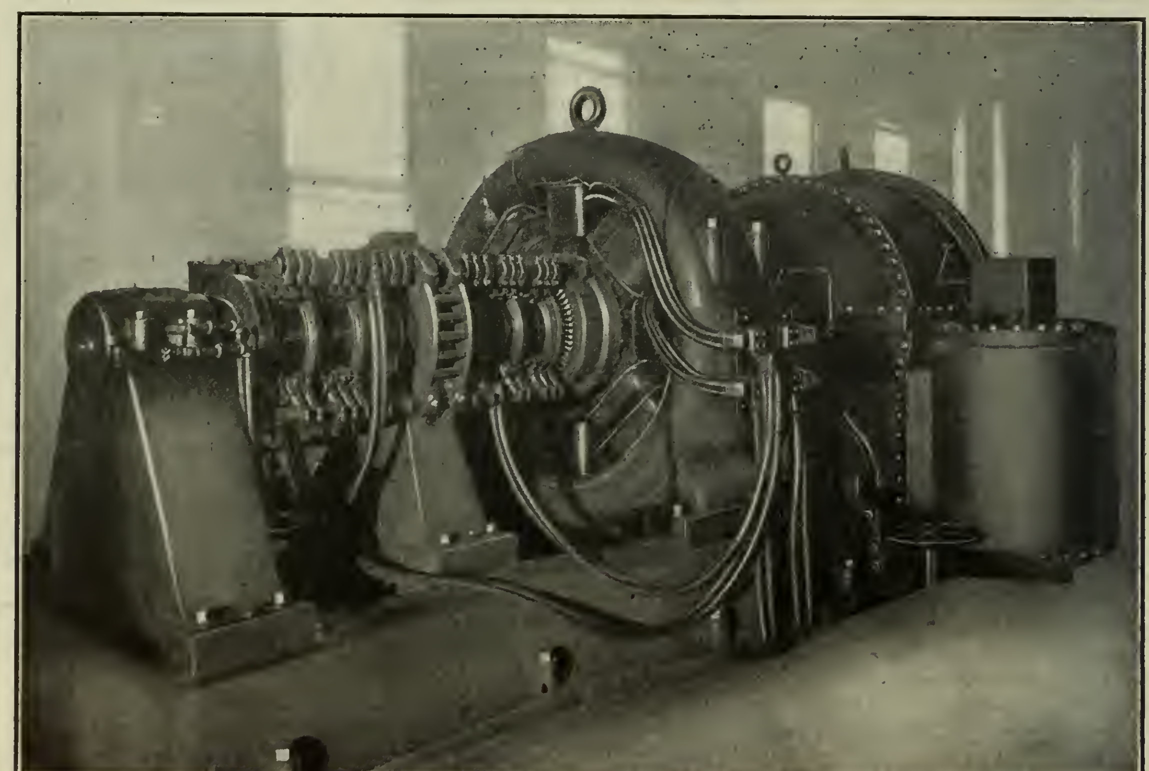


FIG. 1. SIDE VIEW OF LOW-PRESSURE TURBO-GENERATOR INSTALLATION AT VANDERGRIFT, PENN.

The Regenerator

The regenerator in this instance is a cylinder 40 feet long by 8 feet in diameter and contains about 45 tons of water. This water is kept in constant circulation by the steam from the mill engine, which is passed through it in pipes arranged for the purpose. Two results are obtained from this circulation, a practically uniform temperature throughout the water and as thorough an exchange of heat as possible between the steam and the water. The temperature of the water is thus made to correspond to the pressure of the steam in the pipes, so that when the steam pressure falls, owing to the closing down of the engines, the water liberates part of its heat in the form of steam, and when there is an excess of steam the temperature of the water is raised accordingly.

The Vandergrift regenerator is of such size that the mill engines may be completely shut down for periods of two minutes and during this time the regenerator will supply steam to the turbine at the rate of 25,000 pounds per hour. A 24-inch relief valve is set for 3 pounds above atmospheric pressure, so that the pressure of the steam in the regenerator is constantly maintained between 14.7 pounds and 17.7 pounds, absolute, and the back pressure of the engine never exceeds 3 pounds.

If the mill engines are shut down for periods longer than two minutes, or if the exhaust steam is insufficient for the turbine, a connection between the regenerator and the boilers is automatically opened, admitting live steam for the continued operation of the turbine. The action of the live steam, which enters the regenerator through a pressure-controlled reducing valve, is exactly similar to that of the exhaust steam, an equilibrium between the pressure of the steam and the temperature of the water being maintained which gives a very exact control over the amount of steam admitted and absolutely prevents the steam escaping to the atmosphere.

It will be seen from the foregoing that just as the flywheel of an engine is for the storage of energy so the water in the regenerator may be termed a flywheel for the storage of heat, taking this heat from the steam when the latter is in excess, and giving it up when the steam supply diminishes or ceases.

The Low-pressure Turbine

The Vandergrift low-pressure turbine is of 600 kilowatts capacity, operating at

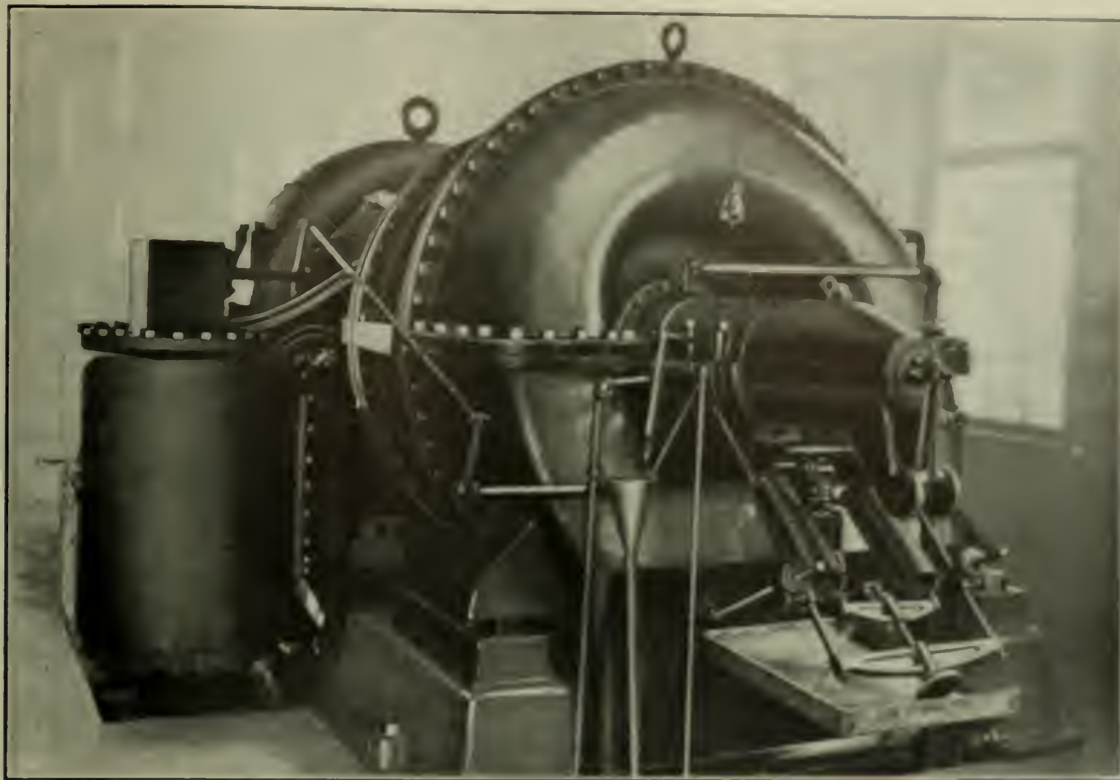


FIG. 2. END VIEW OF LOW-PRESSURE TURBO-GENERATOR INSTALLATION AT CAMBRIDGE

1500 revolutions per minute. It is of the impulse type originated by Professor Rateau, but the installation under discussion was redesigned by C. H. Smoot, of the Rateau Steam Regenerator Company, to meet the requirements of standard American shop practice. The turbine receives the steam from the regenerator and makes use of it between the limits of the pressure of the atmosphere and the vacuum obtained from a condenser, the entire expansion of the steam taking place in the fixed diaphragms.

Due to this fact that there is no expansion of the steam in the moving vanes of the turbine, there is no difference of pressure between the inlet and outlet sides of each rotor, and consequently there is no tendency for the steam to leak past the tips of the blades. On this account the clearances in this turbine are extremely large, running up to ten times the amount possible in a turbine of the type where the expansion takes place in the rotors, and giving absolute immunity from blade stripping.

The rotating element has an extremely high factor of safety, such in fact that the turbine can be operated at speeds greatly in excess of its rated speed without causing any strains in the different parts which will exceed the elastic limits of the materials used.

The Hyllien governor controls the steam admission directly through a positive connection between the flyballs and the steam valve. It is located on an extension of the main shaft with its thrust opposed to the steam thrust and always twice as great. As will be seen from Fig. 3, the flyballs work on knife edges against a spring and are positively connected to the throttle valve. The regulation is controlled from the outside by means of springs mounted on a frame and connected to the governor links. These springs are so arranged that they can be adjusted while the turbine is running, which also enables the engineer to alter the speed of the unit without interfering with its continuous operation. The speed variation is less than 2 per cent. between no load and full load.

The turbine has six rotors, each a [illegible] of [illegible] and [illegible] provided by a [illegible] diaphragm. Nozzles are [illegible] in the [illegible] and [illegible] [illegible] which [illegible] [illegible] the [illegible], are mounted on the diaphragms. Fig. 3 is a vertical section through the turbine and

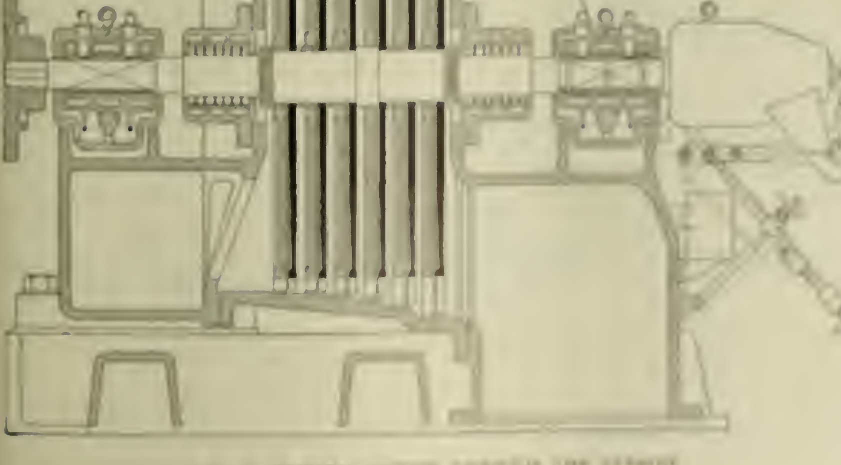


FIG. 3. VERTICAL SECTION THROUGH THE TURBINE

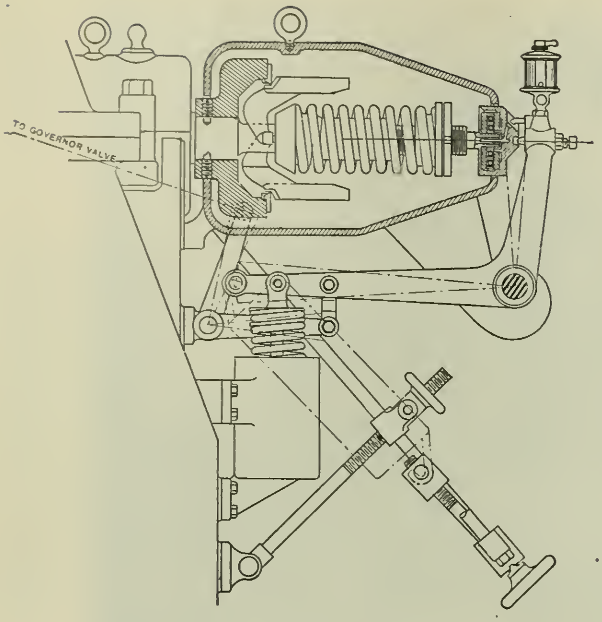


FIG. 4. SECTION THROUGH THE GOVERNOR

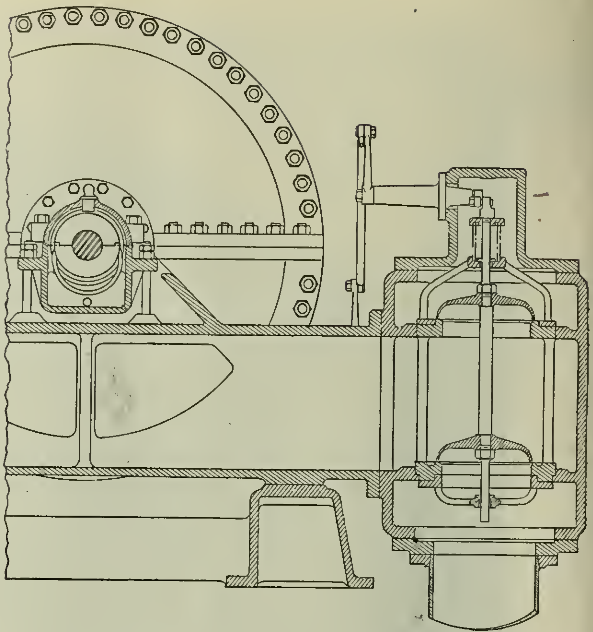


FIG. 5. SECTION THROUGH THE THROTTLE VALVE

shows the general construction, while Fig. 5 shows a section through the throttle valve.

The turbine is connected to the generator by a coupling which consists of two hubs mounted one on each shaft. The torsional movement is transmitted by means of pins so used as to permit smooth operation even though the shafts should become materially out of line.

The Generator

The generator is a 600-kilowatt machine running at 1500 revolutions per minute, and delivers continuous current at 250 volts. It is of the open-frame type with no forced-air circulation, but the design is such that the temperature rise above the surrounding atmosphere is extremely low. The machine has four poles and four intermediary poles. The commutator is in two sections, held together against centrifugal force by nickel-steel retaining rings shrunk in place. No sparking whatever occurs at the brushes, and these do not have to be shifted for any load up to full load. The commutation is first class and the fact that the commutator does not have to be lubricated removes a serious objection to the use of direct-current dynamos in plants such as at Vandergrift, where the metallic dust in the air might settle on the oily surface and cause short-circuits which would seriously injure the machine.

This generator is believed to be the first of its size that runs at that speed to be built in this country, and great credit is due to Mr. Smoot for the successful design. In 1906 two 250-kilowatt 250-volt direct-current generators were installed in the plant of the International Harvester Company, at South Chicago,* both direct-

*See Power for June, 1907.

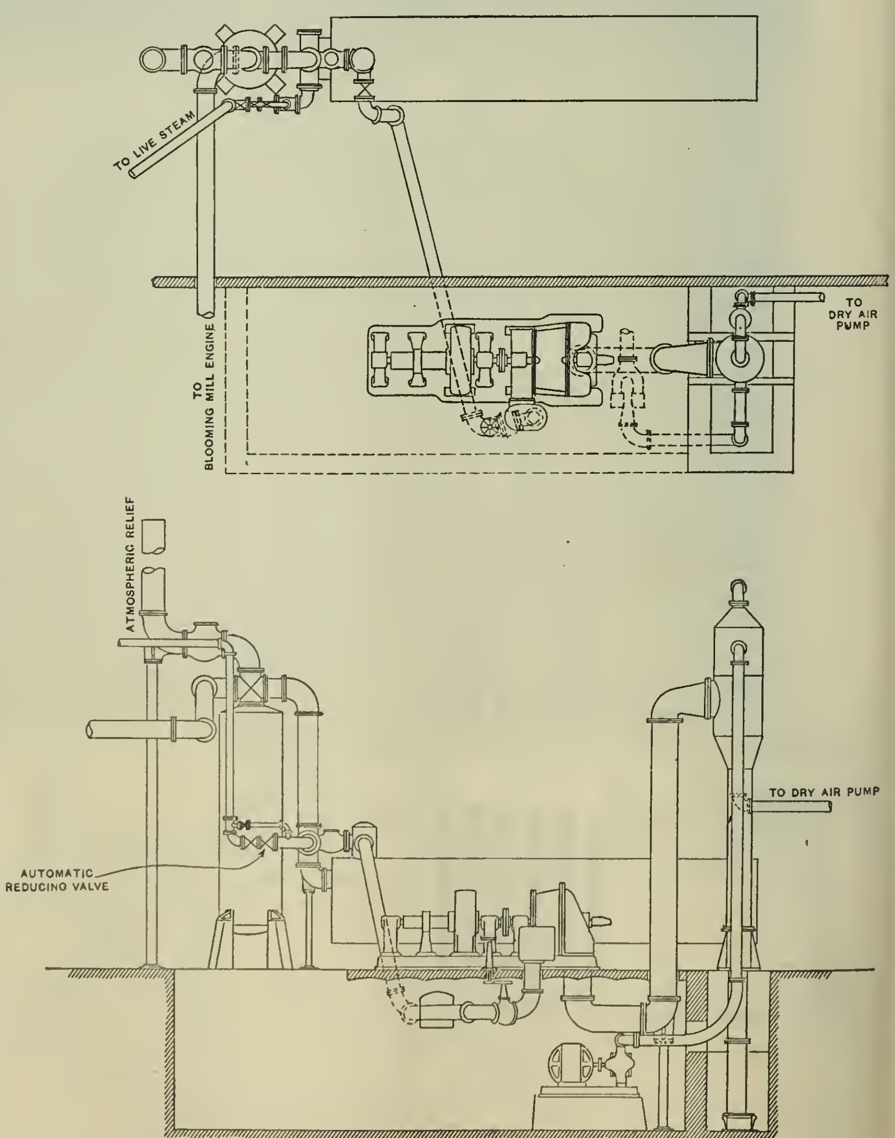


FIG. 6. PLAN AND ELEVATION OF LOW-PRESSURE TURBINE INSTALLATION

connected to a 500-kilowatt low-pressure turbine operating at 1500 revolutions per minute. This was the first low-pressure turbine plant of the Rateau type installed in the United States and it has been in successful operation ever since. All three of these generators are from Mr Smoot's design.

Operating Conditions

The mill engine at Vandergrift, when working under normal conditions, uses about 70,000 pounds of steam per hour, and the turbine when operating at 500 kilowatts uses less than 40 pounds of steam per kilowatt-hour, or less than 20,000 pounds of steam per hour. There is thus some 50,000 pounds of steam per hour still available for future low-pressure turbine installations, and this with practically no increase of operating expenses.

The Rateau-Smoot turbo-generator unit is an extremely simple one to operate, and ordinarily the regular engine-room force required to run the reciprocating engines is fully able to take care of the turbine. When it is desired to place the unit in service, it is merely necessary for the engineer to start up the condensing apparatus, then open the throttle valve gradually, bringing the turbine slowly up to speed. He should, of course, first make sure that there is plenty of oil for the different wearing surfaces.

Power Station Economies at Baltimore

At the Franklin Institute, in Philadelphia, Thursday evening, March 25, Horatio A. Foster, well known to the public as the author of Foster's "Electrical Engineers' Pocketbook," delivered a lecture, illustrated with lantern slides, on the subject of "Power Station Economies at Baltimore." Mr Foster sketched rapidly the situation of the United Railways Company, of Baltimore, at the time of the fire in 1905, which nearly destroyed its main generating station at Pratt street. This station contained about half of the generating capacity of the system, the other half being scattered about the city in eight smaller plants which were mainly noncondensing. He told of the studies which led to the dismantling of all but three of these smaller plants, now held in reserve, the building of the three modern substations, the reinforced-concrete steam station built near the amusement park not far from the bay shore, 11 miles from the city, and the rehabilitation of the partially burned Pratt street station. At present the Pratt street station contains three 1800-kilowatt units, five 2000-kilowatt units and two 5000-kilowatt units, all driven by McIntosh & Seymour engines, and one 5000-kilowatt Curtis turbine, a total of 30,400 kilowatts of rated capacity.

In 1905 the Pratt street station carried 50 per cent. of the load, in 1908 it carried 95 per cent. In the meantime the yearly output had grown from 60,000,000 kilowatt-hours to more than 100,000,000 kilowatt-hours, and the coal consumption per kilowatt-hour had dropped from 4.25 pounds in 1905 to 3.23 pounds in 1908.

The lantern slides showed in a very marked way the difficulties to be surmounted in the reconstruction of even such a modern power house as this, and included the work on the foundations to prevent vibration, which was rather severe in the old engine room, the cable ducts, manholes and switchboard, and numerous changes in location of the smaller engines. The new construction of dock wall was described but not shown. The reinforced-concrete work of the Bay Shore power plant was shown in detail.

The entire work was done, for the United Railways Company, under the direction of Stillwell & Van Vleck, consulting engineers, with the author, Mr Foster, in charge of the work at Baltimore.

To Honor Charles T. Porter

There will be a special meeting of the four national engineering societies, at the Engineering Societies building, 29 West Thirty-ninth street, New York, at 8:30 p.m., Tuesday, April 13, for the purpose of awarding the John Fritz medal for 1909 to Charles T. Porter, for his work in advancing the knowledge of steam engineering and in improvements in engine construction.

The presence is requested of members of all branches of the profession, and particularly of those represented in the four national organizations of engineers participating in the creation of the medal fund. Besides the simple ritual of the presentation of the medal, in the presence of invited guests and distinguished representatives of engineering, there will be addresses by representatives of the four groups of the profession most concerned as follows:

"The Debt of Modern Industrial Civilization to the Steam Engine as a Source of Power," Dean W. F. M. Goss, of the University of Illinois.

"The Debt of the Modern Steam Engine to Mr Charles T. Porter," Prof. F. R. Hutton, of Columbia University.

"The Debt of the Era of Steel to the High-Speed Steam Engine," Robert W. Hunt, of Chicago.

"The Debt of the Era of Electricity to the High-Speed Steam Engine," Frank J. Sprague, of New York.

The board of award will be gratified by a large and representative gathering to do honor to the donor, to the recipient and to the great achievement which the John Fritz medal is intended to commemorate. While evening dress is not imperative, its use is encouraged and requested. Ladies are invited and check rooms will be provided for their use.

Birmingham Won First Test

At Newport, R. I., March 26, the scout cruiser "Birmingham" won first place in the 100-mile endurance and coal-consumption test at 10 knots speed over her sister ships, the "Chester" and the "Salem."

The "Birmingham" is fitted with reciprocating engines, and according to official data the coal consumption for each hour was only 30 tons.

The "Chester," fitted with Parsons turbines, took second place, the consumption being 40 tons, while the "Salem," with Curtis turbines, used [illegible] tons.

No. 27's Housewarming

John Ericsson Association No. 27, N. A. S. E., of Brooklyn, held a smoker and "housewarming" Friday evening, March 26, to celebrate its removal to more spacious quarters in the Masonic Temple on Manhattan avenue. A large majority of the members and many friends attended. President W. T. [illegible] and John M. Lockwood, chairman of the arrangement committee, made the addresses of welcome. A pleasing entertainment was given by Frank Corbett, William Murray, Henry Elder, John Richards and John Armour. Frank Martin officiated as master of ceremonies. There were refreshments of all kinds. The committee is to be congratulated.

Progressive Council, U. C., Reception

Progressive Council No. 12, Universal Craftsmen, Council of Engineers, of Newark, N. J., held its annual reception and ladies' night Friday evening, March 19. There was an enjoyable entertainment and an address by Brother Whitehead. A number of distinguished guests were present. Walter Pratt was presented a [illegible] and Mrs. Pratt a handsome bouquet of flowers. Refreshments were served. J. Gallow was the chairman of the committee.

On Tuesday evening, March 23, H. J. [illegible] spoke before the Modern Science Club of Brooklyn, on the subject of "Steam Engine Governors." The speaker spent some time in the beginning in definitions of terms to be used in the discussion. He then went into the mathematics of the [illegible] governor, both of the Watt and the weighted types. The subject was exhaustively treated and was followed by an interesting discussion by members of the club.

POWER AND THE ENGINEER

DEVOTED TO THE GENERATION AND TRANSMISSION OF POWER

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April 6................ 42,000

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Contents

The Manufacturer's Responsibility

When a man buys an automobile the selling agent turns it over to him and is through. If the purchaser wants to get his money's worth out of it in transportation and pleasure he must learn to run it or hire a man who knows how; and if he punctures tires, strips transmission gears, cracks his water jacket, etc., he expects to pay for replacements and repairs. Only when obvious imperfections in workmanship or material are responsible for the trouble can he expect the builder to see him out of his difficulty. But when a man buys an engine or a boiler, or a stoker, or a condenser, or a water-heating or purifying outfit, or even a little appliance like an injector or an indicator, he often appears to think that he has paid for all the benefits and advantages which it promised when he settles the bill, and that all he has to do is to turn on the steam and gather in the profits. One cannot become a mechanical engineer simply by buying an indicator. He must have the intelligence and the patience, and the skill to apply it so as to get correct and intelligible diagrams, and he must have the ingenuity and intelligence and knowledge of the subject necessary to interpret his diagrams after he has taken them.

A man buys an engine and puts it so far away from the boiler that the steam is full of water and has lost twenty-five per cent. of its pressure; he exhausts it through a back-pressure valve and because it does not come up to his requirements, because the water washes the lubricant off and lets the cylinder cut, because a slug of water makes a wreck of it, he writes indignant letters and condemns the engine and its builder. A man buys a condenser and connects it up with a job of cheap pipe fitting, or runs a lot of leaky engines and pumps into it, and telegraphs the maker to "send man at once," because he gets twenty inches of vacuum instead of twenty-six or twenty-eight. A man buys a grease-extracting and water-softening system, and because he fails to take away the grease after it has been extracted, or because he uses too much or too little lime or soda, and gets priming or scale, he either condemns the system out of hand or expects the manufacturer to keep an expensive man on the job for several weeks to demonstrate that the plant will do its work.

There is a growing tendency on the part of manufacturers of steam machinery and apparatus to resent these impositions; to take the ground that they will furnish apparatus adapted to the conditions as they are represented and guarantee that apparatus to be free from defects of material and workmanship; that they will set it up and operate it for a time if desired, the price to include the expense thereof; that they will bring to bear upon the execution of the order the results of their experience and special knowledge of the subject; but when they have provided the means the purchaser must work out his own salvation, and pay for the benefits which he receives in ordinary vigilance and intelligent use, as well as by his signature on a check.

Look for the Cause

Oil salesmen are generally supposed to be slick artists in every sense of the word, and they usually live up to their reputation. Rare instances crop out here and there, however, to indicate that, after all, they are human and not infallible in escaping every trap that may be set for them. The following is a true instance of how one was snared, and the pleasing feature was that it left no bad feeling on the part of engineer or salesman:

The salesman in question was endeavoring to make a sale in a plant which was purchasing its lubricant from a rival. He was a good salesman and thoroughly understood the art of how to present the merits of his own goods without denouncing those of his competitor, and for this reason his frequent visits were tolerated with good grace. Finally he suggested, as a clincher to his statements regarding the merits of his goods, that if there were a bearing around the plant that ran warm or hot, he would furnish a five-gallon sample, so the quality of his oil could be put to practical test. The engineer thought awhile, and then said that he had an excellent place for such a test, and took the salesman to the engine room, where he was requested to feel the bearing on a belt-driven dynamo. This bearing was always so warm that it could barely be touched. The engineer stated that this was a chronic case and he would certainly welcome any relief.

The salesman extracted a thermometer from his grip and proceeded to take the temperature of the oil in the bearing, at the open end next to the commutator, and made a note of it in his little red book, for comparison with the temperature-to-be of a real lubricant. The next day, while the dynamo was idle, he came with his sample of oil, and to gain the respect of the engineer he insisted that he should prepare the bearing for his sample. He thoroughly cleaned out the old oil and went about the job as if he had obtained his diploma from "Professor Time" in the "School of Experience." After finishing the job, he inquired the starting time and said he would return about two hours later, so as to give the bearing time to warm up. When he returned at the appointed time, the temperature of the bearing was found not to vary more than a degree from the previous reading he had obtained with the old lubricant. The salesman was somewhat crestfallen, but game, and requested that he be allowed to test another sample. The engineer told him to go as far as he liked, so the performance was repeated the following day, with the same result.

Now, this oil man was no "quitter;" he felt he was duty-bound to cool that bearing if it became necessary to try every grade of lubricant his company made, so he brought a fresh sample every day, first using the best grades and finally, in desperation, trying the cheaper ones, but with practically unvarying results. When sample cans began to get so thick in the engine room that walking was difficult, the engineer had a fatherly talk with the oil man. He said:

"Young man, you evidently have great faith in your goods, and I am beginning to have faith in them on that account, but this trial has been going on long enough. I don't want you to waste any more time or oil on that bearing. You could put different oils in that bearing from now until doomsday and never lower the temperature but very slightly. The lubrication of the bearing with the oil you first found in it had practically nothing to do with its temperature. The heat in this bearing is transmitted to it from the armature through the shaft, and the only thing that produces a perceptible change in it is a variation in the load."

The salesman looked at the situation like a man, and insisted that all of the samples be accepted gratis, as "the experience was worth the money."

What Is Trouble?

Different persons have different ideas as to what constitutes trouble. To some it means an aggregation of petty annoyances; to others, it means the difficulties encountered when apparatus fails to operate, or when an accident occurs; while to still others, whose characteristic is to take everything as it comes and make the best of it, there is no such thing as trouble.

What is trouble to one is merely an incident to another. For instance, an engineer, after putting in a somewhat lengthy suction pipe, had considerable trouble with air getting into the pump, which would eventually cause it to lose its water. This caused trouble galore—for him—but when another engineer assumed charge of the plant, he had a steam siphon, fitted with a check valve, tapped to the top side of the suction pipe, which allowed the air accumulation to be drawn out of the suction pipe before entering the pump, and obviated all semblance of trouble for that engineer. This would seem to show that what is frequently termed trouble is the result of ignorance as to what should be done to relieve or counteract certain conditions.

It often happens that conditions are such that the regular work of the plant cannot be carried on without unnecessary manipulation of various devices, which work could be greatly simplified if the devices were in proper condition. This extra work, necessary to obtain a given result, is sometimes taken as a matter of course and not looked upon as trouble. To illustrate: A certain engineer, when asked if he had any trouble with superheated steam with reference to valves, gaskets, etc., replied that he had not, although at the same time his men, in order to do some work on a leaky flange on the turbine steam line, after closing all the valves they could, found it necessary to run the turbine on a vacuum in order to clear the pipe of steam which leaked past the valves. The leakage past the valves was due to distortion of the seats by superheated steam, but the engineer did not think such a little thing as that of moment, or that work necessary to clear the pipe so the men could work was a matter of trouble.

What is trouble, anyway?

Robbing Peter

"Robbing Peter to pay Paul" is an expression that admirably fits a great many conditions that arise when so-called improvements are made in a power plant on the word of the zealous salesman, who is chiefly concerned in having you register on the last page of a formidable contract.

This does not mean that the salesman is not thoroughly honest, for reputable firms cannot afford to have any but reliable representatives. Salesmen are not always posted on the change in effect that may result in the performance of their apparatus from the varying conditions met in each installation, which, although entirely external to the added equipment, may be vitally necessary to its satisfactory operation. If the salesman is thoroughly experienced he should not be expected to serve you gratis as a consulting engineer and, after spending his time investigating the conditions of your plant, tell you that if you wish to gain the maximum return for the limited amount of money you intend investing his apparatus should be omitted from the scheme. This, however, is frequently done.

In this connection there comes to mind a place where the limit to steaming capacity was finally felt. The proprietors began to discuss how the shortage was to be met, but it never occurred to them to call in a reliable engineer to advise them how they could best spend the amount of money available to accomplish the desired increase in the capacity of their boiler plant. While the owners were in this very receptive mood for the advent of the [illegible] salesman, one came along who represented a [illegible] firm [illegible] economizers. The salesman drew a [illegible] coal economizers working up over what the apparatus could do for an overburdened steam plant, took them over the Marathon route of high economies and financial effort to carry over the peak of the load. Now, this salesman was perfectly honest, and every claim he made was justly his, with the apparatus installed under proper conditions, and his argument was so convincing that an order was given at once, and the economizer installed. After installation, which was accomplished in a light-load season, everything ran smoothly and there was an apparent economy in the coal consumed, and if there had not been the engineer would have been satisfied after consulting the stack and feed-water temperatures. When the normal load was restored to the plant, strange to say the total output was apparently less than before the change in the equipment, but this was accounted for by the supposed increase in load due to some new machinery, for the low stack temperatures [illegible] convinced the owners that they had trapped every B.t.u. that could be coaxed from coal to water.

At this stage an experienced engineer, who was familiar with the equipment of the plant before the economizer was installed, was called in to give information as to what was required to meet the demands made upon the steam-generating apparatus. After casually looking over the improvements he went back to the office and, getting comfortably well established on the right end of the proffered cigar, said:

"I understand that your wish to increase the capacity of your plant was the reason for the changes you have made; if so, why did you cut the capacity down about twenty per cent. by installing an economizer?"

The senior member of the firm gripped the arms of his office chair, to make certain that everything was real, and mentally running back through the flywheel effects and low stack temperatures, finally managed to say:

"What do you mean?"

"Exactly what I have said. Your plant has always lacked draft capacity, and what you have been needed to increase its steaming capacity was ability to burn coal; and instead of your first installing a stack of reasonable size, you have diminished the capacity of your already overburdened one with the result of reducing the capacity of your plant as I have stated. Your only salvation is ample stack capacity to care for your economizer and boilers, and then you will begin to realize on your [illegible] investment."

The owners were so astonished at the engineer's statements that they proceeded to test the plant with and without the economizer in service, and found the figures the engineer had given them were not far from the truth.

Some Useful Lessons of Limewater

An Excursion into the Realm of Hydrogen, Made Exceptionally Interesting and Instructive by Means of Several Simple Experiments

BY CHARLES S. PALMER

In the last two parts we studied the making of oxygen, because oxygen is the active part of the air insofar as burning is concerned. But, more than that, oxygen is one of the great "oxidizers," and as such it is contrasted with the opposite sort of chemical agents called "reducers." The relation between the oxidizers and the reducers is a very broad and fundamental matter in chemical study. The oxidizers include not only oxygen and a great many of its compounds which give off oxygen under certain conditions, but also such things as chlorine, bromine and iodine. Later we will give a list of some of the more important oxidizers, and I will also show how there may be such a thing as "moist combustion;" that is, burning in solution without any flame, but with all the results of real burning or combustion.

The reducers include such things as hydrogen, and many other compounds which act like hydrogen, in being opposed to oxygen and the oxidizers in their action and results. That is why it is necessary about this time to study hydrogen, although it is not found "free" in the air as oxygen is. You will want to read these first paragraphs over several times to emphasize in your mind the fact of the natural distinction between the "oxidizers" as a class and the "reducers" as a class; for theoretically any of the oxidizers can play proxy for each other in their opposition to the reducers; and similarly any of the reducers can play proxy to each other in the similarity of their action and in their opposition to the oxidizers.

An illustration of all this might be found in business accounting; thus, one might have all sorts of debts or debit accounts which would resemble each other insofar as they represent a balance of loss; and, on the other hand, one might have all sorts of credit accounts, represented by coin, paper money, bank checks, credit on real or personal property, etc. Thus we might liken the oxidizers to the debit or debt account, all the debts of whatever character or amount being entered in the same column and being opposed to the credit items of whatever character or amount, represented by the reducers.

This metaphor (of likening the contrast between the oxidizers and the reducers, to the contrast between debit and credit) is no mere childish fancy, but refers to a very real condition in all chemical reactions; and Mother Nature never neglects to keep a perfect account of the exact balance between the oxidizers and the reducers. Indeed, this balancing of accounts in nature concerns not only the kind and weight of the material substances which act on each other, but it also concerns the balance account of the amounts of *energy*. This also you will want to read over several times; and you will want to impress on your attention the fact that when the various chemical reactions go on, nature is at the same time using these reactions with a severity and rigor, in accounting for every particle of matter and every unit of energy, and to a degree of perfection which are simply astonishing. All this means that we must lose no time in getting acquainted with a typical reducer, hydrogen.

Hydrogen

Hydrogen is a light gas, invisible, colorless, tasteless, odorless, but very inflammable. Hydrogen is a metallic gas; that is, in its *physical* properties it is like any common gas, such as nitrogen, oxygen, carbonic-acid gas or the like, but in its *chemical* properties hydrogen is just as metallic as iron, copper, lead, zinc, sodium, potassium, calcium or the like. By this we mean that chemically hydrogen plays proxy with the metals, and the metals with hydrogen, in that they are all reducers. Also, hydrogen and the metals can replace each other in hundreds and thousands of salts. And, further, as when the electric current acts on soluble salts all of the metals proper go with the positive current, from the anode to the cathode, hydrogen does the same thing. Thus hydrogen, in an electrolytic cell, appears at the same pole where copper comes down; and this is practically a perfect demonstration of the fact that hydrogen is a chemical metal; but we will take up that side of hydrogen later. Just now you want to make some hydrogen and study it, just as you made carbonic-acid gas and oxygen, because if you have made a thing and handled it you have something that books alone can never give you.

Making Hydrogen

The first thing to do is to make a simple apparatus like that shown in Fig. 1. This has the same wash-dish pneumatic trough, with the same fruit jar filled with water and inverted in the trough, as you used in preparing oxygen. You have the same glass delivery tube and the same glass leader or conducting tube connected with a perforated cork; only, instead of having a glass flask containing a dry mixture, you will have a small bottle like an ordinary horseradish bottle or small pickle jar, and in this jar you will have some metallic zinc covered with some dilute acid, like sulphuric or hydrochloric (muriatic) acid. Get a strip of sheet zinc (not galvanized iron) and, with ordinary metal-cutting shears, cut off a dozen strips or so, 4 to 8 inches long and ½ or ¾ inch wide. Roll each of these strips up as though it were a ribbon, making a circular roll like that shown in Fig. 2. Then drop a handful of these zinc rolls into the bottle.

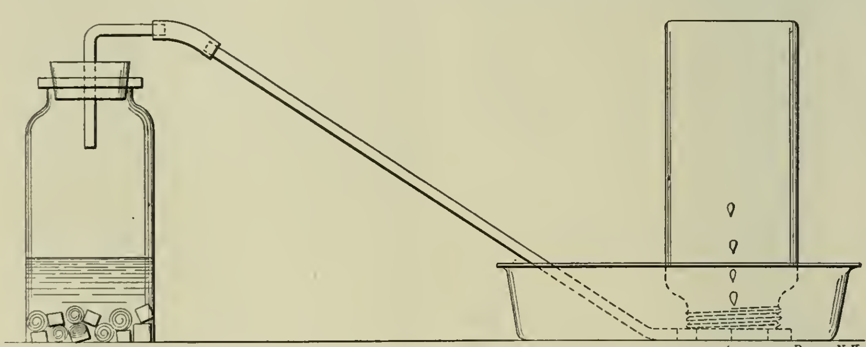


FIG. 1

You will see that the object is to get a supply of the metal in compact form, which will yet have a large amount of exposed surface. The inside and the outside surfaces of the various coils will amount to several square inches. You will see that the acid will have a chance to act on the zinc much better than as if you should cut it into flat strips and throw them into the bottle where they might lie so closely together that they would choke each other and hinder the action of the acid. The next thing is to cover the handful of rolls of zinc in the bottle with an inch or two of water, and then to pour in carefully two or three tablespoonfuls of sulphuric acid. If your sulphuric acid is already diluted, you will have to add more of it; if of the heavy concentrated "oil-of-vitriol" variety, of course you will add less of it; and in this case and always *when working with concentrated sulphuric acid remember to pour it carefully into the water*—never

FIG. 2

the water into the acid. The reason is that a great deal of heat is developed when sulphuric acid is mixed with water, and if you make one or two little breaks in mixing it with water never mind. But look out for any spattering, and look out for your eyes. In case you are using the strong sulphuric acid, as you pour it into the water and zinc, it being a heavy liquid—almost twice as heavy as water—the acid may settle to the bottom in a sluggish layer, but you can mix it with the water by shaking the bottle a little; pretty

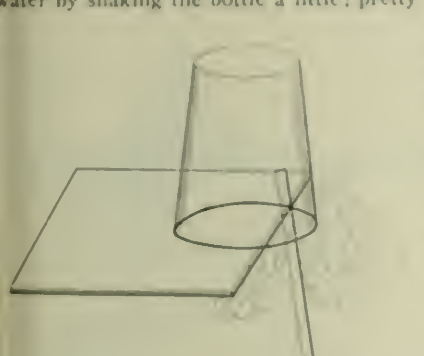


FIG. 3

soon the diluted acid ("diluted" means mixed with water) will begin to act on the zinc, and then the current of hydrogen bubbles will keep the liquids well mixed.

Look Out for Explosions

Now there is one thing that you should remember: Hydrogen makes an explosive mixture with the oxygen of the air. Therefore, do not bring a flame near the hydrogen apparatus for some minutes after the action of the acid and the metal has begun. You will see, as you stop to think of it, that the air in the pickle jar above the dilute acid and zinc is being mixed with the hydrogen, and it will take some few minutes for the current of hydrogen in the bottle to flush out the air from the bottle so that it will consist mainly of hydrogen. If you should neglect this caution, you will get a sharp, sharp explosion, the cork will be blown out of your bottle, and the bottle itself might be broken. Consequently, it is always safer to wrap an old towel loosely about the hydrogen-making jar, so that in case of an explosion there will be no flying glass.

The correct thing to do is to fill a tumbler with water, cover it with a cardboard, invert it in the trough and, after a few moments, collect a tumblerful of hydrogen. Then covering the mouth of the tumbler under water with a cardboard, remove the tumbler and cardboard together from the trough and set them on the table with the tumbler mouth downward, because the hydrogen is a light gas, much lighter than the air, and a jar full of hydrogen can be preserved in the air for some minutes if the mouth of the jar is kept downward. Now take a splinter of wood, light it and, holding the jar mouth downward, raise it from the cardboard cover and thrust the lighted splinter up into the jar. If the hydrogen burns quietly, it is a sign that you have driven off all the air from the space in the hydrogen apparatus above the liquid, and you can go on and collect it by filling the jar in the trough; but if there is a sharp explosion, indeed if there is any noticeable explosion, you must let the hydrogen apparatus run a few moments longer, when you will collect another tumbler of hydrogen, testing it in the same way until you get a sample that burns quietly.

When you have got to this stage, then you may get ready to go on and collect several jars of hydrogen. You will want at least four jars, perhaps five; one to test its burning, two or three to test its lightness and one to test what is called the "diffusion" of hydrogen, or what the old books used to call the "osmose" of hydrogen. We will now discuss, in anticipation, each of these tests so that you can be ready to make the experiments quickly, and so that you can understand well in advance something of what is going to happen. It may not be necessary for you to collect all of the jars of hydrogen at once, for you can easily have two or three jars, and you can use one jar while you are waiting for the next to fill, and so on.

Testing the Hydrogen

The first Jar. We will suppose that you have collected a jar of hydrogen from the pneumatic trough. You will remove this jar just as you did the first tumbler, from the water, holding the [illegible] downward, and when you are ready you will raise the jar with one hand, still holding it mouth downward, and thrust the long lighted splinter full way up into the jar. Now keep your eyes "peeled," and notice that the hydrogen is burning with a soft and almost colorless bluish or yellowish flame, but the end of the taper up in the jar is itself extinguished. That is, the hydrogen burns at the mouth of the jar with the oxygen of the air, but the hydrogen does not support the combustion of the splinter up in the inside of the jar; although that part of the splinter near the mouth of the jar will probably be re-ignited by the hot hydrogen flame.

The set of experiments concerning the lightness of the hydrogen, and the pouring it upward in the air from one jar to

FIG. 4

FIG. 5

another, we will leave until the next lesson.

The next experiment is something which will take a little more time in preparation, but it is well worth the trouble. You want to hunt around and find a small cup of unglazed earthenware, about [illegible] inches wide and 2 or 3 inches long. You can get such a cup [illegible] called a "porous cup" from the [illegible] in the February number; but perhaps you can use a [illegible] if you [illegible] one small enough, although the trouble with [illegible] is that they usually are too wide at the bottom. A [illegible] will do [illegible] as shown in Fig. 5. Fit a cork [illegible] the mouth [illegible] and [illegible] the cork make a hole [illegible] for a tightly fitting glass tube, several inches long.

If you use the tobacco pipe, cover the stem but not the bowl with glue to give it an air-tight layer. The mouth of the pipe bowl must also be closed with a tight, flat cork. The lower end of the glass tube leading up into the tiny jar, or the lower end of the stem of the tobacco pipe, should be connected with a bit of rubber tubing to a straight delivery tube of glass, 10 or 15 inches long. In the case of the tobacco pipe you can lengthen the stem by connecting it with bits of rubber tubing to several pieces of stem broken off from other clay pipes and varnished. The point is to have a closed porous jar, with a straight air-tight tube, 10 or 15 inches long, leading to its interior. If you use a baby flowerpot, you will have to be careful to plug up the small hole usually found in the bottom of such pots with a tight cork; and also be careful to get a wide, flat cork thick enough to close the mouth air-tight.

Another point: If you use a tobacco pipe in this "osmose" experiment your fruit jars will serve very well; but if you use a baby flowerpot, you will have to find a larger-mouthed jar, something like a wide-mouthed candy jar. The point is (as shown in Fig. 5 in triplicate to suit various conditions of our readers), you are going to place a jar of hydrogen, the mouth of which is open to the air, down over the pipe bowl, or the porous jar, or the tiny flowerpot, each of which is connected, by a well fitting cork and air-tight tube, with a tumbler of water some 10 or 15 inches below, as shown. If you are successful, you will see this simple but very remarkable result: some bubbles of air will be forced down through the long straight tube and will bubble up through the tumbler of water. This is all the more remarkable because the jar of hydrogen, which is open to the air, acts on the closed pipe bowl, or porous jar, or tiny flowerpot, as though it were blowing in gas through the unglazed and porous walls of the pipe bowl, or porous cup, or tiny flowerpot, down through the long tube into the water.

The "Kinetic Theory of Gases"

When you get this apparatus ready, you can test it in anticipation by lowering, mouth downward, a jar of common air over the pipe bowl, or porous cup, or tiny flowerpot; and with no bubbles, because air will not act on air, while a jar of hydrogen will act on air. I will not stop now to explain just what happens, but you will note that it is quite remarkable to have an open jar of hydrogen act on the air within the pipe bowl, or porous cup, or tiny flowerpot, as though the hydrogen could blow through into it and down the air-tight tube with considerable pressure. It will be worth your while to try to get this experiment and to make it work, because it will prove to you something which the books call the "kinetic theory of gases."

The explanation of this experiment, which is one of the most remarkable in all chemical physics, is that the nitrogen, oxygen and hydrogen of the air are made up of little parts called "molecules." Now these molecules are jostling each other about in a very rapid and rude way, and the walls of the porous jar mark the "rush line" in this hand-to-hand battle of the molecules. But the hydrogen fellows, although much lighter, are much more active, and they easily get away with the heavier and more sluggish molecules of the nitrogen and oxygen of common air in the fine passageways of the walls of the porous jar. Therefore, the hydrogen fellows force back the nitrogen-and-oxygen team, "rush" them down the long tube, and force them out bodily as bubbles through the water in the tumbler, as shown in Fig. 5.

Scientists have figured that the molecules of the nitrogen and oxygen of the air are moving around, swinging and bombarding each other, at a rate of some 2000 or 3000 feet a second, and the hydrogen molecules are swinging about at a rate of about 8000 feet a second at ordinary temperatures. This does not mean that either is moving at this rate *as a mass*, but that the small physical units or parts of the gases are moving at this rate. It is almost inconceivable, almost incredible, that such should be the case; but after you have performed the experiment, and especially after you have studied carefully the conditions of the experiment, you will see that you have got something so remarkable in fact that the explanation is not incredible but is in keeping with the fact.

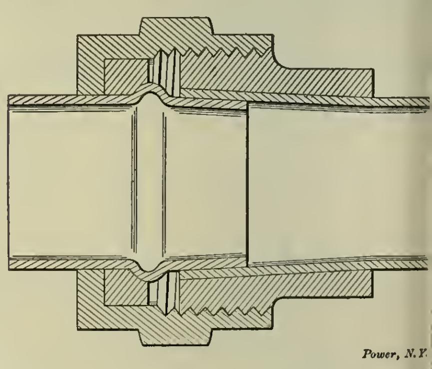
Acids Are Salts of Hydrogen

There is one other point which I want you to notice, and that is that it is not alone the acid that attacks the zinc, but the zinc attacks the acid, forming sulphate of zinc, or "white vitriol," in driving off the hydrogen. You will note that if the zinc can drive off hydrogen from dilute sulphuric acid, then the zinc has taken the place of the hydrogen; that is, the hydrogen is a metal. Further, if the zinc acting on the sulphuric acid makes zinc sulphate, then the acid itself is a sulphate of hydrogen, and this will introduce you to a new way of looking at acids; namely, that all acids are "salts of hydrogen."

Thus, sulphuric acid is hydrogen sulphate, nitric acid is hydrogen nitrate, hydrochloric or muriatic acid is hydrogen chloride, phosphoric acid is hydrogen phosphate, tartaric acid is hydrogen tartrate, acetic acid (acid of vinegar) is hydrogen acetate, citric acid (acid of lemons) is hydrogen citrate, and so on through the long list. From each of these acids, theoretically, any metal will drive off the hydrogen, but practically some metals act better than others and some acids act better than others. The metal commonly used is zinc, although you can use clean iron turnings or filings; the acid commonly used is sulphuric acid, although you can use hydrochloric acid; but you cannot use nitric acid if you want to collect the hydrogen, because nitric acid is itself an "oxidizer" and eats up the hydrogen as fast as it is formed.

New Joint for Copper Pipes

A simple and effective form of joint for copper and brass tubing is being introduced by J. M. Leigh & Son, 67 Deansgate, Manchester. It is illustrated in the accompanying engraving, is known as the "compression" joint, and is made between the ends of the two tubes themselves, one end being forced into the opposite expanded end of the other tube, the coupling being merely intended to keep the tubes together. Two small hand machines are



JOINT FOR COPPER PIPES

used in the making of these joints. The screwed portion of the joint or union is slipped on the end of the tube, which is then put on the expanding machine and the end of the tube expanded until it fits tightly into the union piece and forms a lining for it. The union nut and ring are next slipped on the other tube, which is then beaded as shown. The tubes are afterward placed together, the beaded end inside the large end, and the joint is tightened up with a spanner, no jointing material being required. It will be seen that the connection is complete with only one joint. The amount of force required on the union is small; in fact, a tight joint under pressure can almost be made without the use of a spanner. We are informed that a test of an arrangement of various sorts of fittings attached to a 1¼-inch diameter seamless-copper tube, 20 wire gage, proved perfectly tight at a pressure of 700 pounds per square inch, a tensile stress of 8½ tons being necessary to sever the joint.—*The Engineer.*

Helander Barometric Condenser

In Fig. 1 is shown the manner in which the Helander type A barometric condenser is installed. This type of condenser is used with either a basement or an overhead exhaust main, but is particularly

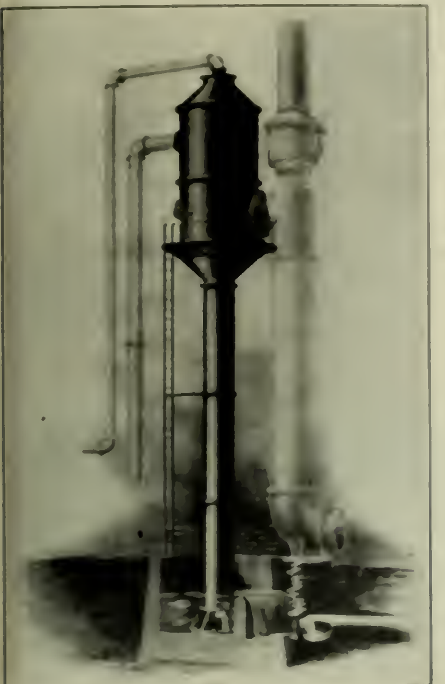


FIG. 1

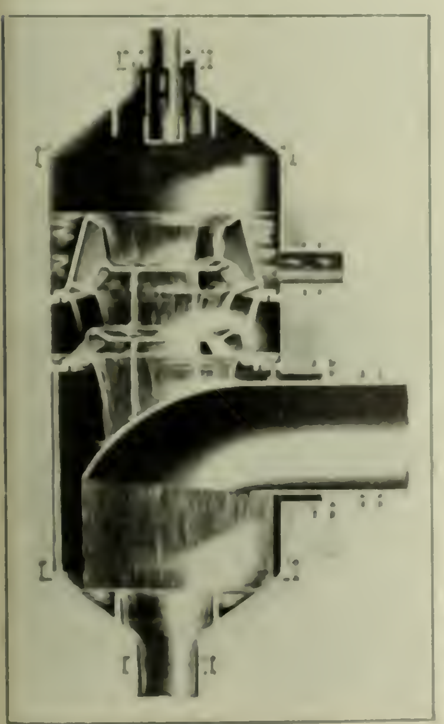


FIG. 2

adapted to the latter. Fig. 2 is an interior view, an examination of which will bring to notice the large number of water pools between the steam inlet and the top of the vessel, where the air is extracted, which keep down the temperature of the cooling water. It also shows that a large surface contact for water and steam is afforded by a series of waterfalls.

This condenser is fitted with a new type of release valve which does not in any way depend upon a mechanically tight joint to seal the vacuum when operating the condenser. This valve is placed at the foot of the barometric column and automatically comes into action whenever the vacuum is lost and the barometric column of water falls to the hotwell level. The steam then passes down the overflow pipes and out through this valve to any convenient point.

Some of the advantages claimed for this type of condenser is the simplicity of construction and erection, and as it is built entirely of cast iron it is said not to be injured by acid or silt water. It is also claimed that it has a large overload capacity without impairing its efficiency, and there are no movable parts and [illegible] adjustments to suit conditions of operation.

Due to the peculiar internal design and construction, the noncondensable gases are removed by the air pump when their temperature is approximately that of the cold injection water. At this point the density of the vapor is a maximum and the volume a minimum, thus permitting the use of a small air pump, which results in less first cost, maintenance and power required, it is said. This condenser is manufactured by the Mesta Machine Company, Pittsburg, Penn.

A Turbine Gasolene Engine

This engine is a gas or hydrocarbon type. As shown in Fig. 1 it has no balance flywheel, set between a pair of cylinders, acting on a turbine rotor. Its operation is as follows: When the first cylinder in a four-cylinder engine is firing, the third cylinder is compressing and, just at the point where the compression or resistance is at the highest, the exhaust [illegible] the [illegible] cylinder [illegible] and the exhaust gases strike the turbine [illegible] before the piston [illegible] the compression stroke. It is claimed that the turbine [illegible] [illegible] a period [illegible] the cylinder [illegible] [illegible] the engine and [illegible] it [illegible].

In Fig. 1 are shown exterior and sectional views of the arrangements of the cylinders and turbine. Fig. 2 shows end views of the engine and turbine. This construction is the invention of [illegible], Elmira, N. Y.

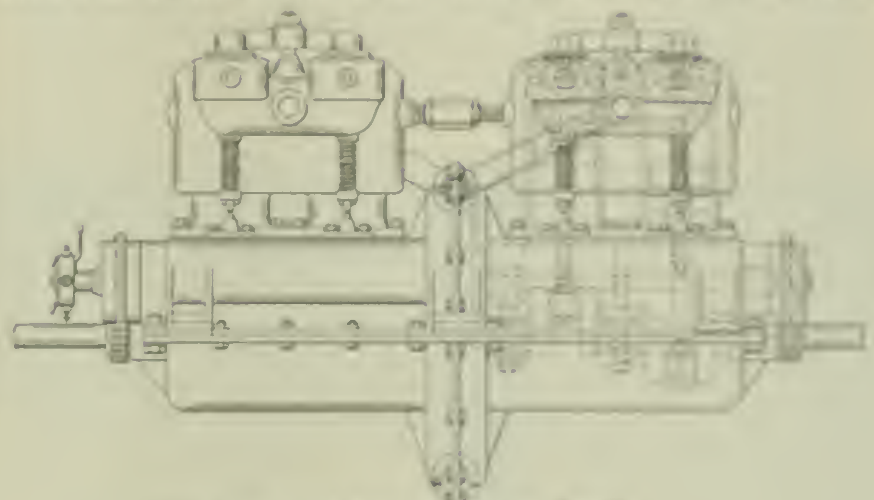


FIG. 1. [illegible] TURBINE GASOLENE ENGINE

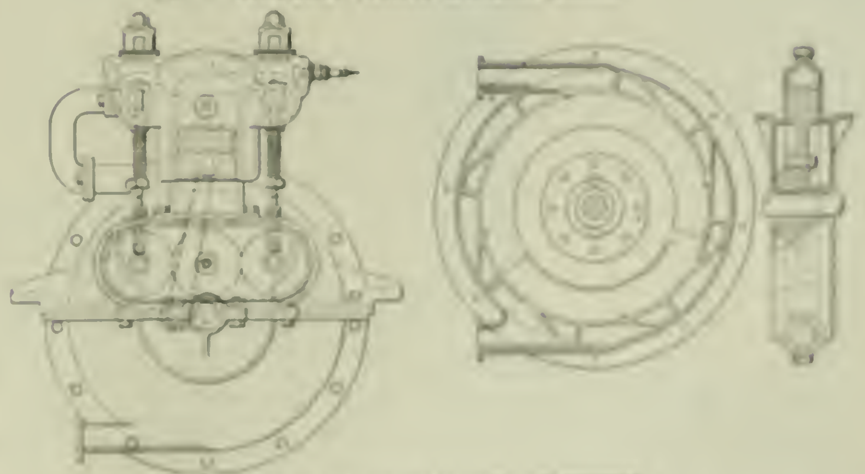


FIG. 2. END VIEWS OF ENGINE AND TURBINE

Business Items

The Quaker City Rubber Company, of Philadelphia, has opened a branch office, in charge of Charles W. Thomson, at 50 Church street, New York City.

The Crocker-Wheeler Company, of Ampere, N. J., recently received an order through its Denver office for a number of small motors for the Cox-Clark Engraving Company, Barclay building, Denver. The motors will be used for individual drive on engraving and electrotyping machinery. They are all 230-volt, direct-current motors of the form L type, which is built in sizes from 1-20 to 7½ horsepower.

Owing to the growing demand for "Komo" steam traps, it has been necessary to increase the manufacturing and sales facilities. Therefore, the business formerly carried on by P. A. Moulton, as sales agent of the "Komo" steam trap, at 92 Liberty street, New York, will hereafter be transacted by the Linton Machine Company, of 26 Cortland street, N. Y., which is in a position to furnish these traps in any desired quantity. The standard of material and workmanship will be maintained, and P. A. Moulton will be associated with this company as manager of the steam-trap department.

The Mesta Machine Company held an "at home" Saturday afternoon, March 27, at its works at West Homestead, Penn. Thither wended a large number of persons interested in works of that character, including many engineers and the Engineers' Society of Western Pennsylvania. It was an afternoon of inspection, followed by a lunch. The fireproof office building, the roll and steel foundry departments, the new foundry and the new pattern shop were duly viewed and appreciated. Among the chief objects of interest were a 36x72-inch Corliss engine, with 100-ton flywheel, which was built in 30 days from receipt of order; a blast-furnace blowing engine, with steam and air cylinders each 84 inches in diameter and with 60-inch stroke; and machinery for a 600-ton metal mixer, which will be double the size of the largest now in use.

One of the largest orders booked by the Crocker-Wheeler Company during a recent week was for 14 three-phase, 60-cycle, squirrel-cage induction motors, aggregating 220-horsepower, for Johnson & Johnson, New Brunswick, N. J. Other induction motor sales of the week were 160-horsepower of the wound-rotor type for the Buffalo Copper and Brass Company, of Buffalo, and a 20-horsepower for the Frick Company, Waynesboro, Penn. The demand for direct-current apparatus still continues. The Eastwood Wire Manufacturing Company, Belleville, N. J., has ordered a 250-kilowatt, engine-type generator, and the Atlantic hotel, Bridgeport, Conn., has purchased a 35-kilowatt machine. A large rolling mill near Pittsburg has placed an order for 244 horsepower of direct-current motors of the rolling-mill type. Other direct-current sales are those of 20 motors for the Lanston Monotype Machine Company, Philadelphia; a 75-horsepower motor for the W. W. Herron Lumber Company, Mobile, and six motors for the F. P. Little Electric Company, Buffalo. There were a large number of smaller orders.

The former American Boiler Economy Company, of Philadelphia, manufacturer of the Copes boiler-feed regulator and the Copes pump governor, has been consolidated with the Northern Equipment Company, Old Colony building, Chicago, which will assume all obligations of the former company, including guarantees to replace free of cost any part of any Copes regulator that may develop a defect within five years from the date of purchase. The branch offices of the American Boiler Economy Company, viz., Tribune building, New York City; Oliver building, Boston; 226 East Pleasant street, Baltimore, and the Frick building annex, Pittsburg, will be continued under the style of the Northern Equipment Company, while the sale of Copes regulators will be handled in Philadelphia by the Adjustable Grate Bar Company, North American building. The Northern Equipment Company announces that it will continue to install the Copes regulators on 60 days' free trial. The following recent sales to prominent concerns are mentioned: Nichols Copper Company, the Delaware & Hudson Railroad Company, the Clark Thread Company, the Consolidated Gas Company, of New York, and the Boston Elevated Railway Company.

Keystone grease, made by the Keystone Lubricating Company, of Philadelphia, is claimed to be especially adapted to shafting lubrication, for the reason that it cannot drip, but remains in the bearing where it belongs. In the silk-ribbon manufactory of Smith & Kaufmann, New York City, and in the silk mills of Pelgran & Meyer, the Harmony Silk Company and Cramer & King Co., of Paterson, N. J., this product is stated to give perfect satisfaction. Other instances of the successful use of Keystone grease are the Botany Worsted Mill, Passaic, N. J.; C. M. Hedden Company, Newark, N. J., manufacturer of fine soft hats; C. B. Rutan, West Orange, N. J., and the No-Name Hat Manufacturing Company, Orange Valley, N. J.

The owners of the "New Belnord" apartment house, at Eighty-sixth street and Broadway, New York City, which is to be one of the largest apartment houses yet built, recently placed an order with the American Engine Company, of Bound Brook, N. J., for three angle-compound engines, one of 500-horsepower, one of 400-horsepower and one of 160-horsepower. This type of engine is adaptable to isolated-plant work because of its relatively small space requirements and the absence of vibration. It gives the advantages of compounding while requiring less floor space than a horizontal simple engine of the same output.

New Equipment

Bids will be received by C. W. Jackson, city clerk, Plymouth, Wis., some time in May for laying about 16,000 feet of 6, 8, 10 and 12 inch vitrified sewer pipe. W. G. Kirchoffer, Madison, Wis., engineer.

The Waukegan, Rockford & Elgin Traction Company has been incorporated with $1,500,000 capital to construct an electric railway. Principal office at Waukegan. Incorporators, R. D. Wynn, C. C. Edwards, Fred Bairstow, etc.

The Pennamaquan Power Company, whose head office is at Providence, R. I., has taken over the property and holdings of the Pembroke Power Company, at Pembroke, Me., and will rebuild plant which was burned some time ago.

The Sioux Falls & Sioux City Electric Railway Co. will commence construction of proposed railway soon. There will be two power stations, one at Sioux Falls, S. D., and one at Sioux City, Ia. G. W. Burnside, Sioux Falls, is general manager.

L. Adler Bros. Company, Rochester, N. Y., has awarded contract for the construction of a new factory building. Equipment will include boilers, engines, generators, motors, blowers, etc. Chas. A. Alexander, Rochester, is consulting engineer.

Sealed bids will be received by P. D. Hendershot, city clerk, Platteville, Wis., until 7:30 p.m., April 2, for furnishing and installing a pumping system. Plans and specifications can be had of W. G. Kirchoffer, consulting engineer, Madison, Wis.

The Central City Refrigerating Company, Syracuse, N. Y., is erecting a cold storage and electric plant. Gas producers, engines, generators, refrigerating machines, etc., will be needed. R. S. M. Mitchell, Kirk building, Syracuse, is consulting engineer.

The Agricultural and Mechanical College of Texas, College Station, Tex., is contemplating installing new equipment in the machine shops and engineering laboratory, including centrifugal pump, air compressor and internal combustion motors.

The Water Power Light Company, Ozark, Mo., contemplates installing additional equipment, including 50-kilowatt alternating-current generator, water turbine, engine. It is said the company also contemplates installing an ice and cold-storage plant.

The finance committee of the Council, Pittsburg, Penn., has approved ordinance providing for bond issue of $1,975,000 to purchase plant of the Monongahela Water Company and $700,000 bonds to purchase machinery for same. N. S. Sprague, city engineer.

The Paris and Mount Pleasant Railroad Company has been incorporated with $75,000 capital to build an electric railway from Paris Texas, to Mount Pleasant. Headquarters at Paris. Incoporators, R. F. Scott, T. J. Record, J. J. Culbertson and others.

The Walsenburg (Colo.) Light, Power and Ice Company is contemplating increasing the capacity of its ice-making plant by the installation of a 12-ton ammonia compressor and the necessary cans, tank, condensers, etc. S. B. Richey is manager and P. A.

W. F. Cooper has purchased the plant of the Winnfield (La.) Light and Power Company and will rebuild same with new and modern machinery, such as dynamo and engine, switchboard and line material. H. W. Wright, Winnfield, is engineer in charge.

Bids will be received by R. Sutton, city clerk, Richland Centre, Wis., for furnishing and laying about 5000 feet of 8 and 10 inch cast-iron pipe. Special castings, valves and hydrants will also be purchased. W. G. Kirchoffer, Madison, Wis., is consulting engineer.

The Portland (Ore.) Water Power and Electric Transmission Company has been incorporated with $1,000,000 capital and will erect a power plant. W. H. Hurlburt, formerly president of the Oregon Water Power and Railway Company, is at the head of the new company.

Help Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

Power System of Louisville Lighting Co.

Single-phase Engine Installation Remodeled into Two-phase Turbine Plant. Novel Features Are the Water Supply and Removal of Ash

BY OSBORN MONNETT

For some time alterations have been in progress at the Fourteenth street station of the Louisville Lighting Company, during which a great deal has been accomplished in changing the character of the station to one of the most modern kind.

Coal-handling Facilities

The property is adjacent to the main line of the Pennsylvania railroad and together with the coal-storage facilities occupies one entire city block. A spur track from the railroad enters the coal- [illegible] making a total coal-storage capacity of [illegible] tons, neglecting the working capacity of the coal bunkers themselves inside the station, which will hold [illegible] tons [illegible].

Each car of coal is weighed on a plat-

FIG. 1. EXTERIOR OF FOURTEENTH STREET POWER STATION, LOUISVILLE, KY.

The old engine room is now occupied on one side by a row of boilers, leaving the other side available for doubling the boiler capacity when required, and a new turbine room has been built on the west side, giving the completed station the appearance illustrated in Fig. 1.

[illegible] yard, [illegible] the old boiler room, as indicated in the plan, Fig. 2. This storage yard has space on either side of the track where coal may be unloaded, and in addition to this a further emergency supply is stored [illegible] on the other side of the tracks. The [illegible]

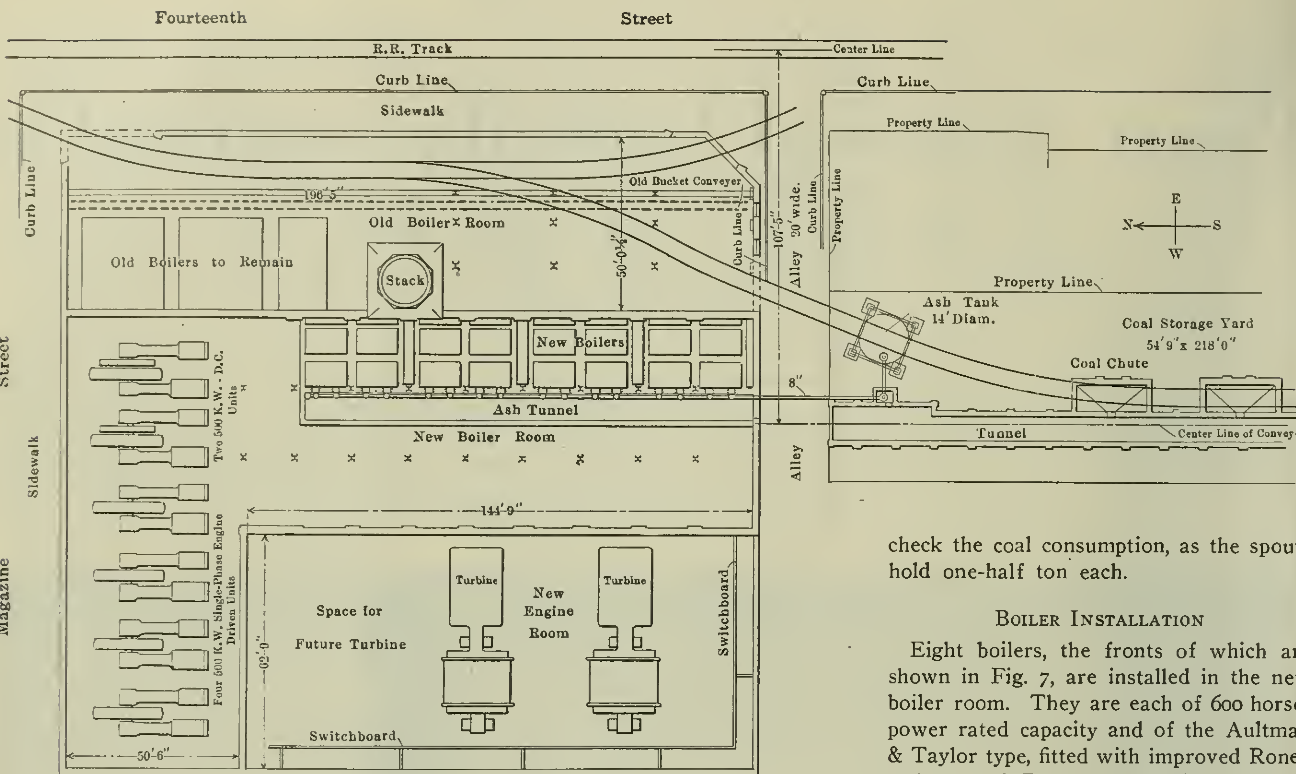


FIG. 2. GENERAL PLAN OF YARDS AND PLANT

to a motor-driven crusher, discharging onto a bucket elevator which raises the coal above the bunkers and it is then distributed automatically on another Robins belt conveyer as shown in Fig. 6. This conveyer is provided with an automatic traveling tripper which distributes the coal uniformly the entire length of the bunkers, reversing itself automatically at the end by means of a lever engaging the trip on the rail. This tripper may also be spotted over any boiler along the line of the coal bunkers. The bunkers are of reinforced-concrete construction and deliver the coal to spouts in which Hunt valves are arranged, making it convenient to check the coal consumption, as the spouts hold one-half ton each.

Boiler Installation

Eight boilers, the fronts of which are shown in Fig. 7, are installed in the new boiler room. They are each of 600 horsepower rated capacity and of the Aultman & Taylor type, fitted with improved Roney stokers and Babcock & Wilcox superheaters. The boilers have vertical headers and are installed with a clearance of only 18 inches between the rear header and wall, the gases passing upward between the drums to the uptake, as shown in the elevation, Fig. 4. This drawing also shows the relative location of the old boilers which have been retained as reserve. Of these there are 1800 horsepower of Babcock & Wilcox make, with

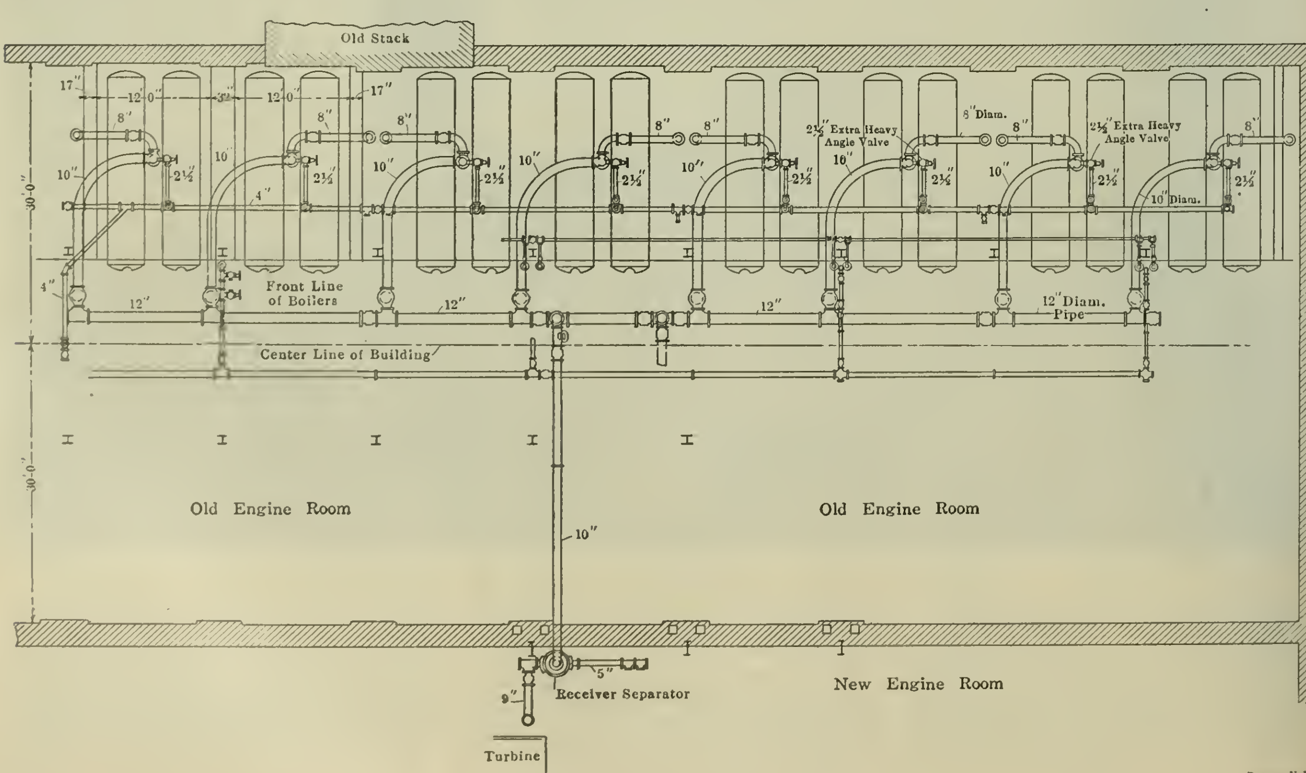


FIG. 3. HIGH-PRESSURE STEAM PIPING

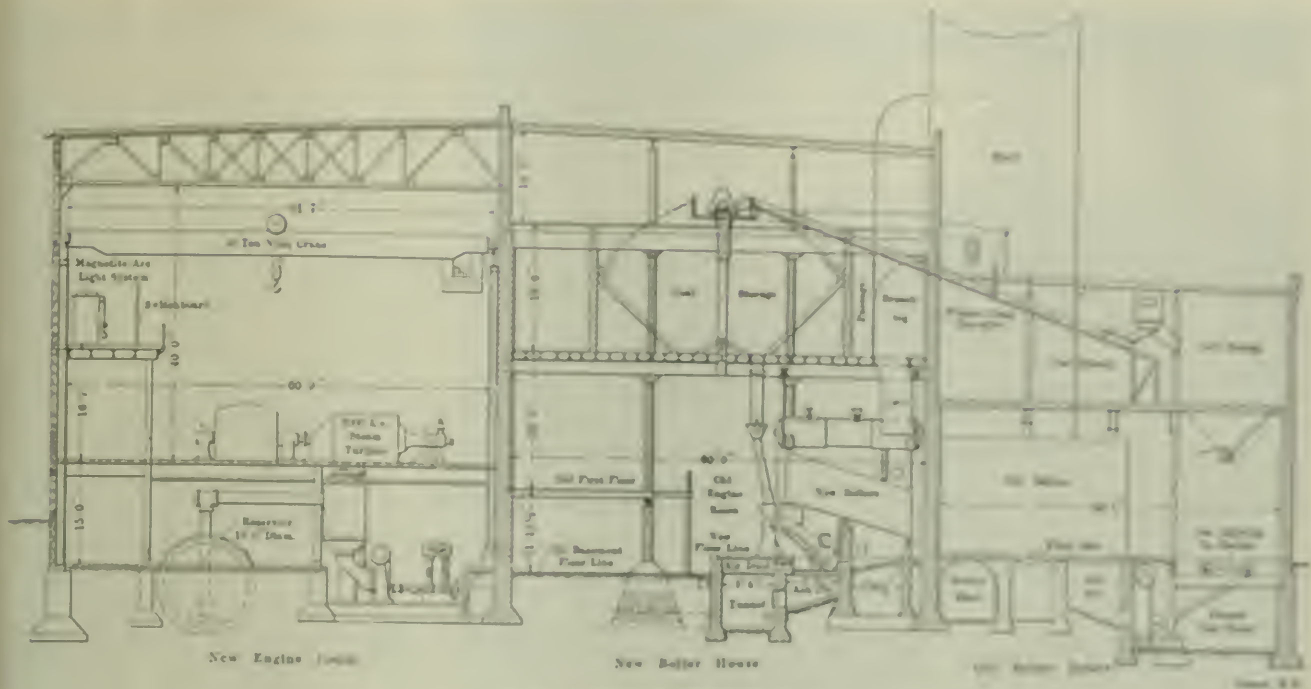


FIG. 4. ELEVATION THROUGH PLANT

Babcock & Wilcox chain-grate stokers. The manner in which the former coal-handling arrangement is utilized as an auxiliary is indicated in Fig. 2. The bucket conveyer has been retained and a Robins belt conveyer is installed to shift the coal into the main hoppers when necessary.

Exceptionally complete facilities are provided for determining conditions in the boiler room. Located at a central point on the firing floor is an Ellison differential-draft gage, and each boiler setting is tapped at the furnace and in the rear gas pass with ¼-inch pipe leading to a manifold, which may be connected at will with the gage. In this way the draft at all important points may be quickly determined. A line extends also to the stack at a point 50 feet above the ground where the main uptake enters; the draft at this point shows 1.4 inches of water. The stack is of brick, 208 feet high, octagonal in shape, with a 13-foot circular flue.

In addition, a board located in the office of the operating engineer is fully equipped with recording and indicating gages, enabling the engineer to determine the steam pressure, vacuum obtained or draft on any unit at any time. An indicator on the switchboard gallery also shows in large numbers the total amount of load that is being carried at all times.

Referring to the sectional elevation of the boiler room, an air duct will be noticed immediately under the boiler-room floor in front of the stokers. This has been put in as an extra precaution, so that the furnaces may be run with closed ash-pits under forced draft, if circumstances should ever require it. Two Buffalo engine-driven fans are installed for this purpose.

Ash Removal

The ash-handling arrangement is simplicity itself. Extending along in front of the ashpit doors is an 8-inch wrought-iron pipe, with a 6-inch opening at each furnace according to the Darley system. The openings are loosely fitted with

FIG. 5. STEAM AND FEED-WATER PIPING

FIG. 6. AUTOMATIC ROBINS DISTRIBUTER OVER COAL BUNKERS

cast-iron plugs, but the farther end of the pipe is open. The pipe extends out through the basement wall and upward into a large elevated steel tank of 50 tons capacity. At the entrance to the tank, the ashes, which are frequently red hot, are sprinkled with water as they drop into the receptacle from which they are loaded into cars. At the top of the tank there is an 18-inch connection which is carried down into the adjacent crusher house and is connected to a Connersville high-pressure blower with a capacity of 200 cubic feet per minute and driven by a 30-horsepower induction motor. This installation maintains the vacuum upon which the operation of the system depends. Fig. 8 shows an elevation of the system as installed, and the tank itself may be seen in Fig. 1.

In operation a plug is removed from one of the tees, a funnel is inserted and the ashes are raked into the pipe, being taken away as fast as introduced. As the suction is always inward, there is no dust nor dirt in the ash tunnel. At the point *X*, Fig. 8, a special elbow with extra thickness of cast iron is used for the reason that the particles of ash in changing their direction from the horizontal to the vertical impinge on the metal at a speed of several thousand feet per minute. This is really the only part of the system subject to severe conditions, but as the elbow can be easily replaced there need be no trouble at this point.

Boiler-room Piping

The high-pressure piping is designed for 100 degrees of superheat. An 8-inch riser leads from each superheater into the end of a 10-inch horizontal bend with a radius of 6 feet 6 inches and terminating in a 12-inch main header from which 10-inch leads pass to the turbines. The only separators in the system are those at the turbine throttles, one being a Cochrane receiver and one a Swartwout receiver-separator.

Kellogg valves and fittings are used and the gate valves all have their stems looking downward, the main boiler stop valves being operated from the boiler-room floor. A 4-inch auxiliary header is also provided to furnish superheated steam to the pumps, etc. All high-pressure flanged joints are packed with Goetze asbestos-copper corrugated gaskets. The feed piping is located overhead in front of the boilers, as shown in Fig. 7, and the main lines are in duplicate, with a 3½-inch branch to each battery of boilers. One Lambert hot-water meter is located in the main feed line, and a Worthington meter is used when making individual tests on boilers. Williams feed-water regulators are installed on the system. Feed water is supplied by two Blake, vertical simplex, outside, center-packed plunger pumps, with cylinders 14x20x12¼x18 inches in size and capable of delivering 300 gallons of water per minute against a boiler pressure of 250 pounds. These pumps take water at an average temperature of 200 degrees under a minimum head of 5 feet 2 inches from a 6000-horsepower Cochrane open feed-water heater and purifier. The heater receives the exhaust from the feed pumps, stoker en-

FIG. 7. BOILER ROOM

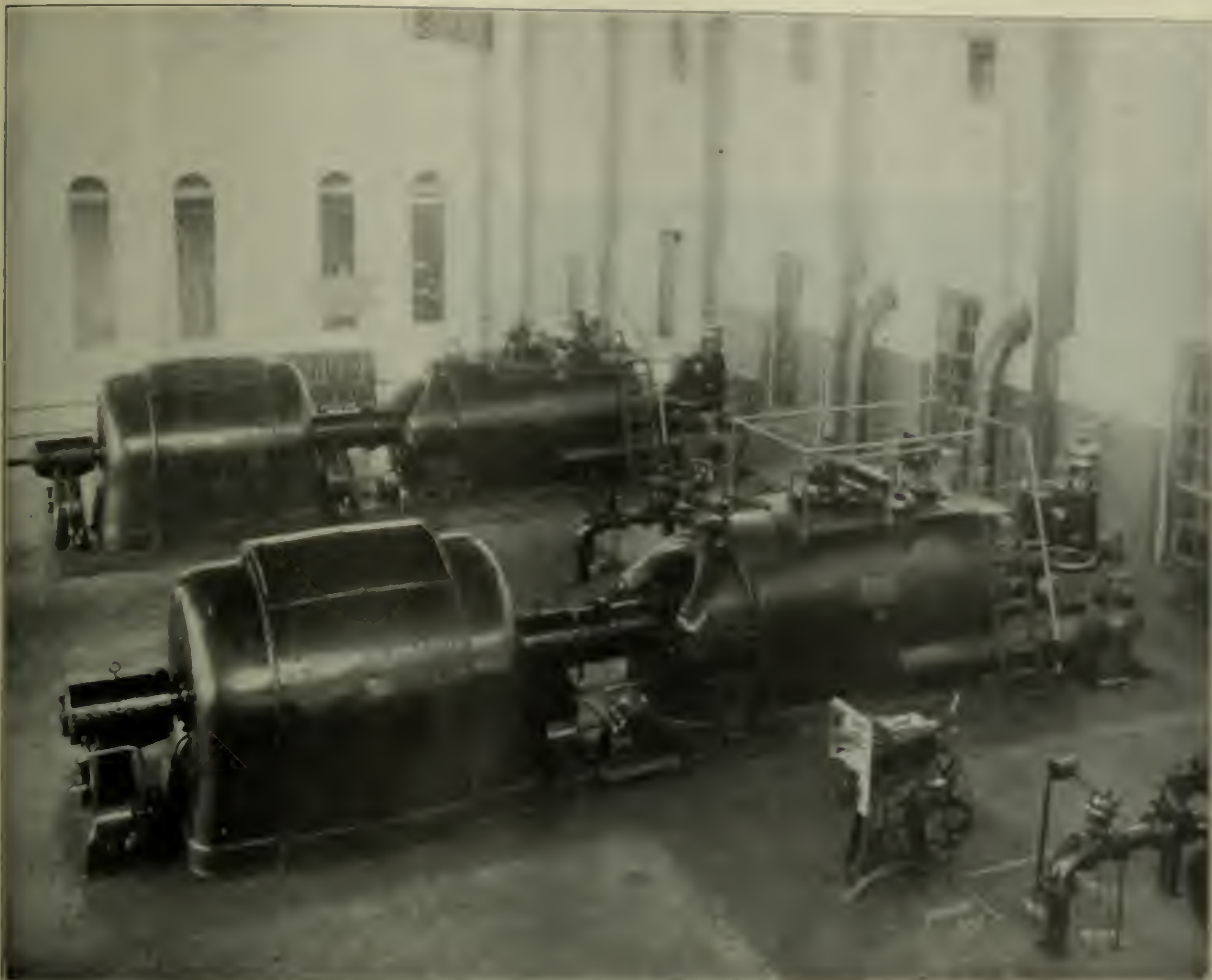


FIG. 9. MAIN GENERATING UNITS

gines, condenser and dry vacuum pumps; all the other auxiliaries are operated by electricity.

Generating Units and Exciters

Two 3000-kilowatt Westinghouse-Parsons turbines are installed. These are of the standard Westinghouse design, with completely inclosed ventilated generators delivering two-phase, 60-cycle current at 2200 volts. The machines run at 1800 revolutions per minute under 200 pounds steam pressure, 100 degrees of superheat and 28 inches of vacuum. The 42-inch gate valve in the connection between each turbine and condenser is operated by a 5-horsepower, 220-volt, direct-current motor geared to the valve stem. This valve is opened or closed by simply throwing a switch up or down, the motor being automatically cut out at the end of the stroke in each case, and a colored signal lamp is automatically lighted to indicate the position. The valve is also arranged with a handwheel in case the electrical apparatus should get out of order.

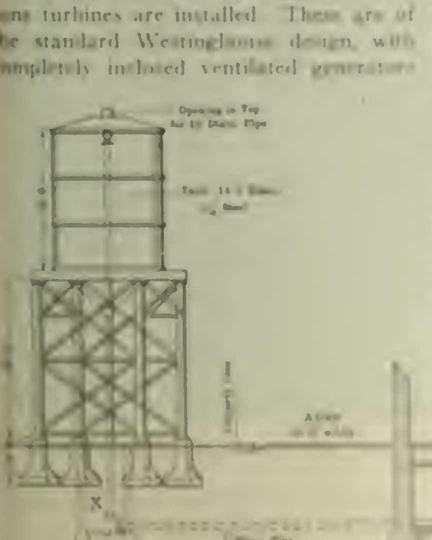
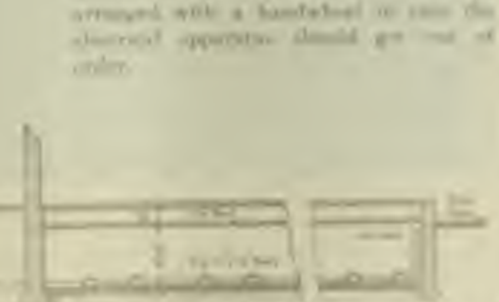



FIG. 8. [illegible] SYSTEM

Fig. 9 is a view in the turbine room, which is spanned by a 30-ton Niles traveling crane. The turbines exhaust into Alberger jet condensers provided with centrifugal steam-driven vacuum pumps which are of single-stage [illegible] make, [illegible] being driven by a [illegible] double engine and the other by a [illegible] and vertical compound. In combination with the Alberger [illegible] dry-vacuum pumps furnished, no difficulty has been experienced in maintaining 28 inches of vacuum at all times.

The Alberger condensers are each fitted with automatic vacuum breakers to insure against water reaching too high a level in the condenser proper. The breaker is essentially a counterbalanced valve connecting to atmosphere and to the exhaust line of the condenser system, the valve being held closed by a trigger. When the water reaches too high a level, it raises a float which releases a trigger and the valve immediately opens. This method of breaking the vacuum is used when shutting down the turbines and is found to be reliable. Fig. 10 is a photograph of one of these breaking valves.

Injection water is obtained from a horizontal concrete reservoir 12 feet in diameter and 140 feet long, located in the basement. The reservoir has a capacity of 400,000 gallons, and as indicated in Fig. 4, the injection pipes terminate in an 18-inch foot valve at the bottom. A 28-inch Crane relief valve is provided on each machine. The exhaust is carried away by a spiral-pipe line which terminates in a riser common to both machines and capped by a Swartwout exhaust head.

FIG. 10. JET CONDENSERS AND CENTRIFUGAL VACUUM PUMP

To the main turbine units the old single-phase equipment of the station is held as a reserve. It will be remembered that at its installation in 1893 this was rated as the largest single-phase generating plant in the world. This notable installation, a view of which is given in Fig. 11, consists of four 500-kilowatt, 2200-volt, single-phase Westinghouse generators, driven by cross-compound Allis-Corliss engines. It has been doing duty ever since installed and works admirably on the two-phase circuits when they are isolated and used in single phase. Two 500-kilowatt, 500-volt direct-current outfits have also been retained. In connection with the generating units there is a complete White Star filtering system installed, with an oil-storage capacity of 3000 gallons.

For regular excitation purposes there is installed a 2200-110-volt, 75-kilowatt motor-generator set taking current from the busbars, or it may take current from the company's Tenth street station. Another smaller 500-110-volt set rated at 25 kilowatts is provided for starting. It is furnished with current from the 500-volt generator in the station or from the Tenth street plant. A third steam-driven set rated at 75 kilowatts is held in reserve. The exciters are all of Westinghouse make, and the engine is a 12x12-inch machine of Chuse design. A 110-volt switchboard is located on the main floor adjacent to the exciter sets. All lighting of the building is at 110 volts from the exciter circuits.

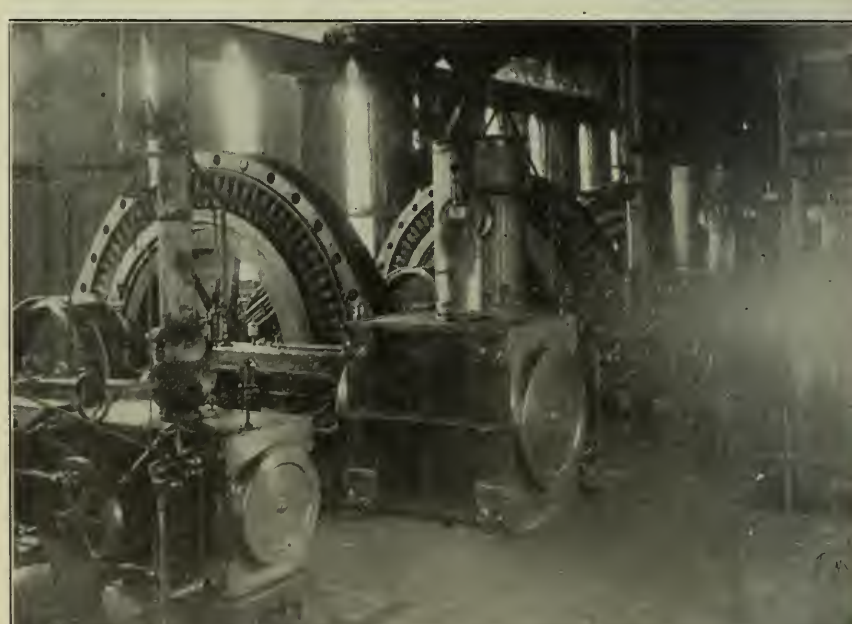


FIG. 11. OLD "WORLD'S FAIR" SINGLE-PHASE INSTALLATION HELD AS RESERVE

Water Supply

One of the most interesting features of the plant is the system of water supply. The station is situated at Fourteenth and Magazine streets at a considerable distance from the Ohio river and does not depend upon this source of water supply, either for condensing or for boiler feeding. As is generally known, the Ohio river is subject to violent fluctuations, the water level varying from 3 to 50 feet, which makes it exceedingly difficult at times to be certain of an uninterrupted supply, either because of low water or on account of the water being so high as to be unmanageable. The river water always contains a certain amount of débris which has to be removed before using in the condensers. Besides, a large amount of mud makes the water undesirable for water-tube boilers. When it was found that the City of Louisville was situated over a natural reservoir containing an almost unlimited supply of clear water not more than 50 feet below the surface, it was decided to take advantage of this and eliminate the many troubles due to a location on the river bank. All the above considerations were gone into years ago when the plant was first built on its present location, and up to the present time the management has seen no reason for making any change. The water is exceptionally fine for condensing purposes, being delivered at a temperature of 55 degrees Fahrenheit the year around. It is, however, quite hard, and for boiler feeding it is treated in a Scaife We-Fu-Go water softener having four setting tanks of 35,000 gallons capacity each.

The principal scale-forming materials

are calcium carbonate and magnesium sulphate, as shown by the following analysis:

	Grains per Gallon
SiO_2	[illegible]
$CaCO_3$	[illegible]
$MgSO_4$	7.44
$MgCl_2$	[illegible]
$NaCl$	2.77
Incrusting solids	[illegible]
Nonincrusting solids	2.77
Total solids	[illegible]

There are at present two deep-well pits in use, the first of which is 500 feet deep, elliptical in shape, with 34 and 48-foot axes, sunk with a steel casing lined with an 18 inch brick wall. At the bottom of the pit around the periphery are 8-inch driven wells, 25 feet deep, with 10-foot well points. Each well is connected by gate and check valves to a 20-inch manifold from which the water is delivered into the large reservoirs in the basement of the engine room by two duplex, tandem-compound pumps, one a Gordon with 12x20x20x24-inch cylinders, and the other a Worthington, 10x20x18x18 inches in size.

The other well is located 200 feet northwest of the first one and consists of a circular concrete-lined steel-shell casing, 25 feet in diameter and 60 feet deep. Fig. 13 is a view looking down into this well. The 24 driven wells here are arranged in a similar manner to those in the first pit, but are alternately 15 and 25 feet deep, with 10-foot well points, the object being to draw from a greater vertical section of the water bed. In this pit a 200-horsepower Westinghouse induction motor drives a vertical single-stage Worthington centrifugal pump having a capacity of 5000 gallons per minute. The motor and pump are connected by a vertical shaft 25 feet long. This outfit operates continuously at full capacity. Sufficient room is available for an additional pumping unit of equal size.

For further water supply the experiment is being made of sinking individual 8-inch wells, fitted with Columbus impeller pumps, driven by vertical induction motors. If this proves successful it will obviate the necessity of sinking the expensive well pits, and will have the further advantage of drawing the supply from a larger area with the consequent decreased liability to failure of supply.

Electrical Control and Distribution

All alternating current from the station is delivered at 60 cycles and is controlled by switchboards in the gallery. The main alternating-current board illustrated in Fig. 14 contains the generator panels, a synchronizing panel, 12 single-phase circuit panels and panels for the motor generators, auxiliaries, arc lights, Highland park and the down-town substation. This board is equipped with a Tirrill regulator for field control and a recording wattmeter. In the Highland park circuit the supply is stepped up to 6600 volts three-phase, is transmitted eight miles and is then stepped down to two-phase 440-volt current. A load of some [illegible] kilowatts is carried. Another notable circuit is that of the 2300-volt single-phase line to Fountain Ferry amusement park, where in addition to upward of [illegible] incandescent lights, there is a load of 150 horsepower in single-phase motors of various sizes.

The feature of the switchboard equipment, however, is the series luminous-arc rectifiers for the magnetite arcs which light the city of Louisville. The board containing the rectifiers occupies the entire length of the switchboard gallery at the western side of the turbine room and consists of 48 panels, each controlling a circuit of 50 lamps, making a total of 2400 lamps for the city. Front and rear views of this board are shown in Fig. 15. It is 144 feet long over all and is the largest board of its kind installed to date.

Each pair of panels operate in conjunction with a General Electric constant-current transformer of 100 lights capacity situated directly behind the board. The rectifier tubes are cooled by an air blast, the openings for which may be seen on the front of the board in Fig. 15. This blast is maintained by two sets in duplicate of motor-driven Sturtevant fans located on the floor of the main engine room below. The life of the rectifier tubes is, of course, uncertain, but it is stated that the record life of a tube on this board has been over 3500 hours.

FIG. 12. EXCITER SETS AND SWITCHBOARD

FIG. 13. LOOKING DOWN INTO WELL PIT

FIG. 14. MAIN ALTERNATING-CURRENT SWITCHBOARD

A vigorous campaign for power business is now being conducted, and on a gallery across the [illegible] switchboard are located some 2300-volt two-phase power panels which control all the alternating-current power circuits in Louisville, except [illegible] the downtown district. The [illegible]

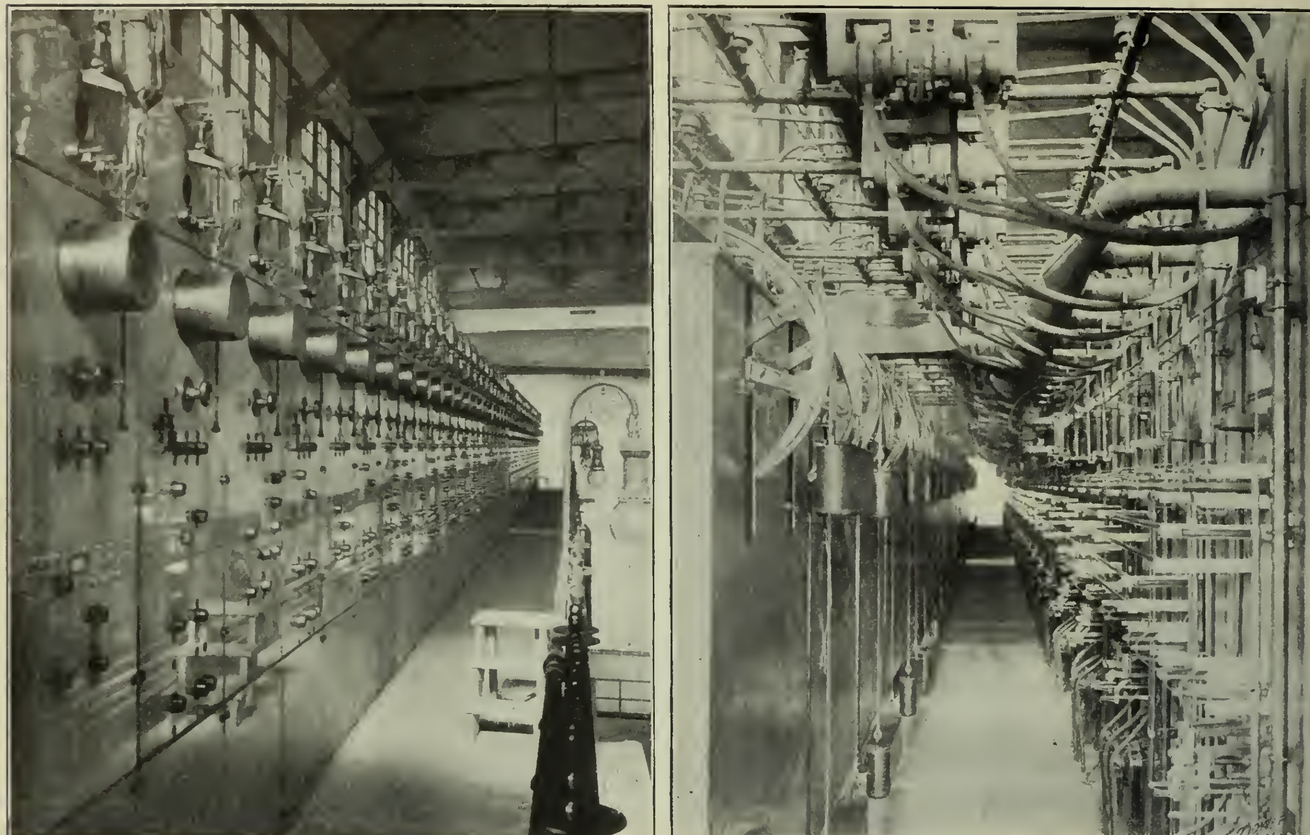


FIG. 15. FRONT AND REAR VIEWS OF LARGE RECTIFIER SWITCHBOARD

the substation and consist of 500-volt direct-current power circuits and 110-volt three-wire alternating-current circuits for incandescent lighting. All circuits are underground.

The substation contains a 1200-kilowatt Westinghouse synchronous motor-generator set supplied with current at 2200 volts through a 300,000-circular mil four-conductor cable. For the alternating-current service there are four sets of two-phase alternating-current static transformers stepping the 2200-volt current down to 240 volts, and at this voltage it is distributed through eighteen single-phase underground circuits to various centers of distribution in manholes. Each circuit has its own regulator on the low-tension side and balance coils in the manholes on the three-wire, 110-220-volt circuits. Fig. 16 is a view of the interior of the substation, which is fitted with a traveling crane and all necessary facilities.

In addition to the synchronous motor-generator set at the substation, there is another of 225 kilowatts capacity at the Fourteenth street station tying the alternating-current and direct-current systems together. These sets have a beneficial effect on the power factor, maintaining it at approximately 95 per cent.

The wiring diagram, Fig. 17, indicates how the load may be handled by the different generators. Ordinarily the machines at Tenth and Fourteenth streets operate in parallel on the turbine busbars, handling the load in general. However, any desired combination may be arranged according to circumstances. Thus the Tenth street station may carry any of the single-phase city-lighting circuits, the magnetite arcs or Highland park, direct. Similarly the old single-phase equipment may serve the magnetite arcs, and any of

FIG. 16. INTERIOR OF SUBSTATION

the city-lighting circuits, including Fountain ferry, but cannot connect with Highland park or the motor-generator at the substation, both of these circuits demanding strictly two-phase current.

TENTH STREET STATION

This station, which has also recently been remodeled, is a brick building, the walls, engine and boiler foundations being built upon a 24-inch concrete slab, which is supported by 12-inch oak piles 35 feet in length. In addition to the 750-kilowatt and 400-kilowatt two-phase generators indicated in Fig. 17, the Tenth street station contains one 750-kilowatt and one 500-kilowatt direct-current 500-volt generator. The two 750-kilowatt units, one alternating and one direct-current, are driven by [illegible]-inch Knowlton & Kelley horizontal Corliss engines, which operate in conjunction with Deane[illegible]-Holyoke flywheel-type jet condensers. Both of the other units are vertical, with McIntosh & Seymour engines, the cylinders in the case of the alternating-current unit being [illegible] inches in size and the direct-current machine [illegible] inches. These engines are equipped with Wheeler surface condensers and motor-driven air pumps.

As this station is located on the river, the precautions taken to maintain a water supply furnish the most interesting feature of the plant. About halfway down on the river bank is located a water-tight pumping station. It consists of a circular cistern about 18 feet in diameter, made of steel boiler plate and having a cone-shaped roof ending in a vertical shaft with entrance at the top. On the up-stream side the structure is protected by a concrete wall.

Inside, the pumping equipment consists of two Worthington single-stage centrifugal pumps, each with a capacity of [illegible] gallons per minute. Each pump is driven by a 60-horsepower General Electric motor taking current from the 500-volt mains. These pumps furnish cooling water directly to the two surface condensers and injection water to the jet condensers. Although normally above the surface of the water, this pumping station operates equally well when entirely submerged. The basement of the Tenth street station would be under water in the spring; [illegible] it is frequently below the water level. The condensing water [illegible] has to be pumped out of the basement, and for this purpose a [illegible] suction pump is held in reserve.

The discharge from all condensers [illegible] into a cistern [illegible] to the sewer. From this cistern feed water is pumped to a Stilwell open heater and thence to the boilers, of which there are three of the Anderson & Taylor type, rated at [illegible] horsepower each and provided with Green traveling-grate stokers.

The work of designing and reconstructing the power stations has been under the direct supervision of G. Wilbur Hubley, superintendent and engineer, Louisville Lighting Company.

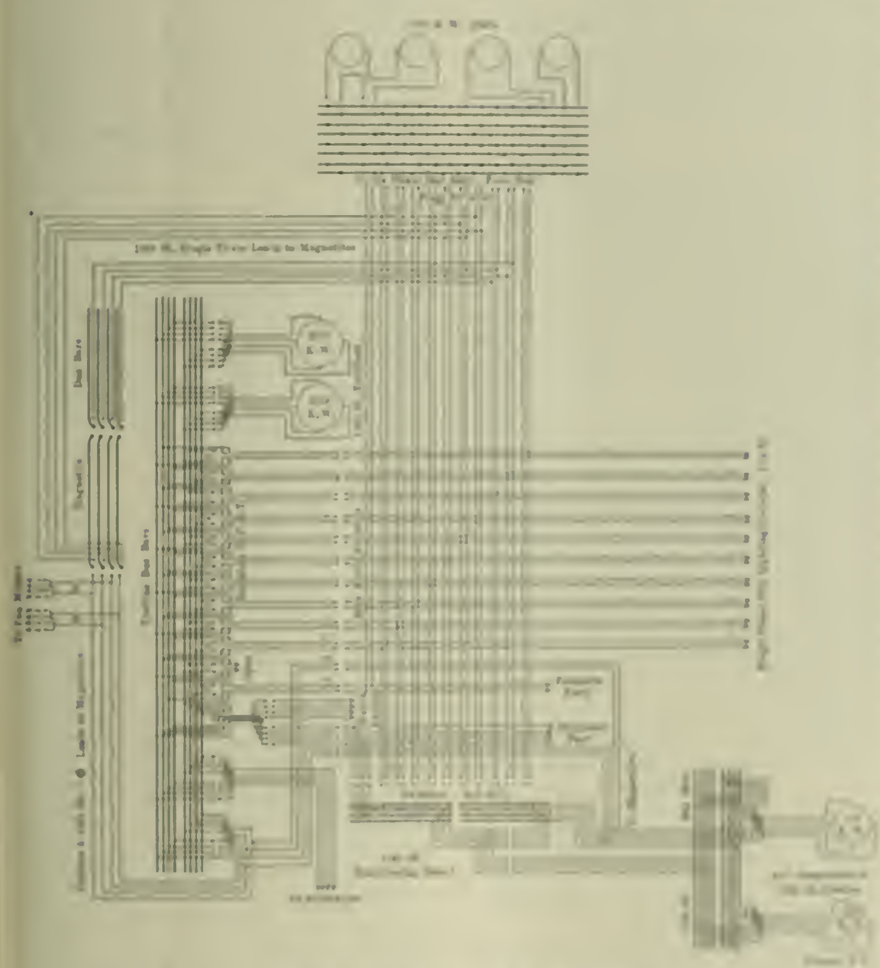


FIG. 17. WIRING DIAGRAM OF STATION

Engineering Societies Discuss Conservation of Natural Resources

Wednesday evening, March 24, a special meeting was held in the Engineering Societies' building on West Thirty-ninth street, New York, under the auspices of the four national engineering societies, American Society of Mechanical Engineers, American Institute of Electrical Engineers, American Society of Civil Engineers and American Institute of Mining Engineers. The conservation of natural resources was the topic under discussion, and four papers by representatives of the societies were presented. Nearly 800 engineers were in attendance and Dr. James Douglas presided.

Before the papers were read, a telegram from President William H. Taft was received with considerable interest. The President was greatly gratified to know of the cooperation of the engineers in the movement for the conservation of natural resources, as the members of the four societies with their technical knowledge were not only better advised as to the necessity for such conservation, but were competent to suggest practical methods by which such conservation could be carried out.

WASTE [illegible]

In a few preliminary remarks, Dr. Douglas expressed his opinion that the waste of coal above and below ground should be regarded more in the light of a relative rather than an absolute waste. Great advancement has been made in chemical and metallurgical engineering, and this advancement means the saving of coal. [illegible] energy in the coal. The efficiency of the Diesel engine is reported as 36 per cent. Improvements along this line should be the aim of the engineer. But the conservation is not being restricted to coal alone. The amount of steel used in buildings and bridges is being cut down, and cheaper materials are being substituted for the rarer ones. All engineers are working with the same end in view, and instead of feeling repentant over the resources that have been wasted, they should rather feel jubilant that there is yet much that they can do toward conserving these resources.

Conservation of Water

The first paper of the evening was presented by John R. Freeman, consulting engineer for the Department of Additional Water Supply for the City of New York. His topic was "The Conservation of Water," and he prefaced his remarks, to the surprise of some of the engineers present, by saying that he did not believe the cutting off of the forests in the Eastern mountains had affected the flow in flood or drought of any important rivers. Land covered with an undergrowth was quite as effective as timber, and the error had been in the failure to differentiate between kinds of soil. It was his opinion that if half the stations of the United States Geological Survey were abandoned and the total appropriation devoted to the remaining half, more precise information on stream flow would be available.

In conclusion, it was his recommendation that each State should collect the facts regarding each of the notable opportunities for power development within its borders. Select the important ones for survey in detail after reconnoissance, prepare an outline plan for each, with all the detail that would be required in the preliminary studies for actual developments, with the full estimates of cost of plant and of the amount of power available in different seasons of the year, and make these matters of permanent public record, printed and widely distributed. In these surveys the conservation idea should have full sway, measuring up the full engineering opportunity, with dams planned at the highest levels and tailraces at the very lowest levels that the topography will reasonably permit, and with the storage reservoirs of the greatest hight and area for which nature has provided a reasonable location, up to the full measure of reasonable flood control. Every noteworthy opportunity for development that will ever exist within the State can thus be soon placed on the map, and there will never be a more advantageous time than the present to take account of stock, so that the public and the promoter can see just what degree of promise there is in each opportunity. The State can perhaps wisely go farther than heretofore, and at some of the great sites itself construct the main works, much as the United States Reclamation Service has built reservoirs and canals, or it can invite private capital, through the removal of the restrictive laws like those now forbidding storage reservoirs in the Adirondacks, or by laws helpful in bringing the full natural opportunity of one proper site under one control, like the mill and the flowage acts of some of the States.

By far the most beneficent policy of conservation of its water power that the State or Nation can adopt is one which will tend toward its being devoted to the founding of industrial communities, and that kind of industry is best which will bring the greatest population per horsepower and the most highly skilled class of operatives. The first step in such a policy of conservation is an accurate inventory and publication regarding each undeveloped or scantily developed opportunity.

Conservation by Legislation Doubtful

"Conservation of Natural Resources by Legislation," the second paper of the evening, was delivered by Dr. Rossiter W. Raymond, secretary of the American Institute of Mining Engineers. As expressed by the speaker, true conservation lies in the diminution, not of use but of waste. The error of our pioneer miners and metallurgists was not that they worked prematurely and imperfectly, but that they too often left their low-grade ores, slags and tailings in such positions as to be unavailable for retreatment by their successors; but no legislation, even if the legislators had been wiser than the engineers, could have remedied this evil half as quickly or thoroughly as it has been remedied without any legislation at all, for the trouble was simply lack of knowledge. The moment the mine operator realized that his tailings were a part of his assets to be turned into money at once, either by himself or by lessee, or by sale to a speculative purchaser with an eye on approaching improved conditions, that moment he began to preserve and protect them. Much the same ruling applies to our timber lands.

The Government had failed to deal competently with the mineral resources of the country, and why should it be trusted to legislate concerning other resources? The progressive education of the people and the steady pressure of economic conditions would do more to prevent waste than any amount of legislation. Of all the extra Governmental functions, the education of the people by the spread of information is the most beneficial, the most potent and the least objectionable. The information presented by the Government should be collected with care and not in a hurry, should be stated without bias or argument in favor of this or that measure or policy; and made accessible to all who desire it, not by the wasteful and inadequate system of giving to members of the Congress so many copies per capita, but by printing in successive editions, if need be, as many copies as individual citizens are ready to buy at cost.

Engineers may render most useful service by freely scrutinizing and criticizing the figures upon which all propositions of reform, private or public, are professedly based. Others will always furnish the motive power of eloquence and enthusiasm. It should be the business of engineers to test the machinery and hold the rudder.

Fireproof Buildings to Reduce Fire Loss

Charles Whiting Baker, editor of *Engineering News,* talked on "The Waste of Our Natural Resources by Fire." The loss by fire in 1907 amounted to $215,000,000, and if all the buildings visited by fire during that year were lined up along a single street, it would reach from New York to Chicago, approximately 1000 miles. In this long line of buildings much of our wood and mineral resources are annually destroyed. An even division of this loss by fire would mean a tax of $2.50 for every inhabitant of the United States, or for every family of six a tax of $15. Similar figures in Europe are much lower and in fact do not even approach one-half this value. A more careful selection of building materials, insuring a fireproof structure, would lessen the annual destruction and to no small extent conserve our natural resources.

Install Water Power to Save Coal

The fourth and last paper of the evening, on "Electricity and Conservation of Energy," was presented by Lewis B. Stillwell. The speaker expressed himself in favor of a much more extended development of water power to develop electrical energy. Excluding locomotives, there are 25,000,000 horsepower of steam engines in the country, 5,000,000 horsepower of water motors and 800,000 horsepower of gas engines. Our water resources are such that 37,000,000 hydraulic horsepower could readily be developed and utilized at a less cost than steam. Every hydraulic horsepower saves from 7½ to 10 pounds of coal, and with the above number of hydraulic horsepower actually installed an enormous saving in our coal resources would result. Centralizing our steam-generating stations into larger plants would also reduce the demand for coal. With this end in view the State should hasten instead of retard our water-power developments.

New York N. A. S. E. Convention

New York State Association No. 34, N. A. S. E., will hold its annual convention this year at Syracuse, June 11 and 12, in the assembly hall of the new court house. The exhibit room will be in the same building.

Analysis of the Subject of Coal Analysis

A Government Expert Discusses the Chief Things Coal Users Wish to Know; Values of the Various Methods Used In Analyzing

BY N. W. LORD*

Within the last few years the subject of coal analysis has become of very great importance to many lines of industry. The demand for the analysis of coal has come from a great variety of sources and largely from those having little acquaintance with chemical methods and the interpretation of chemical results. The chemists, on the other hand, have been compelled to take such methods as were found at hand, and the result of those conditions has been not altogether satisfactory in many ways.

What So-called Coal Analysis Means

If we consider somewhat in detail the various determinations made in the laboratory in connection with coal testing, it will be easy to show how much is commercial and how little what might be called scientific. The so-called analysis of a coal is usually a practical test of purity of the material on a small scale, but it also involves determinations which are supposed in some way to indicate the nature of the coal itself.

To illustrate, suppose we consider an ordinary sample of bituminous coal. It may be assumed to consist, first, of an organic constituent composed of vegetable residues more or less altered but retaining traces of its original woody structure and composite character, and containing as an integral part certain inorganic components. Like its source, woody fiber, it is hydroscopic in its nature, holding mechanically variable amounts of moisture, the equilibrium amount depending upon the moisture percentage of the air; in other words, like a piece of wood it absorbs moisture in damp weather and gives it up in dry weather. The ultimate chemical composition of this material varies with the extent of the alteration, as shown in the peats, lignites and bituminous and anthracite coals, and also, as has been shown, in all probability with the nature of the vegetation from which it has been derived. This extremely complex and indefinite material may be called "coal substance," for want of a better term. Intimately mixed with this are inorganic substances, probably mechanically introduced with the original vegetable debris or else precipitated by secondary reactions from circulating waters. These may be in the nature of clays or fine sand and also intimately mixed iron pyrites. I have examined samples of coal under the microscope in which microscopic crystals of pyrites were scattered through the mass in sufficient amount to give high percentage of sulphur in the total, yet in which a superficial examination of the coal itself practically showed no pyrites to the unaided eye. Other minerals may be present in the same way, even such unusual constituents as zinc blende, and, as Doctor Hillebrand has shown, considerable percentages of vanadium sulphide. The extremely complex nature of the organic constituents themselves may be inferred from the variable but sometimes very large amounts of sulphur they contain, well shown in the case of certain peats. Now in addition to this base, constituting the principal part of the sample submitted to the chemists for analysis, it has, secondly, more or less coarse admixture of slate, clays and other rock-like material occurring in connection with the deposits of coal and not properly separated in mining, bone coal and also streaks of cannel and other associated material, coal-like in character, but differing notably even in the organic material they contain from the coal itself. Add to this enumeration of the constituents of commercial coal the fact that many of these ingredients, on standing or exposure to air, alter by absorption of oxygen, evaporation, etc., and it would appear that the problem is still farther complicated.

Things Coal Users Wish to Know

Now some of the things that the users of coal wish to know and for which they turn to the chemical analysis in the hope of receiving information are the following: The heating power of the coal; the amount of ash or inorganic matter left on burning the coal; the nature of the combustion of the coal, whether flaming, smoky, rapid or slow; the gas-producing quality of the coal, both as to yield and as to the nature of the gas; the nature of the ash yielded by the coal; the coking quality of the coal and the nature of the coke produced; and the possibilities of improving its quality by coal washing.

In addition to these are many questions of special character, such as the demands for scientific investigation as to the nature of the coal substance, the relations of its composition to the geological history of the deposit and the relation of the total heating power to the heating power actually available for technical operations.

Analytical Methods Employed

What are the analytical methods at present used in the laboratory to meet this series of questions and to handle this very complex material? Most of the laboratory work is done upon a sample which represents or is intended to represent the average composition of the material and which in no way recognizes the separate constituents of the very complex mineral aggregate of which it purports to be an average. The methods therefore give results only approximately related to the coal substance and difficult of general application.

We have, as of generally recognized importance, the ultimate analysis as ordinarily made, giving the determination of the hydrogen, the carbon, the nitrogen and the sulphur and the percentage of ash left after burning. This analysis also includes an estimate of the oxygen by difference which is, of course, only approximate, as has been frequently pointed out in discussion on the subject. This ultimate analysis is capable of a high degree of accuracy for certain elements, which I think could be safely stated within [illegible] per cent. in the hydrogen, [illegible] per cent. on carbon, [illegible] per cent. on the nitrogen and [illegible] per cent. on the sulphur. I do not mean that closer results are not obtainable, but ordinary work in the laboratory by competent chemists would, I think, run within these limits. The value of the ultimate analysis in all technical applications of the coal consists of its giving a reasonably accurate basis for the calculation of products of combustion and of comparisons with the heating power of the coal otherwise determined. The weakest point in the ultimate analysis is the uncertainty of its connection with the actual composition of the organic material as distinct from the ash portion. Carbon, hydrogen and sulphur are present respectively as carbonates, as combined water and as sulphates respectively in the slates and other mechanical mixtures and the ultimate analysis does not distinguish between such constituents and those in the coal substance. Ingenious efforts to eliminate these uncertainties in adjusting the heating power by comparing that of various samples of the same coal differing widely in percentage of mechanical impurities have been made by several chemists.

*Chief chemist, technologic branch of the United States Geological Survey. Paper read at the Illinois Fuel Conference, March 11, 12 and 13.

Proximate Analysis

In addition to the ultimate analysis, we have the more commonly made "proximate analysis," consisting of the determination of the moisture, ash, fixed carbon and volatile combustible matter in the coal. Much has been written in regard to these determinations.

On the same sample of coal closely agreeing results can be obtained on the ash and fairly close on the moisture. The variation in the volatile combustible is much larger and can only be kept within reasonable limits by very careful adherence to a definite method of procedure. The term moisture simply means the loss in weight under fixed conditions of treatment. It is intended and does bring the material to a condition which can be duplicated closely and represents a fixed basis for comparison, but in nowise stands for all the water in the coal. The volatile combustible, as has been carefully investigated by Professor Parr, is by no means properly named. Only a fraction, and a variable fraction at that, depending largely on the kind of coal, is combustible, and a considerable fraction, consisting of water vapor, carbon dioxide, nitrogen and other dilutants is inert or noncombustible. It is well to recollect that the proximate analysis of coal was devised many years ago, and primarily as a means of testing the amount of coke left by coal. The volatile combustible has since been the subject of much discussion and many attempts have been made to correlate it with heating value, geological changes and the various questions arising in coal utilization. Some undoubted connections have been shown, but I feel that possibly too little recognition has been given to the empirical and more or less uncertain nature of the determination.

"Float-and-sink" Tests

Of growing importance, particularly in connection with coal washing, and as a tool for the study of coal samples is the application of the separation by gravity or the so-called "float-and-sink" tests, in which the coal crushed to a moderate degree of fineness is separated on solutions of high specific gravity, chloride of calcium for specific gravities up to 1.35 and chloride or sulphate of zinc for higher gravities. Chloride of zinc solution can be made of a specific gravity as high as two and by dilution any of the intermediate gravities obtained. I have used this method in my laboratory for years to separate heavy mineral materials like slate and pyrites, as preliminary to the study of the composition of coal. The method is excellently adapted to tracing out the variations in composition as the intermixed mineral substances are eliminated. It will enable the experimenter to distinguish with considerable accuracy between the inherent intimately mixed ash and the sulphur compounds and the coarser and mechanical contaminations.

In recent years the leading factor in the commercial valuation of coals has become the calorific value or heating power of the coal and today the most important demand on the laboratory is the determination of this. The widely extending use of the bomb calorimeter is leading to new problems for the investigation of the chemists. Here again the heating value of the sample is modified more than by mere dilution by the nature of the mineral aggregate. As Mr. Turner and others have shown, the heating value is not entirely proportional in a given kind of coal to the residue left after deducting the ash and the moisture, but that there are factors depending on the influence of the inorganic material. Work of this kind is of great importance in order that the effect of ash, moisture and pyrites on the commercial value of coals may be more accurately shown.

Calorimetry Requires Skill

Calorimetry is, unfortunately, work demanding considerable training and experimental skill and the recently adopted policy of the Bureau of Standards of furnishing materials of known heating value so that the constants and correction of the calorimeter can be determined is greatly to be commended. The possibility of error in calorimetric determinations due to alteration of samples should be borne in mind. A very finely pulverized coal sample will oxidize in many cases very rapidly and comparative results by different chemists on such a sample are liable to vary unsatisfactorily unless all made approximately the same time on samples that have been sealed in air-tight receptacles. Experiments made by the fuel-testing plant afford ample evidence of the extent to which this alteration may take place.

The determination of the water equivalent of the calorimeter experimentally gives rise to many difficulties and hence except for those having had a great deal of experience in fundamental measurements it is far better to use the calorimeter as a comparative instrument and depend for its constants upon burning substances of known calorific value such as are furnished by the Bureau of Standards. Commercial chemicals are quite variable and different samples of napthalene, benzoic acid, etc., from different dealers will differ notably in their heating value. Recently the writer has obtained very successful results by the method of mixtures, adding hot water to the calorimeter from the Dewar flask or thermos bottle in which it is possible to read with great accuracy the temperature of the added water and to add the water to the calorimeter with a very small correction for radiation loss during the addition. The method has proved successful in the hands of students who have made a number of water equivalent determinations agreeing within a very small limit of error with the calibration of the calorimeter obtained in other ways. Of course, this method has the advantage of being absolute and not relative.

Weakest Point in the Results

The foregoing outline has dealt with the laboratory side of the question. All the analytical work, calorimetric work and everything else in connection with the testing depends for its economic value on the fundamentally representative nature of the sample of coal tested in the laboratory. Here is the weakest point in the commercial application of the results. Coal sampling is a matter now prominent before the technical world. Now that the extending recognition of the value of laboratory work is leading to the purchase of coal on chemical specifications the whole question is under review. The ingredients most affected by sampling are obviously moisture, ash, sulphur, and calorific value. In a recent paper of great interest, E. G. Bailey has presented a large number of results in which he criticizes existing methods and lays down certain general deductions from carefully conducted experiments as to the general principles involved in the securing of correct samples. Mr. Bailey has, in my opinion, done a very valuable piece of work, both in calling attention to the importance of the subject and in the experiment he has brought forward. As having been connected with the Government work in St. Louis, I feel called upon to correct certain misapprehensions in regard to that work which I think unintentionally on his part led him to place it in a somewhat false light as to the accuracy with which the sampling was done. As I followed this paper he makes a fundamental assumption that the variations in the portions of coal taken at the plant from the same car shipment and sent to the boiler-gas producer, briquet and washing plants were identical in composition with the carload sample, and that the variations shown in these different portions were due to variations in sampling of the portions at the various plants. Whereas, the facts of the case are that the different portions taken from the car were not supposed to be sampled from the car, but simply portions unloaded at different points and the reason why analyses were made of the separate portions was because it was recognized that the carload was not uniform as far as contents of ash, sulphur, etc., were concerned, and that the carload analysis could not be taken for the different portions without a preliminary thorough mixing of the whole carload which was not practical. This is clearly stated on page 284 of professional paper 248, part 1, from which I quote:

"It was intended that the car sample should represent the average of the whole car while the other samples stood for different portions of it. These would average about 5 tons each. In some cases the car sample was taken on only part of the car. The large variation in the different samples in a few cases shows the irregularity in the coal in the car."

Experiments were made at St. Louis and published in this same work giving the analysis of duplicate samples, and while the results were not very satisfactory and some errors were found, they were not of the magnitude as given by Mr. Bailey from his comparison of the other samples based on the assumption which I have shown was not warranted and which was contrary to the facts as we stated them at the time. Mr. Barrows has discussed the question of mine samples, but the comparison of those with coal shipped from the mines makes no allowance for the extent of cleaning that the coal underwent in shipping and in taking the mine samples. As stated, several duplicate samples on the carloads were run to check the St. Louis sampling, and the worst result obtained I think was the one given on page 287, in which an extreme variation in ash on a coal averaging about 15 per cent. ash, was a little over 2 per cent. This coal was selected as the worst obtainable from the standpoint of sampling and the variation of the highest and lowest samples from the average of all the experimental samples on this coal was only a little over 1 per cent. Notwithstanding the criticism that I felt compelled to make of Mr. Bailey's representation of the St. Louis work, I feel that his general proposition in regard to the uncertainty of much coal sampling is well sustained. His conclusions as to the amount of sample necessary in order to obtain a representative sample are of great interest. However, I do not feel that the difficulties are quite as great as his experiments would lead one to conclude.

Things Important to Consider

Two things are important to consider. In the first place, in crushing coal a large proportion of fine material is produced so that the average size of particle is but little more than one-half of the maximum size and therefore results on the distribution of the maximum size pieces greatly exaggerate the difficulties. I recently took four samples of screened coal and had them put through a jaw crusher and screened.

In No. 1, 8.8 per cent. was retained by a ½-inch screen and 91.2 per cent. passed a ½-inch screen. This sample of coal was sampled in duplicate at this stage of crushing, portions of coal of about 5 pounds were taken. The two 5-pound portions were each separately pulverized, mixed and analyzed. The first portion gave 13.86 per cent. ash and the second portion 13.56. A similar experiment on a second sample of coal gave 16.3 over a ½-inch screen and 83.7 per cent. through a ½-inch screen. The ash in the first sample, 14.50, in the second sample, 14.41. A third sample of coal gave 7.2 per cent. over a ½-inch screen and 48.1 per cent. through a ½-inch screen. The ash in the first sample was 15.11; in the second sample 15.10. In two of these samples the percentage of ash in the finer portion was considerably greater than the percentage of ash in the coarser portion.

Of course, these results are too few in number to amount to anything, but they show that the finer material is in sufficient proportion to diminish the irregularity introduced by the bad distribution of the coarser lumps in the sample.

A further point in coal sampling which has to be considered is that in the larger sizes there is a natural mixture in the material of the slate and coal, so that a 4-inch lump coal does not represent a mixture of 4-inch lumps of coal and 4-inch lumps of slate to any appreciable percentage of the ash present. In other words, the inspection element must enter coal sampling, and no man would draw a moderate-sized sample of a coal in which he has a large percentage of lumps of slate as large as the lumps of coal, while the occasional presence of even a large lump of slate would have but little influence on the ash percentage of the resulting sample.

Mr. Bailey gives what he names the size-weight ratio or the relation between the maximum sized piece of coal in the sample and the weight of coal necessary to take in order that the sample may be certainly representative within an error of 1 per cent. of ash.

Now his figures lead to very large samples in cases of lump coal, but the foregoing indicates that the size ratio should probably be that of the maximum slate sizes present in the coal lumps, or free, rather than the actual coal lump size. The moderate variations in the ash percentage of the different lumps would have far less influence in disturbing sampling than the presence of equivalent-sized lumps of slate.

Obviously, therefore, careful inspection must precede the sampling in the case of lump coal and the presence of large pieces of slate and pyrites in lumps in the coal allows due consideration in determining the size of sample necessary in order properly to sample the coal.

I have always directed samplers to inspect the coal carefully and break up any small pieces with traces of slate, bone coal or pyrites found, or anything that does not look like coal, before taking or finishing the sample.

Of course, it is well known that no system of sampling which is purely mechanical is satisfactory for materials in which coarse distribution of the constituents exists, unless the whole of the material is crushed to approximately such limits as are defined by Mr. Bailey. This is the principle involved in the sampling of lead and copper, gold and silver ores where the system of sampling involves the crushing of entire lots of material. Such a system of sampling is, of course, out of the question with lump coals where the crushed material would be to a certain extent rendered of small value. The system of sampling adopted in this case must be based on an estimate of the maximum size of slate and pyrites, constituting an important portion of the impurities.

The difficulty of eliminating the personal element in doing such sampling is one of the problems which the committee on specifications will have to contend with. Meanwhile, the sampling problem is before us and must be adequately solved before the laboratory analysis of the coal reaches its full application.

The preparation of the laboratory sample from the field sample is a much easier matter and is easily within the reach of the present methods. One of the principal difficulties involved at this point is the avoiding of changes in the composition of the sample due to loss of moisture and to oxidation. I notice in many experiments the coal is ground to 100 mesh or even 200 before analysis. I think this is a step in the wrong direction. The finer the powder the more prone to oxidation and loss of moisture, and I think the effect of the samples should be to determine a lower limit for Mr. Bailey's "size-weight ratio" as well as a higher, and not to reduce the sample beyond this point before weighing out.

We have considered that a 60-mesh sample will meet the ordinary requirements where 1 gram is taken for the determination, which is within Mr. Bailey's figures as I understand them.

Saving by Purifying Water

In a plant containing eleven horizontal return-tubular boilers, each rated at [illegible]

[illegible]

The Status of the Wave Motor

By James T. Barkelew

Now that there is a comparative lull in the production of new designs and ideas for wave motors, it is well, perhaps, to make a resumé of the different forms and their relative effectiveness before taking further steps in the actual reduction to practice of the theories already advanced, and to lay out the probable conditions under which it is possible that the wave motor may become a commercial success.

In general, inventors have approached the problem with the single notion that there is unlimited power in the waves awaiting utilization, and the result has been a motley array of devices which take up the motion of the waves and transform it, in some method or another, into a power of practical utility, generally electrical. All this has been done without any thought of efficiency, but with the sole idea that, as there is unlimited power, a device of any character would take up a sufficient amount to raise the designer to opulence. After numerous trials of various machines it has been found that the results do not come up to expectations, in the majority of cases the market price of the power produced not equaling the interest on the capital invested, and being more than offset by the maintenance cost. It is true that some devices have excelled others in efficiency and are also less susceptible of destruction by storms, but even with these better machines the returns have not seemed to be large enough for the investment demanded.

Maximum Average Energy in Wave Motion

It is the purpose of this article to investigate the basis on which the profit-paying chances of the present motor rest, and to point out, if possible, the line of advancement to the future successful machine. The first step will be to ascertain the maximum average energy in wave motion at accessible and practical localities, where the power produced may be marketed without excessive costs over that of initial production. For this purpose a simple and easily understood formula will be deduced and then maximum average values applied.

Referring to Fig. 1, which represents a greatly exaggerated contour of a wave from crest to crest, we will be able to deduce a simple formula for the total power, sufficiently accurate for the purpose of this paper. Deductions which take into account the theoretically exact trochoidal form of the wave give a resulting equation different in form from the following, but the numerical calculations of the different formulas will check fairly closely. The superiority of the simpler formula is that its derivation can be easily reasoned out and the logic of its being perceived without the aid of higher mathematics.

Let L represent the length of the wave from crest to crest, D the depth from crest to trough, and C a constant depending upon the configuration of the wave. Then the weight of water in a single wave, the shaded portion in Fig. 2, a foot wide, is,

$$W = \frac{62.35\,D\,L}{C}. \qquad (1)$$

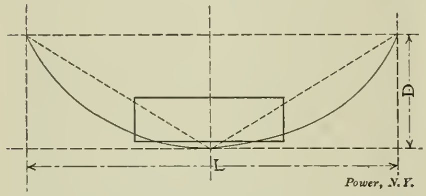


FIG. 1. EXAGGERATED CONTOUR OF WAVE FROM CREST TO CREST

In long waves the contour approaches the dotted lines in Fig. 1 and the value of C approaches 2, the area of the shaded portion on the diagram being nearly that of a triangle whose base is L and altitude D, so that the formula may be written:

$$W = 31.18\,D\,L. \qquad (2)$$

It will readily be observed that every particle of water on the contour of the wave must at one phase of its motion be at the top of the crest, and in the opposite phase be at the bottom of the trough. This is true of the surface water, but the vertical movement of the particles below is not so great, diminishing to zero at a plane just under the surface. The average motion may be taken at $\frac{D}{2}$, and the total energy for a single wave a foot wide may be expressed,

$$E = \frac{31.18\,D^2\,L}{2}\ \textit{foot-pounds}. \qquad (3)$$

Then, if N be the number of waves per minute, the total power of regularly succeeding waves will be:

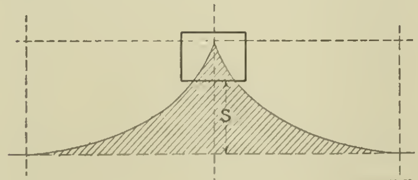


FIG. 2. THE SHORT FLOAT

$$H.P. = \frac{31.18\,D^2\,L\,N}{2 \times 33{,}000}, \qquad (4)$$

all the dimensions being in feet.

To strike a high average the number of waves will be taken at four per minute, the distance between them, 300 feet, and the depth as 6 feet. These are figures well over the average for fair weather. In reality, waves of this size do not succeed regularly, there usually being a short succession of large waves followed by a longer succession of smaller ones. It is not just to take into account the storm figures, as it is impossible to use the energy of the waves at that time to any advantage. With these figures the actual horsepower per foot breast of waves becomes:

$$H.P. = \frac{31.18 \times 36 \times 300 \times 4}{33{,}000 \times 2} = 20.5, \qquad (5)$$

or approximately 20 horsepower per foot of width. In favored localities conditions may be found which will average at the above power, but on the larger part of our coast line this amount of power is not available. As this amount is possible, however, it will be taken as the basis of the following:

Wave Motors Depending on Horizontal Motion

Having determined to fair accuracy the amount of available power, the next step is to ascertain, if possible, the proportion which may be absorbed by the different classes of wave motor. These may be divided broadly into those utilizing the vertical movement of the water and those depending for their motion on the horizontal motion of the surface water or of the breakers on the beach. In regard to the latter class it may be noted that the energy of the horizontal motion is always a small fraction of the total energy. In the case of the movement of the surface water, the layer in which slow movement takes place is very thin and the proportionate amount of energy is consequently very small. This fact reduces the available amount of power to an extremely small per cent., so that a motor built to utilize this form of energy is necessarily inefficient. And there is usually a farther limitation in the motor itself, in that some portion of the power receiving member is always submerged in water which does not partake of the horizontal movement, the free motion of the member being thus greatly impeded and its transmitted power cut down.

This action alone probably reduces the power available from a horizontal-movement motor to the extent of 50 per cent., and it is consequently doubtful whether the output is equal to 5 cent. of the total energy of the waves. The other form of horizontal-movement motor probably gives better results from an efficiency standpoint, but the impulses from the breakers are more spasmodic and the energy therefore more difficult to handle. Moreover the total energy available from a breaker is only a part of the energy of the wave forming the breaker, as a large part of the movement is taken up by the cause of the breaking. the contact with the sloping shore. Also the falling of the water from the crest of the breaker effectually removes a large amount of energy. For these reasons the final efficiency of the horizontal-movement motor is singularly small, being much lower than that possible with the vertical-movement machine.

Motor Utilizing Vertical Movement of Water

Coming now to the vertical-movement type, it may be taken that about 75 per cent. of the total energy is available in the vertical movement of the water. The proportion available in this direction is far above that on any other direction, and consequently motors built to utilize this movement have more chances of success than others. However, there are limiting circumstances which prevent the present devices from utilizing but a diminutive fraction of the energy, these circumstances residing mainly in the inherent principles and construction of the motors. With a device showing a respectable efficiency, it is possible to finally utilize about 50 per cent. of the available power, about 37 per cent. of the total, or about 7½ horsepower per foot of breadth on the basis of the previous calculations. Even this possible figure is high, as there are several distinct losses in transforming the energy into a practical form suitable for transmission. In the usual case electrical energy is the final product and its production involves three transformations. The first is mechanical, being the conversion of the irregular motion of the waves into a reciprocating or a rotary motion. Striking an average, this means the loss of approximately 25 per cent., assuming that all of the energy of the waves is taken up by the floats or other members. The next operation is one of storing the energy in such a manner that it may be used regularly. In the typical instance the operation consists in pumping water into a reservoir under pressure, a loss of another 15 per cent. under the best conditions obtainable. The final step is that of converting the water pressure into electrical energy. On the water-motor side of this step the average loss will be at least 15 per cent. and on the electrical side about 10 per cent. The total loss in such a system would then figure approximately 51 per cent., or say 50 per cent.

The previous figure of 7½ horsepower per foot breast of wave is based on a float or other device which will absorb from the waves their full energy. Even with what might be termed a perfect device, this is not possible, the loss even then being at least 10 per cent. on account of mechanical limitations. If all the power were absorbed it is evident that the waves would be perfectly leveled out and that the last part of the power would be taken on an infinitesimally small movement. Practically, this is impossible and the average efficiency of such a device would be around 90 per cent., or the final horsepower in electrical energy produced would be 6.75. At this figure it would probably be profitable to produce and sell power at the prevailing rates, but this naturally depends to a great extent on the capital required for installing the plant.

Efficiency of the Float

The next point in question is that concerning the efficiency of the float or the device for taking up the energy of the waves. In all of the devices so far produced, these parts have been remarkably inefficient, being merely more or less buoyant objects moved by the waves and absorbing in most cases an inappreciable portion of their power. In some instances, however, a genuine attempt has been made to increase the efficiency by adding special devices to the float, and it is with this class the following will deal.

Referring to Fig. 2, where an exaggerated crest of a wave form is shown, the following will deal with possible and average float efficiencies. In Fig. 2 a comparatively short float is represented

FIG. 3. LONG FLOAT

floating on the crest, while in Fig. 3 a longer float is illustrated. In Fig. 2 the stroke of the float is approximately the distance S, and the power derived depends directly on this distance and the buoyancy of the float, or the weight of water displaced. In Fig. 3 the longer float is shown in full lines as having the same stroke S, and consequently displacing the same amount of water, riding equally high in the water as the smaller float. Its length is therefore useless, unless it is sunk to such a position as shown in dotted lines with a corresponding stroke S'. But the displacement has been increased and this increase has practically been proportional to the square of the decrease of the stroke, so that the energy available from the float increases directly as the stroke diminishes.

If this were the only condition imposed it is evident that by increasing the length of the float to equal that of a complete wave and sinking it so that it had its maximum buoyancy, the maximum power would be obtained. But there are conditions which prevent this being true. Looking again at Fig. 3, where the longer float is shown in the trough of the wave, it is seen that it does not sink to the same depth as the shorter float would, so that by increasing the length of the float we decrease the stroke from below as well as from above. Taking this factor into account for the shortest average wave lengths on which the float is designed to tally, the effectual length of the float will be reduced to approximately one-quarter of the wave length. Other considerations of a purely mechanical nature usually reduce the size farther to a fraction of this quarter length, a float of any considerable size being extremely unmanageable at sea, especially when in working connection with some fixed structure.

Taking the quarter length for the purpose of calculation, it is seen that only one-quarter of the wave energy is possible of absorption, as the float only comes into contact with and is operated by, one-quarter of the water in a single wave. On this basis the final power available is 6.75 ÷ 4 or 1.69 horsepower per foot breast. A float of, say, 20 feet breast would then afford 33.80 horsepower, a float of this size being fairly typical and amply large to be difficult to manage in storm conditions.

Cost of Installation and Upkeep

The cost of installation and upkeep of such a device and the attendant mechanism for transforming the power is variable with the style and nature of the machinery used. Calculating, however, on the formerly outlined plan, an approximate result can be obtained which is instructive. In the first instance the cost of the float and anchorage in the most inexpensive system known to the writer will average a minimum of $1000 per unit, this figure presuming the construction of a large number of units to aggregate about 10,000 horsepower. Reducing this to cost per horsepower, the outlay is $29.59. The next cost is that of running gear for connection with the fluid-pumping machinery. This may be reduced as low as $10 per horsepower, depending upon the design of the float and its relation to the pump. The pumping-machinery cost will average approximately $20 per horsepower, including piping, etc. The reservoir cost is so extremely variable that it is difficult to make a fair estimate. In the majority of cases, and it seems to be the most practical, water is the fluid used to store up the energy and it is pumped to a reservoir on the nearest and most suitable shore. Taking a fair average at a head of 100 feet and under favorable conditions as to location, an estimate might be placed at $20 per horsepower, allowing sufficient [illegible] water for twenty-four hours' run. The cost of electrical installation with water power would average around $60 per horsepower.

The sum of these economic figures gives a total outlay of $139.59 per horsepower, but it must not be assumed that there has been a complete, commercial, [illegible] installation built at a figure at all approaching this. [illegible] horsepower installation, it is [illegible] to presume that the [illegible] would [illegible] and that the [illegible] will be placed at [illegible]. Calculating all these factors, together with a possible return of $35 per horsepower-year, the following totals are obtained:

Interest on $210.50 at 6%	$12.63	
Caretaking, etc.	10.00	
Deterioration	21.05	
Power sale		$35 00
Totals	$43.68	$35.00

This leaves a balance of $9, in round figures, per horsepower-year on the wrong side of the account. Allowances have been made in favor of the motor at every step of its construction and operation, so that, although the above figures probably do not represent a possible installation, they give a fair idea of what the average motor lacks in the direction of making financial returns.

Reverting again to the consideration of a float or other device which will absorb a large proportion of the wave energy, it will be assumed as before that a total of 6.75 horsepower per foot breast may be finally produced in electrical energy. This increase in efficiency over the above-tabulated figures would lead to the following possible results:

Anchorage cost per H.P.	$ 5
Connection to pump per H.P.	5
Pumps per H.P.	75
Reservoir per H.P.	10
Electric installation per H.P.	50
Total	$145

These figures are again minimum, as every previous figure is cut with the exception of the electric installation. This would not be reduced, as it was supposed for the first figures that there would be a single electric plant for a large number of motor units. Again tabulating the expense and income, a small balance is obtained on the profit side of the account:

Interest on $145 at 6%	$ 8.70	
Caretaking, etc.	8.00	
Deterioration	14.50	
Power sale		$35.00
Totals	$31.20	$35.00

This gives a profit of $3.80 over all expenses. Thus, even with everything in its favor, it is doubtful whether the motor in its most highly efficient form would be a dividend-paying investment.

At any rate, until there appears a float or barge device which will absorb a fairly large per cent. of the energy of the waves, it is evidently impossible to deliver enough power to place the motor on a paying basis. Until this device appears it seems that the wave motor must remain undeveloped. If such a device is produced, it will probably be devised by someone who has made a scientific investigation of the facts in the case and has experimented with and tested the actual efficiency of models of machines growing out of his investigations.

Heat Transmission Through Pipes and Tanks

By F. E. Matthews

Given two rooms of the same dimensions and insulation, one cooled by a brine pan of a given cubical capacity and the other by coils of 2-inch pipe of the same capacity. The brine is circulated through the pan and pipes at a temperature of 10 degrees Fahrenheit during the day, but the brine pump is shut down at night and the rooms are refrigerated only by the rise in temperature of the brine (about 200 cubic feet) in the pan or coils, respectively.

Will the cooling devices be equally efficient? Will they both perform the same amount of work in a given time? Will the brine temperature in each be the same in the morning?

Heat transmission per square foot of surface from still air through a given thickness of iron to still brine should be the same in all cases where the temperatures of the air and brine are the same, or where the difference in temperature between the air and the brine is the same. Whether the heat transmission in a given time and subsequently the rise in temperature of the brine in the case in question will be the same, will depend directly on whether or not the two heat-absorbing devices present the same amount of heat-absorbing surface to the air to be cooled. This is on the assumption that all other conditions such as difference in temperature, direction and velocity of the air traveling over the heat-absorbing surfaces, and the resistance to the passage of heat offered by the heat-absorbing surface (which depends on material, thickness and structure) be the same.

In the case in question the kind of material, iron, of which the devices are constructed, is the same; the thickness of the material is slightly different, but this difference probably need not be considered provided the surfaces are not coated with ice, or are coated with ice of the same thickness and density. The velocity of the travel of the air over the heat-absorbing surfaces may be assumed to be about the same if the pipe coils occupy about the same space and same relative position in the room as the pan. The direction of travel of the air as regards the heat-absorbing surfaces will probably be a little more favorable in the case of the pipe coils, but this factor may also be ignored without any great error.

On the assumption, then, that all of the conditions are practically the same except the area of the surface exposed, it may be stated that the heat absorption and rise in temperature of the brine in the two containing vessels of the same volume will be directly proportional to the areas exposed. Except in the case of surfaces of the same shape there is no fixed geometrical relation between the area of the superficial surface and the volume. Of the more common forms the sphere contains the greatest volume within the least surface. Next to the sphere comes the cylinder, of which a pipe is the best practical example. It is farther evident that the ratio of volume to superficial area of the pipe may be varied by varying the shape of the cross-section. The surface of a square pipe would be greater than that of a cylindrical one containing the same volume, and that of a very deep, thin tank greater than that of a square pipe.

It is reasonable to assume in general a form of brine tank that would be commercially practical to construct, will have less heat-absorbing area per unit of volume than a coil of pipe of the same volume, and in the present case that the heat absorbed, the rise in temperature of the brine and subsequently the refrigerating capacity of the devices in question will be directly proportional to the superficial surface exposed. A single example will suffice.

A form of tank more or less commonly used in refrigerating systems in connection with brine circulation, and known as a congealing tank, is usually 10 feet long, 3 feet deep and 3 inches thick. Such a tank would have 66½ square feet of surface, including the open top, and a volume of 7.5 cubic feet.

A cube having the same volume would measure 1.957 feet on a side and would have 23 square feet of surface, or only 34.5 per cent. as much as the congealing tank.

To contain 7.5 cubic feet of brine a 2-inch pipe would have to be 322 feet in length and would have 201 square feet of surface.

The rate of heat absorption by the cubical tank of 7.5 cubic feet capacity, a flat congealing tank of the same cubical capacity, and a coil of 2-inch pipe of sufficient length to contain 7.5 cubic feet will be directly proportional to the 23 square feet, 66.5 square feet and the 201 square feet, respectively, of heat-absorbing surface exposed. This rate of absorption would continue so long as the conditions above defined are kept constant. It is obvious, however, that when the brine pump is shut down the cooling device having the greater area will absorb heat so much more rapidly that the brine contained will soon become much warmer than that in the other vessels, and as there is a lesser difference in temperature between the brine and the outside air, the heat absorption per square foot will be reduced, which would tend, but never allow, the brine temperatures in the other receptacles to become quite the same except in the limiting case in which the brine finally becomes as warm as the room and heat absorption accordingly ceases.

Reversing Direct-Current Machines

The Effect of Reversing the Residual Magnetism of a Generator, and the Change of Connection Necessary When Running as a Motor

BY F. P. M'DERMOTT, JR.

In solving problems concerning the reversal of polarity, or of rotation, of direct-current machines, certain principles can be used to advantage. It is the purpose of this article to show the application of some rules for studying these problems, including the problem of the behavior of the same machine as a motor and as a generator.

Rule 1—If the current through all of

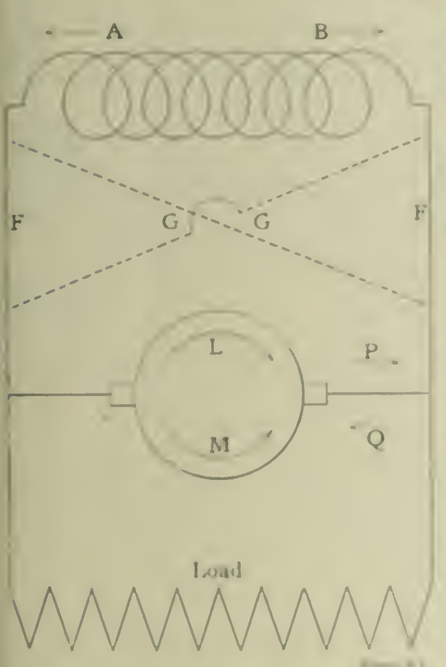


FIG. 1. SHUNT-WOUND GENERATOR

the field windings of a machine is reversed, the field magnetism is reversed. In a machine containing only one field winding, such as a shunt-wound or series-wound machine, reversing the current through this one winding reverses the magnetism, but in a machine with more than one field winding, such as a compound-wound generator, the field magnetism depends on the current in all of the field windings, and reversal of current in one of them may reverse the field magnetism or may merely change its strength.

When there is no current in the field windings there is generally some residual magnetism present. For convenience in discussing such magnetism, its direction will be referred to as corresponding to that direction of field current which would produce it.

Rule 2—Reversal of the field magnetism reverses the electromotive force generated by the armature if the direction of rotation is unchanged.

Rule 3—Reversal of the direction of rotation reverses the electromotive force generated by the armature if the direction of the field magnetism remains the same.

Reversing Residual Magnetism

The effect of reversing the residual magnetism of a generator is the first problem to which these rules will be applied. The discussion applies both to the shunt-wound generator, Fig. 1, and to the series-wound generator, Fig. 2.

For a certain direction of rotation *L*, let *P* be the direction of the generated electromotive force when the field magnetism corresponds to current in the direction *A*. According to rule 2, reversal of the field magnetism reverses the generated electromotive force and consequently if the residual magnetism corresponds to current in the direction *B*, the generated electromotive force is in the direction *Q*. Does it make any difference whether the field winding is connected to the brushes according to the lines *F F* or according to the lines *G G*? First, suppose that the connections *F F* are employed. When the residual magnetism corresponds to *A*, the generated electromotive force *P* forces current through the fields in the direction *A*, which is the proper direction for strengthening the magnetism. If the residual magnetism is in the direction corresponding to *B*, the generated electromotive force *Q* drives current through the fields in the direction *B*, which is still the direction of field current required for strengthening the magnetism.

Now change the field connections to *G G*. If the residual magnetism corresponds to *A*, then the generated electromotive force *P* drives current through the fields in the direction *B*, thereby weakening the magnetism. With the residual magnetism corresponding to *B* the generated electromotive force *Q* will send through the field windings a current which opposes the residual magnetism. From this it is evident that the machine cannot build up with the connections between the brushes and the field windings according to *G G*, but, whatever the direction of the residual magnetism, the generated current weakens it, whereas with the connections *F F* the generated current tends to increase the magnetism, whatever its direction, thereby causing the machine to build up. Of course, even with the correct connections there are many causes which may keep the machine from building up.

It is seen, therefore, that the same connections are required between the fields and the brushes for either direction of residual magnetism, but that with residual corresponding to *A* the generated electromotive force is *P*, and with the residual corresponding to *B*, the generated electromotive force is *Q*. Reversal of the residual magnetism, therefore, reverses the direction of the electromotive force generated by the machine.

Now let the direction of rotation be changed to *M* and the residual magnetism correspond to current *A*. The generated electromotive force has now the direction *Q* instead of *P*, according to rule 3. With the connections *F F* the current supplied by the armature reduces the residual magnetism, but with the connections *G G* it builds it. Similar reasoning

FIG. 2. SERIES-WOUND GENERATOR

with the residual corresponding to *B* shows that the connections *G G* are those required for building up. This shows that if the direction of rotation be reversed, it is necessary to reverse the connections between the fields and brushes.

It may be remarked here that to shift the brushes through an angle equal to the angular distance between adjacent poles has the same effect as reversing the wires connected to the brush holders. The actual angle through which the brushes should be shifted, if it is desired to change the direction of rotation without disconnecting the wires connected to the brush holders, is in most cases slightly greater or less than the angular distance between adjacent poles, so as to give the brushes the proper lead for the reversed direction of rotation.

These principles also apply to a compound-wound machine, Fig. 3, but here there are two branches through which the generated current flows. The direction of magnetism which the generated current tends to produce should be the same for each of these branches. If this is the case with the connections *F F*, it is also the case with *G G*, since reversal of the connections at this point reverses the current in both windings. If, however, the

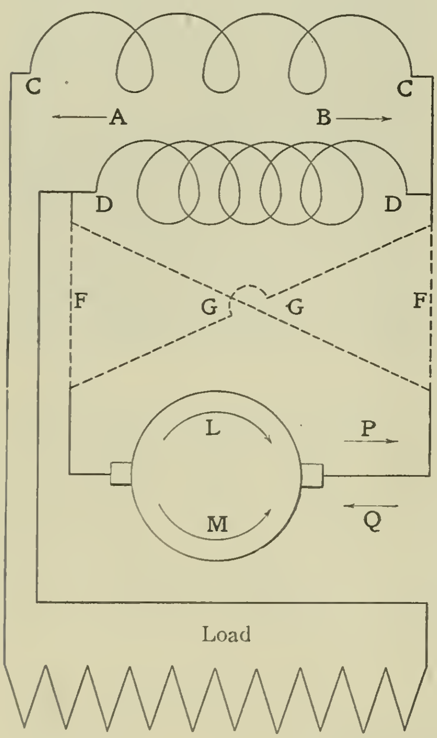


FIG. 3. COMPOUND-WOUND GENERATOR

fields be disconnected either at the points *C C* or *D D* and transposed, their magnetizing tendencies oppose one another when the generated current passes through them. Even though the two field windings both tend to magnetize the fields in the same direction, that direction may be such as to destroy the residual magnetism, just as was seen to be the case with a machine having a single field winding.

Generator as Motor

In studying the behavior of a machine as generator and as motor a fourth rule must be added to the three preceding.

Rule 4—When a machine acts as a motor, it generates an electromotive force, known as the counter electromotive force, which opposes, but is less than, the electromotive force applied to the brushes.

Fig. 4 represents the same machine as Fig. 1, with the fields connected according to *F F*. Supply current to the machine from a source of power, as shown. This sends current through the field winding in the direction *A*, and through the armature in the direction *Q*. The counter electromotive force must oppose the electromotive force applied to the

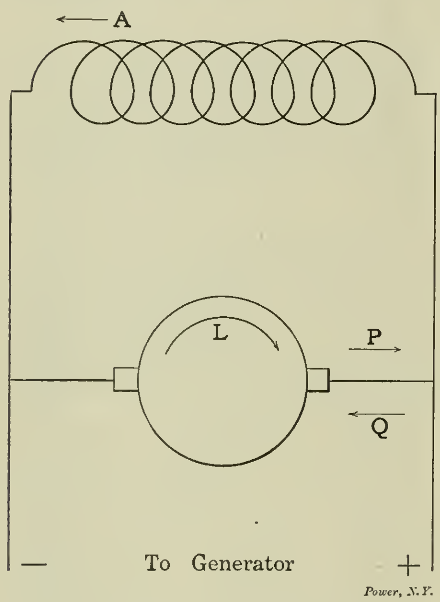


FIG. 4. SHUNT MACHINE AS MOTOR

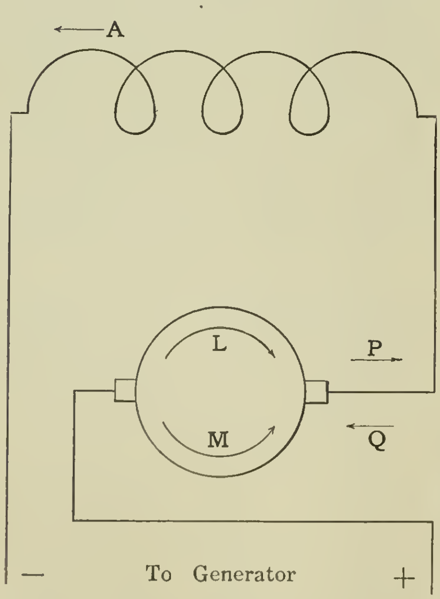


FIG. 5. SERIES MACHINE AS MOTOR

brushes, and hence have the direction *P*. But, as generator, with field current in the direction *A*, and connections as shown, the armature rotates in the direction *L* when producing this electromotive force. This is the same direction of rotation that the machine must have in order to generate. A shunt machine, therefore, acting as a motor, has that direction of rotation with which it must be driven in order to generate, supposing that the connections remain unchanged.

Fig. 5 shows the same machine as Fig. 2, connected according to *F F*. Pass current through the machine from a source of power in the direction *A*. The motor must run so that its generated electromotive force opposes the electromotive force of the source of power, that is, the counter-electromotive force must have the direction *Q*. To produce a counter electromotive force in the direction *Q* when the field current is in the direction *A* requires that the armature rotate in the direction *M*, which is opposite to the direction *L* in which the machine must be driven in order to generate. A series machine, therefore, operates as a motor with the direction of rotation opposite to that in which it must be driven in order to generate.

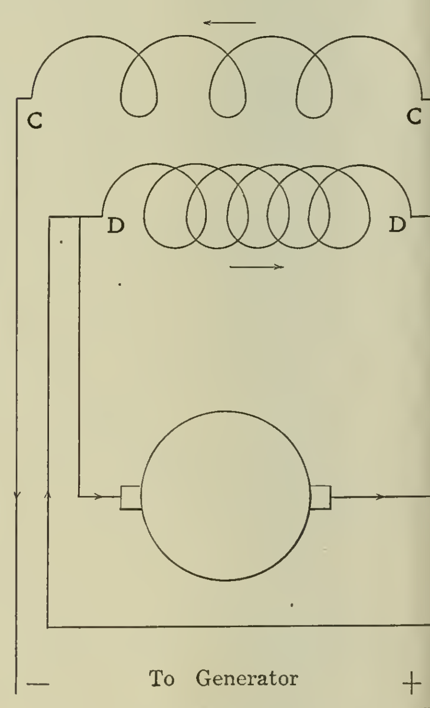


FIG. 6. COMPOUND-WOUND DYNAMO AS MOTOR

If the compound-wound generator, Fig. 3, be connected according to *F F* and supplied with current, the state of affairs shown in Fig. 6 exists. The two field windings oppose each other, giving a differentially wound motor, which is now seldom used. In a compound-wound motor the two fields act together, producing a stronger field as the load increases. To convert a compound-wound generator into a compound-wound motor, it is necessary to reverse the connections to one of the fields; that is, disconnect and transpose at either *C C* or *D D*. A compound-wound generator has the field windings belonging to a series machine and also those belonging to a shunt-wound generator. As a series machine it would be expected to run as a motor and as a generator in opposite directions, but as a shunt machine it would be expected to run in the same direction in either case. Suppose that it is desired to run it as a motor in the same direction that it runs as a generator. The shunt winding tends to cause this, but the series winding tends to cause the opposite, and the series is accordingly the winding to be reversed. When it is desired to have the machine run as a motor in the opposite direction to that in which it runs as a generator, the shunt winding must be reversed.

To test the connections of a compound-wound machine, run it as a motor with the shunt field open, keeping sufficient resistance in the circuit to prevent excessive current or speed, and note the direction of rotation. Next run it as a shunt motor, again noting the direction of rotation. If the machine is connected as a compound-wound motor the direction of rotation is the same in each case, but if it is connected as a compound-wound generator, the two trials produce rotation in opposite directions. It should be driven as a generator in the same direction that it runs as a shunt motor.

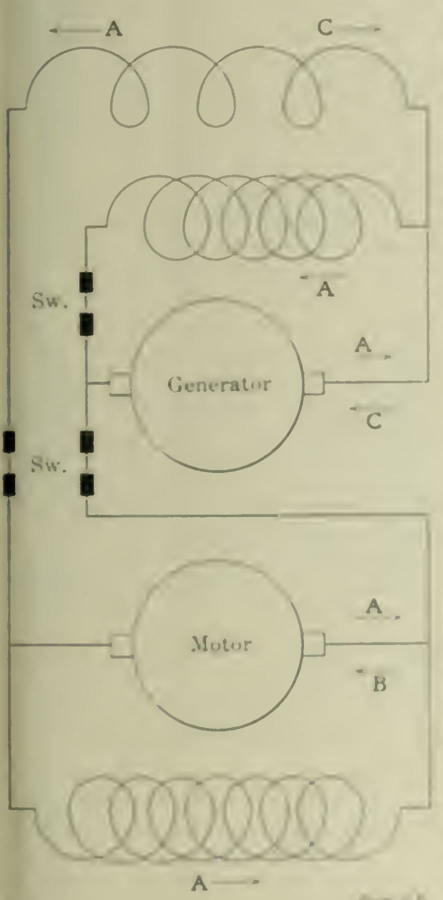


Fig. 7. Compound-wound generator driving shunt motor

A Reversal of Polarity

A special application of the foregoing principles is illustrated in the following problem: A compound-wound generator had as its only load a shunt motor running light. The shunt field of the generator was opened, after which the motor was disconnected. The shunt field of the generator was again closed, and the generator built up with reversed polarity. Why?

Fig. 7 shows the connections. Suppose the original direction of the currents in the various circuits was that indicated by the arrows *A*. The motor produces a counter electromotive force in the direction *B*, almost equal to the electromotive force of the generator. When the shunt field of the generator is opened, its electromotive force falls, owing to the decrease of field magnetism. The momentum of the motor armature causes it to continue rotating, and its electromotive force *B* excites the motor field in the same direction as originally, and also forces current through the armature and the series fields of the generator in the direction *C*. The generator thereby has its magnetism reversed, and when the shunt field is again closed this reversal of field magnetism causes it to build up with reversed polarity.

Drops of Ink to Make You Think

By the Ink Maniac

Yesterday has gone, today is short, tomorrow may never come, so if there is any money to save, get busy quick!

The Engineer Becomes Chatty and Confidential

Say! Have you read that book of Andrew Carnegie's yet? Well, it's called the "Empire of Business," and it's all right! All the way through he shows you've *got to save money!* I guess "Andy" knows what he's talking about when he says "Be thrifty." Why, out there at Gary, Ind., in the new steel plant, the gas from the blast furnaces—gas such as for fifty years they used to manufacture Pittsburg's famous atmosphere with—is now all saved, every bit of it, and all the big machinery and electric lights are run from this gas. They get [illegible] horsepower right along, and they say they don't have to buy coal for power. It's pretty near like getting something for nothing, ain't it? Of course, they have to put in a dust catcher and washing machines, so the gas won't spoil the machinery, but the fellow that won't spend a hundred dollars when it will save him fifty dollars a year is about ready for the scrap pile, in my opinion, when it comes to knowing what the word *investment* means.

The By-products of [illegible]

Maybe old man Armour didn't make some money out there in South Chicago [illegible] machinery and brains, too! Why, now, every old hog, they've got the "by-products" of [illegible] down to such a fine point that [illegible] every [illegible] of hogs they buy they sell a [illegible]

And I guess John D. is pretty wise to this saving game, all right. They used to pump petroleum, get some gasoline and coal oil out of it, and throw the rest away. But nowadays the old chemists dig down in their queer old laboratories, and then we hear of a new "vaseline" on the market, or a "non-fluid oil" or a new axle grease. And so it goes every year, more and more usefulness out of the same old stuff that we ordinary folks thought didn't contain anything new at all.

Explanation of "By-product"

Whether we read about a [illegible], or the expert butcher, or the men that save money, they always use the term "by-product." Now, that sounds kind o' swell and dignified, but I guess it's all right when you think about it. "By" really means "on the side," or extra. Just like when you order roast beef, and the waitress hollers: "Potatoes on the side," why you get them for nothing. So "by-product," when you boil it down, just means that you get something where you used to get nothing, 'cause you had been throwing it away.

The Engineer's Confession

Now, I've been interested in this kind of business lately. You know yourself that I've been an engineer on land and sea for twenty years, and I can keep an engine room slick and clean, without a [illegible] anywhere, and I'm pretty wise to indicators and things, and the electrical game too. Well, last spring I got a jolt that hurt my feelings for a little while. You know, when you jog along regular, and things go smooth, and the boss gives you a raise now and then, why you sort of feel your oats—I guess some fellow would say you get to be a big frog in a little puddle. That's the way I was last spring. But I've changed. I know now that a little frog in a big puddle is a whole lot better off than a big frog in a little puddle. A little frog not only has room to grow, but he is willing and dead anxious to, so as to [illegible] the big fellows [illegible] around him. The big frog can't hardly move around in his little puddle. Well, anyhow, [illegible] always some [illegible] a little better.

[illegible]

Well, [illegible] brought in some outside fellows [illegible] in my engine room. Honest, I didn't think they could do it [illegible] and [illegible] a lot of money. Those fellows were [illegible]. One of them was a [illegible] [illegible] fornia ham and, say, I'll bet he never wasted any of his time, any more than I have, sitting around with the manicure maids holding on to his hand.

I knew right off that he was a practical man, but I didn't believe him when he said the tall fellow was practical, too; at least, not at first. Well, this is what these fellows did: One day they came in, after I had got pretty well acquainted with them, and we made some changes in the firebox. The next day our regular coal truck didn't come but, instead, a new dealer dumped in a lot of dirt, at least that's what it looked like. They told me it was a dollar and three-quarters a ton cheaper than what we had been burning. I had always believed in buying the best coal on the principle that the best is none too good, and I didn't believe that that stuff would burn at all. But one of the men stayed with me for a couple of hours and showed me how it ought to be fired, and she held the pressure all right, and carried the load right through the evening peak without a bit of trouble.

Where the Saving Came in

Then I began to get interested, and wondered how many tons would be needed. I had always supposed that when you used cheap stuff you had to use so much more of it that it would make up for the low price. So it certainly was an eye-opener to me when we found that it didn't take a bit more of this new stuff every day than we used to use. And then I was pleased to find that although it looked like dirt, it really made less ashes by a third than I used to be getting with regular coal. When I got to figuring on this, I could easy see why the boss got interested, because we burn about ten tons a day most of the year, and $17.50 a day saved amounts to over $5000 a year!

And then something happened that I was mighty glad about. I had often told the boss that he could save a good deal of money on the water bill if he would save the condenser water from the refrigerating plant. But the boss was kind of "leary" about spending three or four hundred dollars on my sayso. These fellows were able to show him figures from other buildings, I suppose, and the boss said: "Go ahead and fix it up." Well, sir, it turned out even better than I thought it would, because the water bill is really $200 less a month than it used to be during the same season of the year, and that's about $2400 a year.

These fellows also seem to have a pretty good stand-in with some of the supply people, because they got us oil and ammonia and things like that at lower prices than I could ever get 'em for, even though the same label was on the can.

I'm real proud of my plant, now, and I'm glad I worked with these fellows instead of bucking them, because I get part of the credit for this $8000 a year that is saved. Some of the things that have been done are just what I have been yelling for during the last four or five years. So I don't think the consulting engineer is such a bad fellow, after all—that is, when he's got some good practical men with him that really know what I'm up against down here and who help me to make good. And the boss is so well pleased with everything that he gave me a raise the first of the year, and now "the goose hangs high."

The Garden Variety of Gas Engines

By H. W. Jones

As a rule, the expression "gas engines" conveys nothing to the mind. The writer or speaker may mean engines driven by gasolene or alcohol or distillate or producer gas or kerosene. This brief article, however, relates to gas engines burning *gas*—the kind that you get a bill for each month, the kind of bill that causes a man to increase his vocabulary, the kind concerning which each of us has tried in vain properly to express his inmost thoughts, finding that his mind refuses to act and all he can do is to get red in the face and pollute the air with his emotions.

The primary cause of large power-gas bills is, in truth, ignorance, in many cases equally divided between the user of the engine and the maker of the engine. The situation reminds me somewhat of the statement that "Some Americans are democrats and some Americans are republicans, but the Irish stick together and get all the offices." No matter what the kind of engine, the gas company gets all the money called for by the meters.

The makers of gas engines are to blame in a great measure for exorbitant gas bills because they permit people who do not and cannot make gas engines to sell machines claiming that they are engines, and gas companies are also blamable for allowing imitation gas engines to continue to drive away their business. The buyer is generally the innocent bystander who gets the full force of the brick and has only refuge in "language." And if you really want to hear language "as she is spoke," drop into the office of the man who has purchased one of these so-called gas engines at the time he gets his first gas bill. It is really quite interesting, as well as exciting. I have had this pleasure and I have wondered how it was possible for a man to have so much vitriol in his system and still live. This is especially true when it is that kind of a gas engine that "does not need an engineer to operate it; all you have to do is to pour oil on her and start her up." Words are inadequate with me. Not so with him. I am sure he used all the words there are and he invented several new phrases, one of which I am very proud to possess. How is this one: "An infernal damn piece of misrepresented mechanical iniquity?"

I struck another one of these cases recently. On a cold morning at about 9 o'clock I called at the factory of a man who had (or, rather, thought he had) bought a gas engine. An ominous calm of the kind that precedes a violent storm settled down upon me as I entered the office. The young lady there, knowing me, said: "Oh! Mr. Jones, go down stairs quick, the engine, the engine won't go, and Mr. Blank (the proprietor) is going on something awful!" Hurrying down, I saw Mr. Blank at the wheel making a noise like the blowing off of the pop safety valve of a locomotive. He was surrounded by twelve men—every man on the place—and all of them seemed to be affected with a very tired feeling.

When Mr. Blank saw me (he had been pulling on the flywheel until he was warmed up) he was silent for a few seconds and I have always wondered whether he was thinking what to say, or if he was waiting to get breath enough in his person in order to say it. What he said when he got started was much like the noise of a giant skyrocket just after it is fully ignited. His statements were too explosive to follow verbatim, but I gathered that the entire force had been working over the engine since early in the morning and that on the previous morning three men quit at 10 o'clock because of that "infernal damn piece of misrepresented mechanical iniquity."

Before his vocabulary was anywhere near exhaustion, Mr. Blank was called into the office and I looked over the engine and found the automatic inlet valve stuck. It was not five minutes after we got the engine started when he came down stairs again and in his hand was the gas bill; this was the climax. He was a heavy man and had a heavy voice. His face was *red*. His voice was raised to a high pitch. His oratory was magnificent, and his gestures sublime, but his language was, as the young lady had said, "something awful." His gas bill was $85 for an 18-horsepower engine pulling about 12 horsepower continuously, eight hours a day. After he had cooled down some he told me about it. The salesman had guaranteed that his gas bill would not be over $45 per month.

I persuaded this man to trade off that engine in part payment for a 25-horsepower real gas engine. He added 5-horsepower load on the big engine and his bill has exceeded $65 only once since it was installed.

The first engine had 45 pounds compression; the second had 85 pounds.

The first engine intake-valve spring was too weak and the intake valve opened partly on every stroke that the governor tried to cut out (hit-and-miss regulation), with consequent fuel waste.

The first engine's igniter could not be

set far enough in advance to ignite the mixture properly with so low a compression.

The second engine, well, it was a *gas engine*.

The moral is to find out what a gas engine ought to be, but don't pay too much attention to what interested persons tell you. I'll just suggest this much: Liberal compression and the mechanical construction in accordance with this compression is one of the greatest factors in economical and successful gas-engine operation. How much compression? O, 100 pounds and the indicator card should show a maximum of about 350 pounds; don't let anybody talk you out of it. But the makers must build their engine to stand the strain.

Remember that gas engines are not like politicians; we can't love them for the enemies they have made.

Test of a Six-Ton Jack

By G. A. Gilk

The object of this test was to obtain the efficiency of a six-ton jack, which in this case would be the actual load lifted divided by the theoretical load that should have been lifted, and the quotient multiplied by 100 so as to have the expression as a percentage. Since no means of directly loading the jack and measuring the load were available in the laboratory, an indirect method was resorted to. A beam 6 feet long was placed on the jack as in Fig. 1. The loads were applied at W. The force extended upward by the jack at L times its arm, 1 foot, must be equal to the force W exerted downward times its arm, 6 feet, the moment arms being both measured from A, so that

$$1\ L = 6\ W.$$

A jack lever 1 foot long was used with the jack, and the actual pulls required to raise or lower the different loads measured. From these pulls the theoretical loads were calculated, and by means of these two loads the efficiency of the jack at that load computed. The calculation of the theoretical load was as follows:

P = Pull in pounds at end of lever,

T = Theoretical load that jack might lift were there no losses,

h = Lead of thread in inches,

r = Length of lever arm in inches.

When P, the pull, travels around the jack once and the screw makes one revolution, the work done is

$$W = 2\ \pi\ r\ P \text{ inch-pounds},$$

[illegible] T is raised h inches, so that

$$W = h\ T \text{ inch-pounds}.$$

[illegible] the work done at the [illegible]

$$W = 2\ \pi\ r\ P = h\ T$$

$$T = \frac{2\ \pi\ r\ P}{h}$$

In the jack used for this test, h = [illegible] inch, r = 12 inches and

FIG. 1. METHOD OF LOADING JACK

RESULTS OBTAINED FROM TESTS ON JACK

W	L	Screw and Thrust Washers Unlubricated: P	T	E	P	T	E	Screw and Thrust Lubricated with Heavy Oil: P	T	E	P	T	E
Load on Beam, Lb.	Actual Load = 6W, Lb.	Pull Raising Up, Lb.	Theoretical Load, Lb.	Efficiency, Per Cent.	Pull Lowering Down, Lb.	T, Lb.	Eff., Per Cent.	Raise Up, Lb.	T, Lb.	Eff., Per Cent.	Lower Down, Lb.	T, Lb.	Eff., Per Cent.
29	171	16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
54	424	31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
81	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	2000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Lead of jack (screw) = [illegible]". Length of jack lever = 12".

FIG. 2. EFFICIENCY CURVES PLOTTED FROM TESTS

$$T = \frac{2 \times \pi \times 12}{[illegible]} P = [illegible]\ P.$$

Two tests were made on the jack. The first in which the threads were thoroughly cleaned with gasoline, and the second in which the threads were lubricated with heavy oil. The pulls were taken to raise the load up and to lower the load down. The data are given in the accompanying table.

[illegible]

[illegible]

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

That Harwood Boiler

In the March 22 number, under the above caption, I notice a contradiction, in part, of the article on this subject that appeared over my name in the December 22 issue, wherein I stated that "the crack was not located under the lap, but ran parallel to the edge of the overlapping plate."

The article of March 22 states that after viewing the plate at the office of the State inspector the deduction was formulated that the "crack is plainly one of those internal cracks occurring, as is usually the case, just under the edge of the rivet heads and so hidden by the inside sheet as to be impossible of detection by any inspection short of unmaking the joint."

Now, as to the crack being hidden, I think the engineer's statement "that he removed some of the bricks and found that the steam was coming from a crack 18 inches long at the longitudinal seam" should be credited, especially when it is corroborated by everyone who saw the boiler before it was cut up, and by the State inspectors who examined the crack before the boiler was taken from its setting.

It may be that the writer of "That Harwood Boiler" drew his conclusions from the inside or convex side of the boiler sheet and in that case the crack may have been partially hidden by the lap, but he should remember that there are two sides to every boiler, the inside and the outside, and it is not necessary to take the joint apart, as he expresses it, to view the outside of the overlapping plate, the removal of a few bricks being all that is necessary.

I know that this procedure is not followed by inspectors when making inspections, but if there is any possibility of a lap-joint defect being discovered by the removal of a few bricks and as close an inspection of the outside of the lap as is given the inside lap, I think it would be an admirable innovation.

An instance of what can occur on the outside of a joint and not show on the inside was illustrated to me when the side wall of the setting of a boiler some thirty years old, that had been carrying 60 pounds of steam and was used for heating purposes, was removed. It disclosed the fact that the rivet heads on the longitudinal joint of the middle sheet had been burned and corroded so badly as to be practically destroyed, leaving the boiler in a very dangerous condition, which would probably have been discovered years before had the brickwork down to the joint been removed when making the annual inspections.

ARTHUR F. CLAWSON.

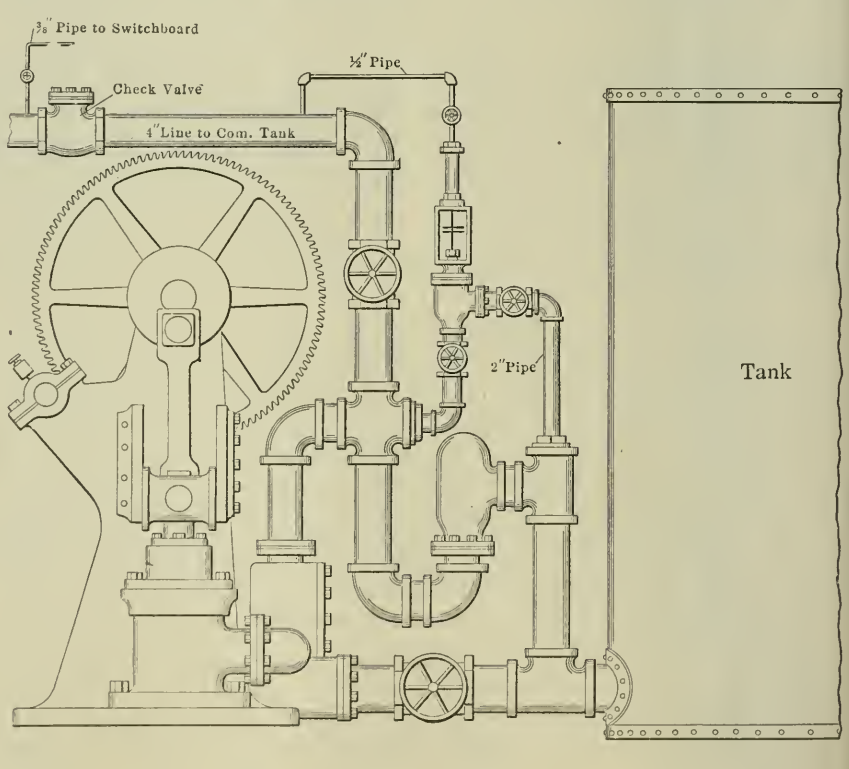
Lynn, Mass.

Pump Piping

The accompanying illustration shows the arrangement of suction and discharge piping in connection with a single-acting triplex power pump operating the compression-tank elevator system in any hotel building. The pump is belt-driven by an induction motor controlled by an automatic switch operated by pressure transmitted through the ⅜-inch pipe shown in the sketch, and adjusted to a minimum and maximum compression-tank pressure of, respectively, 100 and 110 pounds per square inch.

In order to secure the advantage of starting against zero pressure, thereby giving the motor an opportunity to attain full speed before beginning work against the minimum tank pressure of 100 pounds per square inch, a pump governor is rigged up to control a bypass through a 2-inch pipe connecting the discharge line to the suction pipe, as shown.

The philosophy of the device is this: The instant the compression-tank pressure attains the maximum of 110 pounds, and the pump is stopped through the medium of the automatic switch in the motor circuit, the pressure between the pump-delivery valves and the check valve in the discharge line immediately begins to subside by leakage through a very small aperture in the governor valve, and in one or two minutes is reduced sufficiently to permit free action to the governor spring in raising the valve and opening wide a passage to the large tank by way of the 2-inch pipe. This action of the governor permits a direct discharge into the suction pipe during the first few strokes of the plungers when the pump is again put in motion; but as the speed of the pump accelerates, a pressure is created beneath



SHOWING AN ARRANGEMENT OF SUCTION AND DISCHARGE PIPING the check valve, and this pressure, being transmitted through the ½ inch connection to the governor, depresses the valve, closes the bypass, and the water continues to pass on through the check until the pump stops, when the cycle of operations is repeated.

The most objectionable feature of the apparatus, aside from those objections which might be raised on general principles, involving such defects as continual trouble in keeping the switches in order, as well as the infernal noise of the gearing reverberating throughout the house, lies in the wear and tear and constant breaking of the pump-discharge valves and stems by reason of the tremendous impact of the valves against their seats.

The machine grinds away at a rather high rate of speed when in action, and this circumstance, combined with the fact that the area of discharge orifice for each plunger is covered by a single valve, might occasion an excessively high lift of the valve in order to give the necessary annular opening for discharge, as well as to compensate for inordinate water friction. At any rate, the valves came down against their seats with the force of a trip hammer at times.

The builders of the pump made no provision in its design for the use of an air chamber, evidently not intending or anticipating its employment in the service described, and the amount of head room, as well as the leeway laterally, will permit of running up from the riser out of the discharge chamber with a piece of pipe only 4x10 inches. The question is, will this suffice for an air chamber?

The motor for driving this pump is supplied with current from an outside source, while there are two boilers of ample size generating steam at a pressure of 75 pounds per square inch within 30 feet of the apparatus. These boilers supply steam for laundry and heating purposes principally, the drafts upon them for this service being well within their capacity. It might appear, therefore, that under the circumstances a good Duplex steam pump would serve the purpose of the elevator system far more efficiently than the present belt-driven rig, both from a thermal as well as from a mechanical point of view.

A. J. Dixon.

Chicago, Ill.

Repairing Worn Guides

The guides on a high-speed center-crank engine had become so worn, and the piston rod vibrated so, it was impossible to keep packing in the stuffing box and there was a constant blowing of steam, which condition was responsible for several broken rods and one cylinder head. The lower guides had become worn in the center (as is shown somewhat exaggerated at E), and the top guide could not be lowered, as at the ends the crosshead was comparatively tight; so the only real cure was to dress the lower guides true. As these were solid with the engine frame the undertaking was made more difficult.

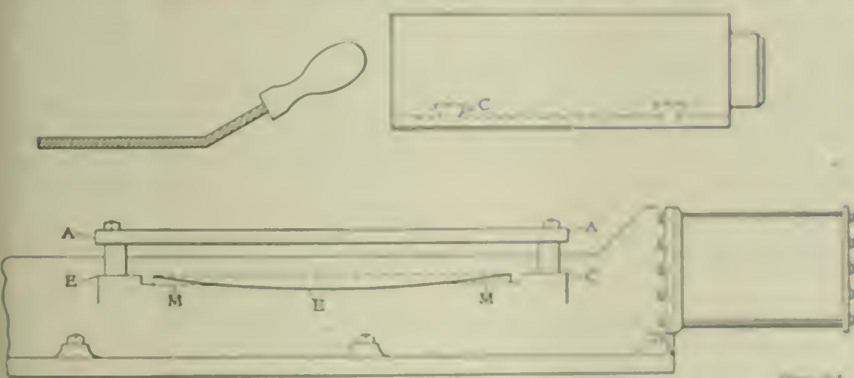
The first step necessary was to determine how much was to come off the ends; therefore, the lowest point in the center of the guide had to be found by first trying the distance from AC and AE and finding this to be parallel (or if not, made so), taking a pair of dividers and scribing a line as shown by MM, setting the dividers so as to make this line low enough to take in the wear in the lower guides. Both sides were treated alike. Then we removed the top guides and carefully chipped the lower guides down at each end. We had several files heated and bent as shown at D. Around the guides down true to a straight-edge and scraped the surfaces perfectly true.

The crosshead had been sent to a machine shop, and as the difference of wear was not sufficient to allow room for a babbitt shoe it was necessary to plane off some of the casting and cut some slots as shown at C. Good hard babbitt was then run onto the crosshead and dressed to the required thickness. The crosshead had to be planed more on the lower side of the line AB than on the top, the distance being obtained by trueing a line through the center of the cylinder, then laying a straight-edge or small scale across the guides, and measuring from the center of the rod to the lower edge of the straight-edge, giving the distance the babbitt had to be dressed on the crosshead.

When the crosshead was finished we placed it in position, after coating the under side with red lead, and, by sliding it back and forth, any high or uneven places could be located on the lower guides, which, by the use of a hand scraper, were lowered, and we soon had a perfect fit. Then we replaced the guides and moved the crosshead back and forth to see that it had proper play. When the engine was started up the blowing of steam from the stuffing box was cured, and no further trouble was experienced.

C. R. McGahey.

Lynchburg, Va.



REPAIRING A WORN GUIDE

Dashpot Troubles

In the replies on page 487 of the March 9 issue, regarding Ellsworth Davis' dashpot troubles, I notice that George W. Harding attributes them to too late a cutoff. As the engine is of the Corliss type, and running on a very light load, I do not see how it could be that.

I am operating a small Corliss engine with dashpots of the double-plunger type, leather-packed, which give the same trouble. On a very light load the head-end dashpot plunger will not seat, but hangs up until the hook drives it down. On anything better than one-fourth load it works very nicely. This dashpot has always worked this way, despite all that I could do.

I have always laid it to the fact that with a light load and a very early cutoff the steam was expanded down to such a low pressure, perhaps to no pressure, in the cylinder that none remained for compression. Consequently, with a boiler pressure of 150 pounds gage, on one of the valves and no compression whatsoever, the valve would work very hard and, as the dashpot plunger had lifted such a short distance, the vacuum in the dashpot was not strong enough to draw the plunger down.

The reason that the crank dashpot does not work on that account is because the crank end of the cylinder has a smaller area, due to the piston rod, and will not receive so much steam for compression.

H. E. Wagner.

Pomeroy, Ohio.

Referring to Ellsworth Davis' dashpot troubles, I had a similar experience, which I found easy to remedy.

It was on a single-eccentric nonreleasing Corliss engine. The dashpot would work fine on light load and low steam pressure, but when the atmosphere was leaked by hand I found the trouble on the valve stems and bent on the valve, due to insufficient lubrication at that place the steam pressure was high or the cutoff was long, the excessive friction was too much for the dashpot to overcome.

To get rid of this I drilled holes in the bonnet behind the washer on the valve stem, and made a groove to them so that the steam would have a tendency to equalize the pressure. Afterward I had two collars made, with two set screws spaced 90 degrees apart, and placed one on each valve stem, so they would come up against the shoulder on the bonnet outside and hold the end next to the valve away from the bonnet next to the valve.

G. Clinton Smith.

Carmi, Ill.

Wrought Iron Pipe

On page 478 of the March 9 number H. E. Schuler tells us how wrought-iron pipe is made and states that to get wrought iron it must be specified as strictly wrought iron. My way of writing specifications and contracts has been: "All dimensions given for all sizes are inside diameter; all pipe shall be wrought iron and full standard weight; all steel pipe, and all pipe not full standard weight and perfect threads will be returned at the expense of the contractor."

It would seem that this was sufficiently stated so there could be no mistake, but I have returned steel pipe, pipe that was of "merchantable" weight only, and pipe that had no protection on the threads and consequently the threads were all battered.

It is surprising how many contractors will furnish light-weight merchantable pipe and steel pipe when it is expressly stated that it will be returned.

W. E. Crane.

Broadalbin, N. Y.

Curing Rubber

Will some reader tell me what will be the number of square feet of 1½-inch and 4-inch pipe surface required to raise a charge of rubber to be cured, using the 4-inch pipe as a manifold, making four coils? The total amount of rubber is about 400 pounds, distributed in 160 galvanized-iron pans weighing 770 pounds, soapstone weighing 2400 pounds and an iron grating weighing 1000 pounds, placed over the pipe. The tanks are placed in the heater on wooden slats, the temperature being 60 degrees Fahrenheit with a gradual rise in six hours to 270 degrees Fahrenheit. The size of the heater is 20x12x10 feet. It is made of matched boards inside and outside, and lined with asbestos paper, and there is a 3-inch air space between the walls. It is 100 feet from the boiler room. The boiler pressure is 80 pounds. The steam main is a 2½-inch pipe covered with magnesia pipe covering.

H. C. Stevens.

Naugatuck, Conn.

What is the Trouble with the Engine?

The accompanying diagrams were taken from an old style Fitchburg engine. What change should be made to get good dia-

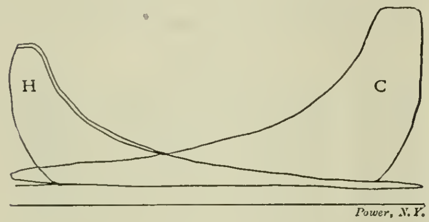


FIG. 1

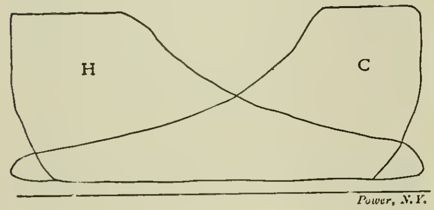


FIG. 2

grams at light loads? The steam lines often meet at times when conditions or load are right.

E. O. Brown.

Boston, Mass.

Wants Diagrams Explained

The accompanying diagrams were taken from a 16 and 32 by 42-inch compound condensing engine driving a flour mill in India. I should like to know why, when

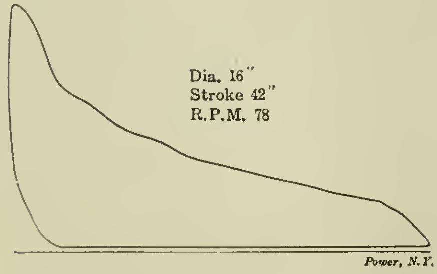


FIG. 1

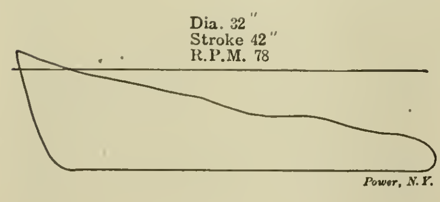


FIG. 2

the cutoff in the high-pressure cylinder (Fig. 1) appears to take place at about one-seventh of the stroke, the terminal pressure is so high? In the low-pressure diagram, Fig. 2, the terminal pressure is higher than it should be. What is the cause of this?

C. K. Desai.

Punjab, India.

Water Power

I was very much interested in the article by Thomas Wilson on "More Water Needed at Colliersville;" also the editorial, "Is Water Power Cheaper than Steam?"

It seems to me that there is a lamentable lack of care in the working out of many hydraulic propositions. In the February 9 number is a very interesting description of the plant at Milford, Me., by S. Rice. One would gather from this description that this plant was very successful in its operation. I am led to believe, however, that this is another of the plants which has not come up to expectations. It would be interesting to know something about its operation, with reference to its success as a commercial proposition, and as to whether it is true that so far it has been unable to develop anything like its capacity during the greater part of the season.

I am not able to state my authority, but I understand that this plant has been unable to develop the power which it was designed to deliver to one or more of the mills whose water rights it took in order to complete the development, and that it is not commercially successful.

I believe this is the case in many plants developed during the last eight or ten years, mainly because the records of flow on the rivers were not carefully and thoroughly investigated and the minimum flow was greatly overestimated. There has also been considerable difficulty from the fact that the maximum flow was equally underestimated, and a number of plants have had the misfortune to back up the water so far as seriously to inconvenience towns and manufacturing establishments along the river, so that the damages resulting from the backing up were so great as to cause much inconvenience to the owners of the water power.

This came principally because the spillway was not sufficiently large to allow the enormous volume of water due to freshets to flow over them without raising it to such a hight as to make trouble farther up the stream. It would seem advisable in any water-power development not only to take the Government records, but also to spend considerable time in the investigation of such records as may be found throughout the region where the development is to be situated. One cannot go too far back in looking up such records, and one cannot be too careful in examining for both maximum and minimum flow of the river.

Henry D. Jackson.

Boston, Mass.

Prony Brake Horsepower Curves

These curves give the horsepower of a prony brake having an effective arm length of 5 feet 3 inches, between the limits of from 5 to 100 horsepower and between 75 and 500 revolutions per minute. The curves were obtained as follows: Let

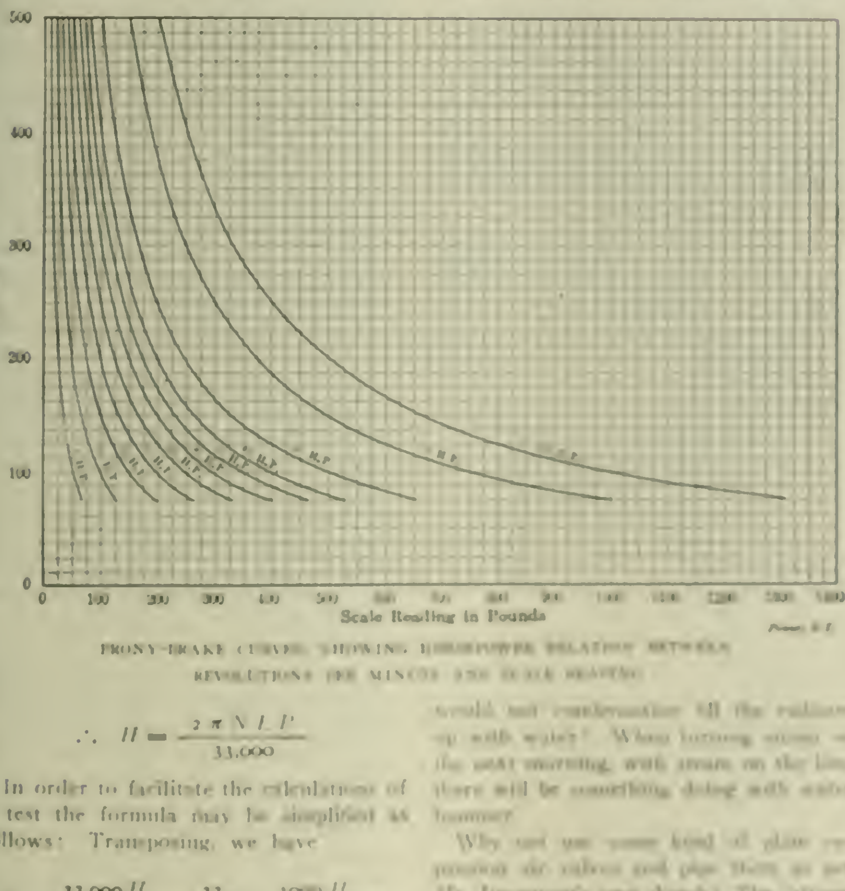
H = Horsepower,
L = Net length of brake arm,
N = Revolutions per minute,
P = Net load on the scales.

Then, the work of resistance, 33,000 horsepower, is evidently equal to the product of the load P into the distance through which it would travel if left free to rotate, that is,

$$2 \pi N L P$$

Or

$$33{,}000\, H = 2 \pi N L P$$



PRONY-BRAKE CURVES, SHOWING HORSEPOWER RELATION BETWEEN REVOLUTIONS PER MINUTE AND SCALE READING

$$\therefore\ H = \frac{2 \pi N L P}{33{,}000}$$

In order to facilitate the calculations of a test the formula may be simplified as follows: Transposing, we have

$$L = \frac{33{,}000\, H}{2 \pi N P} = \frac{33}{2 \pi} \times \frac{1000\, H}{N P} =$$

$$5.25 \text{ (nearly)} \times \frac{1000\, H}{N P}.$$

Therefore, if the net length of the arm is 5 feet 3 inches, we have

$$H = \frac{P N}{1000}.$$

It was from this last formula that these curves were plotted and it must be kept in mind that they hold for no other arm length.

George C. Olmsted.

Chattanooga, Tenn.

Substitute For Air Valves

Mr. Jorgensen recently described a way to overcome some of his troubles with his steam-heating system.

I suppose that he opens all of the radiator valves while his boiler is raising steam; but if he does not, how could a radiator warm up if anyone turns steam on after he has closed the check valve on the air line and there is back pressure therein to check the exit of the cold air?

If the back pressure (not vacuum) becomes the steam will circulate in the air line as long as there is pressure behind it. If anyone should choose to turn off a radiator, what will keep the vacuum thus created within that radiator from "inhaling" steam from the air pipes and keeping the radiator hot just the same, in spite of the fellow who wants to cool off? If this process continues long enough, would not condensation fill the radiators up with water? When turning steam on the next morning, with steam on the line, there will be something doing with water hammer.

Why not use some kind of plain expansion air valves and pipe them as per Mr. Jorgensen's own sketch? The "strong vacuum" will be formed within the radiators while the boiler is cooling off. This will keep a good enough circulation for some time if the check valve on the vent line is closed or if a check valve is so fitted as to forbid entrance of atmosphere to the system.

Alex. D[illegible]

Jamaica, N. Y.

Mr. Jorgensen's method of heating is one of the commonest in use for large buildings where it is not desired to install the more expensive vacuum system. It provides for the removal of the air from the radiators without the necessity of discharging it into the rooms, gives almost as good circulating features as the two-pipe system, and much better than the one-pipe system at only slight additional expense.

Mr. Jorgensen makes the statement that after having the valve in the air line closed for some hours at least there will be considerable condensed water in the air pipe of the lower end, and also a strong vacuum will be formed between this water and the radiator. I am certain that Mr. Jorgensen is in error in making this statement, and should he put a gage on the pipe where he imagines the vacuum to exist he would find that the pressure was above that of the atmosphere.

It is quite certain that in the system under discussion it would be impossible for any part of the piping to be under a pressure below that of the atmosphere, nor should there be any tendency for a vacuum to form due to the condensing of steam, the pressure of the steam in the pipe would at once destroy it.

H[illegible] P. K[illegible]

New York City.

Use of Wooden Wedge Rings

In the March 9 number there appeared an article on the use of wooden rings in pipe installation, and I wish to state my views on the subject. To install a pipe line of water mains of the size stated is quite an undertaking, as well as a costly one, and is usually a permanent installation; consequently, the use of wooden rings would not be practical, as it would only be a question of time, and a very limited time at that, before these wooden rings would become soft from decomposition and would become leaky and useless, thereby necessitating a renewal with, of course, more expense as regards time, etc., to say nothing of the interruption to the service.

It is also stated that a pressure of 150 pounds to the square inch was carried. As we are all aware, wood is more or less porous according to its nature, and, of course, in that class of pressure it was ordinary wood, as it would not be practical to obtain any special kind. These rings, in being formed in one ring, would necessarily have to be cut across the grain at some point in the circle, and it is obvious that with a pressure of 150 pounds the water would be forced through the pores of the wood to a greater or less extent, thus setting up an unsatisfactory job and hastening the work of decomposition.

As an illustration of the porous nature of wood, I recently had occasion to block off a [illegible] line on a low-pressure system and, having no [illegible] or plugs at hand, a [illegible] wooden plug was turned up and driven into the end of the pipe. Notwithstanding that the plug was about [illegible] inches long, and the pressure only [illegible] pounds, the water of condensation found its way out of the pores of the plug the entire length.

As the rings of the 14-inch main would be of approximately 4 to 6 inches face, and a pressure of 150 pounds to the square inch carried, it would appear to me that there would be something doing. In my opinion a much better method would have been to make a mold around the joint and a babbitting, after which the holes could be drilled as required and, with the addition of good gaskets, a good permanent job assured. While wood rings may answer in a temporary job, I believe that anything that is worth doing is worth doing well, especially in the case of a main pipe as large as 14 inches.

CHARLES H. TAYLOR.

Bridgeport, Conn.

Actual Cost of Power

Writing upon this subject in the March 16 number, W. N. Polakov says: "Therefore, it follows that by knowing his actual cost of power the engineer will only learn that the good or poor work of the sales department has made him produce cheaper or more expensive power. What will he gain through such knowledge?"

An engineer who can figure power cost, including fixed charges, depreciation and taxes, and the unit cost of power produced, will be able to keep out the "slick article" that comes around to the back door and says: "How do you do? I see you have quite a plant here—ah, pretty big boilers, nice engines; how big are your boilers?" And if the engineer is "easy," he proceeds to give the dimensions of his boilers and engines, the "slick article" all the while "jollying" the honest fellow and taking in the whole plant, to enable him to do some figuring when he gets outside.

Now, if the engineer can figure the cost of power, etc., he can go to his employer and demonstrate that he can produce a kilowatt-hour as cheaply as Edison. Also, if he can demonstrate intelligently that there are 14,500 heat units in one pound of coal and the boiler absorbs about 9000 heat units per pound, the rest going up the stack, etc., and that the so-called steam specialists cannot get any more heat units out of a pound of coal than the engineer can, isn't that worth knowing? It should satisfy him and his employer that about the best anybody can do is to have the correct proportions of heating and grate surfaces, provide the proper amount of air for combustion purposes, stop leaks through the brickwork, keep the fire level and bright, feed regularly, maintain a constant steam pressure, prevent the safety valve from blowing unnecessarily, etc.

With all these things in mind, why can't the engineer do the figuring as well as the "expert"? There is nothing mysterious in steam engineering ordinarily that one man can master and another cannot. The fact is, the "expert," having a glib tongue, manages to influence the owner or manager more readily than the less polished engineer and, the chances being that the owner does not know any too much about the practical side of engineering, he tells the "expert" to go ahead.

Then what happens? The specialist takes stock of the fittings and packing, inventories the coal in hand and proceeds to cut wages. Of course, he shows a temporary saving—after which the owner begins to wake up, as a rule. I challenge any expert to make a saving in my plant.

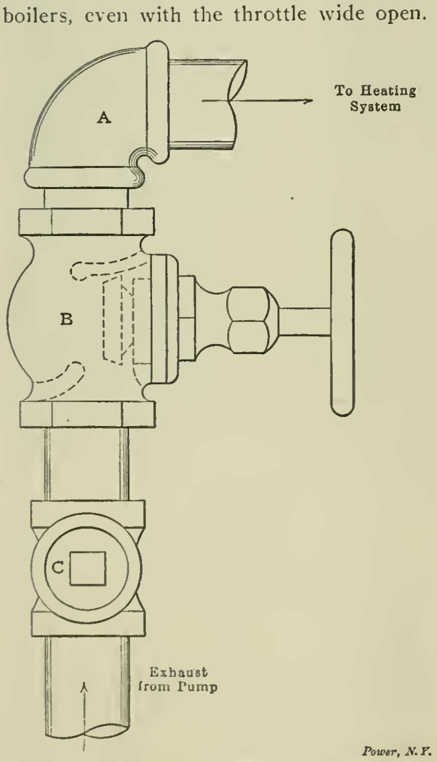
Engineers, wake up and get what belongs to you. Educate yourselves in the business and put the experts out of business, so far as your plants are concerned.

H. E. SAMUELS.

Brooklyn, N. Y.

Cause of High Back Pressure

One of our duplex boiler-feed pumps got to acting sluggishly and at times would not run fast enough to supply the boilers, even with the throttle wide open.



CAUSE OF HIGH BACK PRESSURE

On account of extended radiation it had become necessary to raise the back pressure on the pump to about 12 pounds. I noticed that it was when this high back pressure was being carried that the pump ran so slowly. I removed the plug at *C*, between the pump and exhaust valve *B*, and put on a pressure gage.

When I started the pump with 10 pounds back pressure on the heating system the gage at *C* showed 25 pounds back pressure. I removed the globe valve *B* and put in a gate valve, and have had no more trouble.

As the globe valve was of generous proportions, and had about the same area of opening as the gate valve, I think the high back pressure was caused by the sharp turns in the path of the steam, caused by the globe valve and the ell *A*.

R. L. RAYBURN.

Decatur, Ill.

Setting Gas Engine Valves

After reading the articles of Mr. Hollman, page 167, January 19, and Mr. Tilden, page 416, March 2, I wish to offer the following addition to the discussion:

Nearly all engines of 100 horsepower or less are single-acting and, therefore, have no crosshead nor guide by which the position of the piston can be marked. If the clearance between the valve stem and valve-operating mechanism is too great, the valve will not be held open long enough; if too small the valve may not seat, owing to particles of dirt being caught between parts of the mechanism. The valve stem will also elongate, owing to the heat of the exhaust gases. If a piece of thin paper is held between the valve stem and rod the time of opening and closing can be told by the gripping and freeing of the paper.

Mr. Tilden evidently has never timed the valves on a gas engine or he would find that he is mistaken about the setting. The gases after explosion will drop in pressure, and if the exhaust valve did not open until the end of the stroke, there would be a pressure of from 30 to 50 pounds. The piston during the first part of the exhaust stroke will have to work against excessive back pressure, as the valves and passages are not large enough so that the pressure will fall instantly to atmospheric.

The writer has taken indicator diagrams which show that the pressure does not fall to nearly atmospheric until almost half the stroke has been made. The exhaust valve, therefore, is opened about 30 or 40 degrees before the end of the stroke, so that the pressure will drop to about 2 or 3 pounds during the exhaust stroke.

The exhaust valve closes on the dead center. If the inlet valve opens before the exhaust valve closes there is danger of a back-fire and consequent loss of the fresh mixture. For this reason it is customary to open the inlet valve after the crank has moved through an angle of 2 or 3 degrees.

During the suction stroke a column of gas and air has been set in motion and the inertia of this mixture will cause it to flow, even while the piston is reversing. This insures a larger amount of mixture. For stationary engines the inlet valve will be held open for from 4 to 10 degrees on the compression stroke.

As the valves are operated by cams, they can be opened and closed any time during a revolution, depending on the design of the cam.

It takes certain appreciable time for the flame to pass entirely through the mixture. The maximum explosion pressure is obtained when the volume of the mixture is the smallest, or in other words the compression pressure is the highest at the instant the *entire* mass is ignited. Therefore, the flame must be given time to propagate itself through the mixture by the time the piston starts on the power stroke.

L. J. BUSCHMAN.

Cleveland, O.

In a letter on page 416 of the March 2 number, E. G. Tilden gives his opinion on "Gas Engine Valve and Ignition Timing." I cannot agree with him when he says: "The fact that the gas mixture is burned in the cylinder has nothing whatever to do with the proper valve setting," for it is just this one fact which is the reason for opening the exhaust valve ahead of the dead center.

At the end of the expansion, before the exhaust valve is opened, the burnt gases in the cylinder are still under a pressure higher than atmospheric, say 25 or 30 pounds, and have a considerably higher temperature than would be the case if they had expanded to atmospheric pressure.

The idea in opening the exhaust valve about 40 degrees (on the crank) ahead of dead center is to allow the gases to come down to atmospheric pressure by the time the piston reaches the dead center. This results in two advantages: There is less back pressure on the piston, when it expels the burnt gases, and these gases have now a lower temperature and consequently do not heat the cylinder walls so much, which, again, allows a more complete new charge.

The exhaust valve ought to be kept open until about 10 degrees after dead center, thus allowing the exhaust pressure to come down to atmospheric pressure or even less, as the inertia of the outrushing column of gas may produce a slight vacuum, whereupon at about 12 degrees the inlet valve is opened and kept open until from 30 to 35 degrees after dead center. At this point the pressure produced by the piston starting on its compression stroke will be sufficient to check the rush of the fresh mixture still coming in, according to the law of inertia, which applies to any moving body. This is the point where the valve should close.

This way of valve setting proved to be very satisfactory with two three-cylinder 60-horsepower engines running at 240 revolutions per minute. In the first place the cams were designed to open and close on dead centers. As a result it was almost impossible to keep the engine cool, and in case of an overload back-firing commences almost immediately. Cleaning out the water jacket and lowering the compression did not seem to have any effect at all. Finally a change in the cams was decided on, and the herein-discussed valve setting was tried, first on one engine. The result was striking, the engine being able to carry about 10 per cent. overload without back-firing. With the cams fixed up in the same way, the second engine produced the same results.

Of course, I agree with Mr. Tilden inasmuch as it is impossible to improve upon any engine, the cams of which are designed for valves to open and close on dead centers, by simply advancing or retarding the time of opening. A new cam must be made, which keeps the valve open for more than 180 degrees (measured on the cam shaft), say 105 to 115 degrees.

W. A. ARNOLD.

Los Angeles, Cal.

The Barrus Universal Calorimeter

In reply to the criticism of Charles B. Cooke, Jr., in a recent number, I will say that what is there stated is all right in theory, but is not the actual case.

If Mr. Cooke will carefully examine a "Barrus universal calorimeter" he will find it exactly as described in the article which appeared in the December 29, 1908, number. Or, if he will look up the report of the committee on Standard Method of Conducting Boiler Trials, Volume XXI of the *Transactions* of the American Society of Mechanical Engineers, under appendix XVII he will also learn that its "exception" is a possible. The same report, under appendix XV, states (and that statement was arrived at only after thorough research) that among others, the Barrus calorimeter, when properly handled, gives results which are accurate within one half of 1 per cent. For scientific research and when the moisture exceeds 2 per cent., the committee recommends that "A steam separator should be placed in the steam pipe as near to the steam outlet of the boiler as convenient, well covered with felting, all the steam made by the boiler passing through it and all the moisture caught carefully weighed after being cooled. * * * A throttling or separating calorimeter should be placed in the steam pipe just beyond the steam separator for the purpose of determining the amount of moisture remaining in the steam after passing through the separator."

The per cent. of moisture caught in the separator is determined as in the ordinary separating calorimeter. The total per cent. of moisture in the steam is the sum of the percentages as found by the separator and by the calorimeter.

It might clarify Mr. Cooke's conceptions of the fundamental principle of the [illegible] gage if I say that it (the principle) depends upon the following physical facts. To make a concrete example: The total heat in one pound of dry and saturated steam at a pressure of 100 pounds per square inch absolute is very nearly 1186 B.t.u. The total heat at atmospheric pressure is very nearly 1146 B.t.u. Then, in being throttled from 100 pounds to 14.7 pounds, "doing no work," the steam gives up 40 B.t.u., which are available to evaporate moisture in the steam or to superheat the steam or both. If the thermometer in the calorimeter registers in the neighborhood of 212 degrees Fahrenheit it is a very good indication that the steam is still wet when leaving the calorimeter base gage. It also indicates that all the 40 B.t.u. have been utilized in evaporating moisture and the heat balance does hold so far as the part of the moisture evaporated by the 40 B.t.u. is concerned. By adding the per cent. of moisture thus obtained to the per cent. found by the separator the total per cent. is found.

The assurance that the steam is dry when leaving the separator rests upon comparisons with other calorimeters of recognized accuracy and by checks made with apparatus arranged according to the recommendations of the A. S. M. E. committee report.

CHARLES N. CRANE.

Palo Alto, Cal.

Knock in an Engine

The knock in I. W. Bryan's engine mentioned in the March 2 number, page 415, is most likely caused by varying compression. I think he will find the cause by taking diagrams during both the knocking and the silent periods and comparing them. The engine has a high piston speed, and if the pressure in the exhaust line falls a little under a somewhat light load the compression might not be enough to cushion the reciprocating parts before the knock. That the knock is heard more at the crank end might be due to steam clearance or a later closing of the exhaust at that end. The knock would be continuous if the clearances of the [illegible] were at fault.

H. WILLIAMS.

Indianapolis, Ind.

Suction Pipes and Exhaust Fans

[illegible]

[illegible]

Albany, N. Y.

Boiler Accident Fatal to Engineer

On March 14, a boiler located at Greenfield, N. H., met with a rather peculiar accident. It is a portable boiler, locomotive type, with the engine on top, the firebox end resting on wheels and the rear end supported on blocking. It was fed by a well known lifting injector, the water entering the water leg about 1 foot below the crown sheet and 4 inches from the port, the supply being taken from a barrel nearby. The width of the water leg was 3 inches, the shells being about 5/32 inch thick and supported by forty ¾-inch staybolts, 6.5 inches center to center; the firebox is 2 feet wide, 3 feet high and 4 feet long, and there are thirty 3-inch tubes 12 feet long.

The engineer started up at 7 a.m., as usual, carrying about 60 pounds of steam, and, according to one of the workmen, was sitting beside the boiler, a few inches from the water leg, eating a lunch when the boiler blew up. An examination made by the writer revealed the fact that the staybolts of the water leg had been torn from their holes in the outer shell, allowing both the outer and inner shells to bulge, and also allowing the contents of the boiler to rush out through the holes left by the staybolts and severely scald the engineer, who died about four hours afterward.

The fusible plug, on being removed, appeared to have been badly corroded on the outer end, but had started to melt; in fact, about two-thirds of the metal had melted out before the fire was extinguished by the escaping steam and water, the inner end of the plug being intact. An iron plug was found screwed into the bottom of the water column in place of the usual nipple and valve.

The man in charge informed the writer that he had been in the boiler room about a half hour before the accident occurred and saw about 6 inches of water in the gage glass, the steam gage recording about 60 pounds (the safety valve was set to blow at 80 pounds). He was positive that there must have been water in the boiler at the time of the accident, but everything points to an absence of water; in fact, the position in which the engineer was found, and a statement made by an employee who had left the boiler room not over five seconds before the accident occurred, go to prove that there was little, if any, water in the boiler at the time.

This employee stated that as he ascended from the boiler room to the "glory hole" above the boiler room, he noticed the engineer take hold of the valve on the inspirator as though to start it, and immediately afterward there was a noise as of something being ripped asunder, then the rush of escaping steam.

Although the engineer was severely scalded, there was no sign of his having been struck with boiling water at 60 pounds pressure, nor was there any sign on a wooden partition, located about 5 feet from the boiler, that it had been struck with water, and as there was no escape for it except through the holes left by the staybolts, it is reasonable to expect that the drop in pressure was gradual and not immediate, as would be the case had the shell burst, or a head blown out, and while the writer would not go on record as saying that the accident was caused by low water, everything points to that conclusion.

R. P. Guy.

Bennington, N. H.

Pitting in Condenser

The steel plates of a countercurrent barometric jet condenser show signs of serious pitting, due to the circulating water containing some sulphuric acid. The cast-iron casing of the circulating pump is also affected. Will any reader who has experienced and overcome similar trouble give a suggestion?

George Hughes.

Horwich, England.

Criticism

The surface condenser has been much criticized in its time, and seems to be passing through another spell. Some engineers say that, having bought a "bunch" of tubes in a cast-iron box, they have removed several of the tubes, thus decreasing the cooling surface, and at the same time giving the exhaust steam more space, and that the vacuum has been greatly increased.

A strange part of it is that the amount of condensing water used remains the same in each case, or even less, after removing the tubes.

This would seem to indicate an overcrowded condition of the tubes in certain types of surface condenser, decreases the velocity of the exhaust steam, also the rate of heat transfer through the tubes to the cooling water flowing therein.

It is practically impossible to design a large piece of apparatus that will give entire satisfaction in all respects, the "first crack out of the box." After one or more are built and operated many criticisms can be offered and numerous changes suggested before the apparatus can be called a complete success.

Frequently a change in design means a change in patterns, and even a change in machines required to do the finished work in turning out the apparatus. This is necessarily expensive, and for this reason many manufacturers are not fond of making changes.

A designer, no matter how well experienced, is quite incapable of at first designing anything in the line of machinery that cannot be criticized. The layout of the steam piping in a modern power plant is probably criticized as much as, if not more than, any other part of the equipment. The piping system is one of the most difficult parts of the design, that is, from the designer's standpoint, in arranging and placing the apparatus, valves, piping, etc., in a large station, to insure continuity of operation, minimum friction and condensation losses, etc. For instance, valves may be placed in the most inaccessible positions conceivable, unless the designer imagines himself the operating engineer for the time being when designing his system. Then again the piping system is usually the last thing installed, and the designer is held down to certain fixed conditions and has little or no choice at all in arranging the system.

It is an easy matter to criticize, but the man who does so honestly and intelligently, and can offer a solution to the difficulty, is a man worth while, a man worth knowing.

William F. Fischer.

New York City.

Dynamo Failed to Generate

In starting up for the first time the dynamo in a local mill refused to generate. It was a 10-horsepower 110-volt compound-wound motor. We found the dynamo running at about the speed marked on the name plate, and a test showed that there were no open circuits in the field or elsewhere. The brushes were also carefully adjusted. We decided that it would require only a little outside excitation of the fields to make it "pick up." We procured a few batteries, and applying this current to the fields of the machine, the voltage came up to about 15 volts, but immediately died down when the battery current was taken away. We then decided it was necessary to increase the speed. A smaller pulley was provided and the speed increased about one-third.

Even after this the dynamo would not build up without applying the batteries and could not be made to build up from residual magnetism. After the voltage was once raised it operated satisfactorily until shut down, when it was necessary to go through the same process on starting again.

The design for a compound motor required a shunt field of higher resistance and less current than a plain shunt motor, as the series-field winding assisted in producing the necessary torque. Owing to this resistance, enough current could not be got through the fields at starting to produce the reaction on the armature. To have got satisfactory results it would have been necessary to put on a set of coils of lower resistance. This was not done as another machine was substituted.

John A. Walker.

San Angelo, Tex.

Some Useful Lessons of Limewater

Showing How to Construct a Simple Primary Electric Battery; Some Interesting Experiments in This Very Useful Branch of Study

BY CHARLES S. PALMER

In the last lesson we planned the apparatus for making hydrogen, for collecting it in several quart fruit jars, and for testing it in various ways. By this time you will have got yourself sufficiently familiar with the main points so that you can proceed directly to making and collecting several jars of hydrogen. But remember to test a tumbler or two of the gas, as told in the last lesson, to be sure that you have driven the air out of the generating flask before you collect any hydrogen; because hydrogen and air make a very lively explosive mixture. We will suppose that you have collected one or two jars of hydrogen and are waiting for the other jars to fill. Of course, if your hydrogen generator gets "tired," you can replenish it by opening the cork and quickly dropping in half a dozen more pieces of the coiled zinc; and if this does not wake it up, you can also add a little more of the diluted sulphuric acid. Remember that every time that you open the generating flask you must throw away the first gas that comes off, keeping a flame away from it, afterward collecting a tumbler to see if it burns quietly enough to make it safe to collect more jars of the hydrogen.

The First Test

The first test, keeping your jars covered with cardboard and mouth downward, is to study the burning of hydrogen by lighting a long splinter and thrusting it up into the jar. The way to do this is to lift the jar from the cardboard cover, hold the jar mouth downward and thrust the lighted splinter up into the jar, gradually turning the jar so that it will be horizontal. You will notice that the hydrogen burns with a soft flame, which may be pinkish or yellowish, and that the splinter is extinguished in the hydrogen, the hydrogen itself burning in the air and naturally reigniting the lower part of the splinter, for the hydrogen flame is very hot. You will also note that as the hydrogen is consumed, the flame retreats up into the jar, being, of course, followed up by the advancing supply of air from the outside. Another thing that you cannot help noticing, especially if your attention is called to it, is that the inside walls of the jar become covered with a faint thin layer of sweat or dew. You can easily distinguish this from any of the drops of water which may cling to the inside walls of the jar, these drops being, of course, the original water from the pneumatic trough. This dew or sweat on the inside walls of the jar comes from the condensation of the water which is formed by the burning of the hydrogen with the oxygen of the air. In its nature it is exactly the

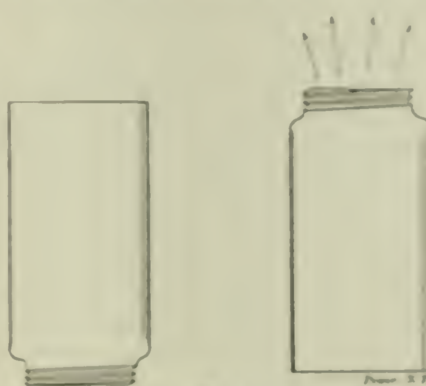


FIG. 1

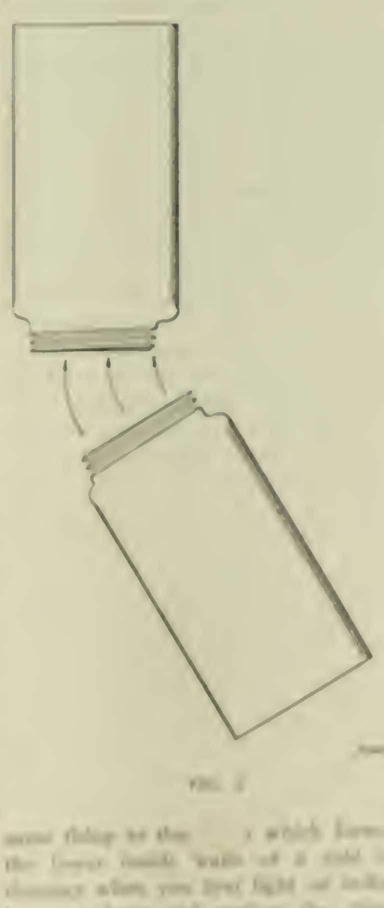


FIG. 2

same thing as the [illegible] which forms on the lower inside walls of a cold lamp chimney when you first light an ordinary kerosene lamp and replace the chimney over the flame; only in the case of the oil-burning lamp, the water comes from the burning of the hydrogen part of the oil, while in this experiment the dew or sweat comes from the burning of the pure hydrogen.

In fact you remove the splinter from the hydrogen pretty soon after the hydrogen is lighted, you can place the jar mouth upward, cover it with a pasteboard cover after the flame has died out, and test it with limewater. Of course, you will not get any precipitate of plain carbonate of calcium, because the sole product of the burning of hydrogen is simply water, and the only carbonic-acid gas which could appear in any quantity would be from the burning of the carbon in the wood splinter.

Testing the Lightness of Hydrogen

The next experiment is to test the lightness of hydrogen. A simple way to do this is to take a jar of hydrogen, remove the pasteboard cover (holding the jar mouth downward) and wait, counting 25 or so slowly and evenly. Then thrust a lighted splinter up into the jar of hydrogen which has been held mouth downward. The hydrogen will ignite with a slight explosion, owing to the mingling of the air with the lower layers of hydrogen; and then the rest of it will burn quietly, probably, in the usual manner, but you must not be surprised if several little variations come in incidentally from time to time. This is part of the game, and if you work carefully, keeping your wits about you, nothing very serious will happen. Now reverse this experiment by taking a full jar of hydrogen and, holding it mouth upward, remove the pasteboard cover, wrapping a towel around the jar for safety, and count as slowly. Then thrust your lighted taper down into the jar and you probably will get no result, because the light hydrogen will have escaped from the jar. In case you should get an explosion after having the jar mouth upward and open while you are counting so, it simply indicates that you did not wait quite long enough to let the light hydrogen escape, and you can repeat the experiment, holding the one jar open mouth downward and the other jar open mouth upward, until you fix definitely the right interval so that you will have hydrogen left in the mouth-downward jar and no hydrogen in the mouth-upward jar. See Fig. 1.

Another way to test the lightness of hydrogen is shown in

Fig. 2, where you take a plain empty jar, empty except for common air, and pour a freshly prepared jar of hydrogen *upward* into it, as shown. You can easily do this by holding the jar of hydrogen in the right hand and the jar of air in the left hand, when the invisible hydrogen will flow upward, as shown by the direction of the arrows in Fig. 2.

The Diffusion Experiment

Next, we will carry out the "osmose" or diffusion experiment, described and figured in last week's lesson. Such a full description was given then that it is not necessary to repeat this, except to remind you that if you prepare the apparatus you have a closed pipe bowl or porous jar connected with a closed tube 15 or 20 inches long, the lower end of which dips

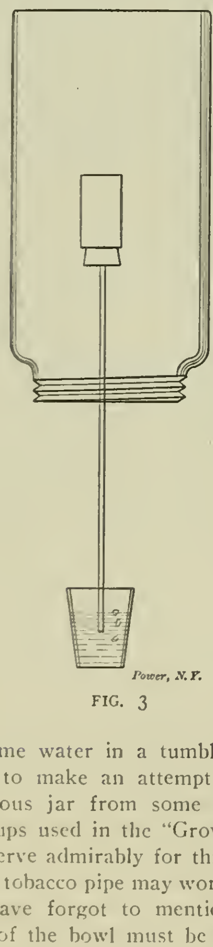


FIG. 3

below some water in a tumbler. It will pay you to make an attempt to get the little porous jar from some dealer (the porous cups used in the "Grove" primary battery serve admirably for this purpose). But your tobacco pipe may work; although I may have forgot to mention that the opening of the bowl must be closed with a well-paraffined cork, and the stem of the bowl—not the bowl itself—should also be covered with paraffin. This paraffin can be easily painted on, after it has been melted. The whole point of this experiment is to place an open jar of hydrogen mouth downward over the bowl of the pipe, or over the porous cup, and to get a few bubbles of air or gas forced out at the bottom of the open tube below the water, as shown in Fig. 3. If you get even a bubble or two to come up through the water in the tumbler, you will be able to prove that the jar of hydrogen acts on the porous cup as though the hydrogen were full of an internal pressure, and the explanation for this was given in the last lesson. This is one of the most remarkable experiments that you will ever perform; and it will pay you to make good on this, for it is a case of an intimate connection between physics and chemistry, a connection that you will have forced upon you at every step.

The Explosiveness of Hydrogen

The next experiment will illustrate the explosiveness of hydrogen and, although it was not described in the last lesson, yet you can easily prepare it on the spot. Get a tin can, as shown in Fig. 4, holding about a pint and having a small opening, say ½ or ¾ inch wide. Clean, wash and dry the can, and bore a small hole in the bottom, say about 1/20 inch wide. Close up this hole with a little wooden plug, such as a pointed match, then fill the jar with water, place your finger over the mouth, invert it in the pneumatic trough and fill it with hydrogen. As soon as it is full of hydrogen remove the tin can from the water, holding it mouth downward, and set it over a couple of bricks, as shown in Fig. 4. Then pull out the pointed match from the little hole at the top of the can and light the jet of escaping hydrogen at that point with a match or burning splinter.

The hydrogen will burn at the little opening with an almost invisible flame; but you can prove that it is burning by holding there an unlighted splinter, which will ignite from the hot hydrogen flame. Probably in a few seconds, almost certainly in a few moments, this hydrogen flame will begin to sing, at first in a very high key, and gradually sinking to a lower tone. Now stand 3 or 4 feet away from the can and await developments, which will end in an explosion. Of course, you can see that as the hydrogen is burning off at the top, the air is passing in at the narrow mouth at the bottom to take its place; and pretty soon the inside of the can will be filled with an explosive mixture of hydrogen and air. As this explosive mixture increases in quantity in the inside of the tin can, and as the explosion gets ready to take place, usually being advertised by sudden lowering of the tone of the singing flame at the top of the can, there follows a sharp report and the can may be blown several feet into the air, owing to the backlash from the open mouth pointed downward.

This will well illustrate the explosive nature of the mixture of hydrogen and air. You can see that as the air contains only one-fifth of its volume of oxygen, a mixture of the air with hydrogen does not make as explosive a combination as would result if you could mix pure hydrogen with pure oxygen. Such a mixture, composed of two volumes of hydrogen with one volume of oxygen, is frightfully explosive, and is dangerous in large quantities. A mixture of two volumes of hydrogen with one volume of oxygen is called by the Germans "knall gas;" that is, freely translated, "bang gas;" and although it may be taking some liberties with language, yet it might not be a bad thing if we had a good name in English for this explosive mixture.

There are many other experiments which you could perform with hydrogen and also with oxygen, if you could get a couple of small rubber gas bags; but you can read about these in the books. One of these experiments consists in filling a gas bag with hydrogen directly from your generator, not by displacement of water, but by leading the gas directly to the bag from the hydrogen generator. Then the rubber gas bag is connected with a rubber tube, having on the end a common clay pipe. This pipe is dipped into a bowl of good soap suds and, by gentle pressure, bubbles may be blown which can be tossed off into the air, when they rapidly ascend, just as do the common rubber toy balloons which, you know, are filled with hydrogen. If you should have the good luck to get hold of a gas bag, so that you could perform this experiment, you will find it quite fascinating to make the soap bubbles of hydrogen and toss them off into the air, lighting them with a long, burning splinter, when they burn with a soft flame and a slight yellow puff or flash. This yellow color comes from the sodium in the soap, soap being merely a "salt" of sodium, with the fatty acids, stearic, palmitic, or oleic.

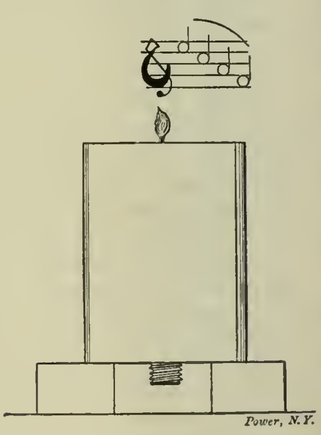


FIG. 4

If you should carry this experiment of the gas bag farther you could mix one volume of hydrogen with two volumes of oxygen and could blow bubbles of the explosive "knall gas;" but in that case you would have to use the greatest care to keep the flame away from the pipe or the opening of the gas bag; and if you should cover the surface of a dish of soapsuds with a good layer of bubbles of this "knall gas" (two volumes of hydrogen with one volume of oxygen), your ear drums would testify to the violence of the report produced by lighting these bubbles, and also to the possible danger of treating this mixture of oxygen and hydrogen carelessly.

"Lead Burning"

There are one or two points which could be further noted in this lesson, not that you will be able to try the experiments immediately, but you cannot help running across their application now and then, and you should know about them. I refer to the use of the plain hydrogen flame in "lead burning," and the use of the pure oxyhydrogen flame in the so-called calcium or limelight, and also the use of the new gas, "acetylene," made from calcium carbide and water. Acetylene and calcium carbide can wait a few weeks, but there can be no harm in your knowing now that lead burning simply consists in the quick and dexterous manipulation of a plain hydrogen flame on sheet lead. The description and study of the lead-burning apparatus, while by no means difficult or complicated, would take us a little too far away from our present purpose.

The oxyhydrogen blowpipe, on the other hand, consists of a metallic jet carrying the oxygen, surrounded by a jacket delivering the hydrogen, and so arranged that the hydrogen and oxygen can burn at the same point in the proportion of two volumes of hydrogen to one volume of oxygen. Instead of hydrogen, of course, one can use common coal gas or city gas, or even air saturated with gasolene, ether, alcohol, or similar combustible and easily vaporizing liquids. In all these cases, whether the burning gas is hydrogen or city gas, an intense heat is produced by the assistance of the pure oxygen, aided, of course, by the oxygen of the outside air. The heat of such flames is sufficient to melt steel, to melt even platinum, one of the most infusible of metals, and when this jet of burning oxygen and hydrogen is turned onto a stick of quicklime, it makes it so hot that it glows with a brilliant white light second only to sunlight and the electric arc.

There are many other experiments which may be tried with hydrogen, and some of them you will try from time to time; but one of them you can try right now. You will remember it was mentioned in the last lesson that we do not use nitric acid with zinc in making hydrogen, although you can use either hydrochloric acid (muriatic acid), or sulphuric acid. Take a strip of zinc and pour a little nitric acid over it. You will note the heavy, corrosive choking brown fumes. These fumes are the so-called "nitrous" fumes; they are produced by the reducing action on the nitric acid and the oxidizing action of the nitric acid on the hydrogen; and this is an illustration of the great chemical battle which is waged everywhere and always, in nature, between oxidizers such as nitric acid and reducers such as hydrogen and the other chemical metals.

One thing you must note here in handling nitric acid, and that is that you should perform experiments with it in a good draft, say just before your furnace door or in front of an open window. Never breathe these brown fumes from nitric acid, for they are frightfully irritating and poisonous to the throat and lungs, and a good dose can easily produce a kind of an acute pneumonia.

These experiments will introduce you fairly well to the study of the metallic gas hydrogen, chemically metallic, but there is another chapter which we must study to illustrate what is meant when we speak of hydrogen as a metallic gas. In one of the last lessons I used the terms "anode and cathode" in speaking of the electrolytic cell. There are one or two simple experiments which you can easily try and which will assist you greatly in getting some fundamental notions, not only about the chemistry of hydrogen, but also about electric batteries and the simple laws of the electric current. About all you need for our present purpose is to get a few feet of common insulated copper wire, as coarse as possible, a small strip of zinc, say 1 inch by 4 inches, another one of copper, and a small pocket compass. You will be surprised to see how much chemistry you will get out of this outfit with the help of your old friend, limewater.

Reciprocating Engines Show Best in Second Test of Scout Cruisers

Unofficial figures of the performance of the three scout cruisers "Birmingham," "Salem" and "Chester," in their second competitive coal-economy test, finished March 31, indicated a victory for the engines of the "Birmingham," which are of the reciprocating type.

The test was a run of 30 hours at 15 knots' speed. According to the figures given out, the "Birmingham" in 24 hours consumed [illegible] tons of coal and [illegible] tons of water. The "Chester," which has Parsons turbines, used [illegible] tons of coal and [illegible] tons of water, while the "Salem," which has Curtis turbines, used [illegible] tons of coal and [illegible] tons of water.

The annual meeting of the National Association of Cotton Manufacturers will be held at the Mechanics' Fair building, Boston, April 28 and 29. Among the papers to be presented which will interest power users are those upon "Commutator Grinding," "Economy in Steam Generating" and "Proper Care of Machinery."

A press dispatch states that in [illegible] township, three miles north of [illegible], Pa., there has been discovered a species of bituminous coal closely resembling cannel coal.

Some Gas Engine Calculations Based on the Volumetric Analyses of Fuel and Exhaust Gases

By A. L. [illegible]

The heating value per cubic foot of a gas may very readily be determined by means of a gas calorimeter, and this forms a very essential element when testing a gas engine for efficiency. If, however, it is desired also to determine the proportion of air to gas in the mixture, the volume of exhaust gas and the heat carried off by the exhaust, some other method must be employed. Volumetric analyses of the gases, if carefully and accurately made, give data which may form the basis of such calculations.

The principal combustible constituents of any fuel gas are carbon monoxide (CO), hydrogen (H), methane or marsh gas (CH_4) and ethylene gas (C_2H_4). The usual analysis gives the proportion of these by volume, and knowing the heat value of each in B.t.u. per cubic foot, the heat value of the gas is readily determined by multiplying the fractional part of each constituent by its heating value and adding together the products.

Table 1 gives the weights per cubic foot and heat values at 62 degrees temperature, Fahrenheit, and atmospheric pressure:

TABLE 1. WEIGHT AND HEAT VALUES OF GASES AT 62° F.

Gas	Symbol	Weight per Cubic Foot, Pounds	Heat Value in B.t.u. per Cubic Foot
Carbon monoxide	CO	[illegible]	[illegible]
Hydrogen	H	[illegible]	[illegible]
Methane	CH_4	[illegible]	[illegible]
Ethylene	C_2H_4	[illegible]	[illegible]

The exhaust gas contains steam and CO_2 from the combustion of hydrogen and carbon, together with nitrogen and, if an excess of air was used in the mixture, oxygen. The proportion of dry gases [illegible] readily be found with the Orsat apparatus for flue-gas analysis. The steam present condenses upon cooling the sample of gas, and can be determined only by calculation from the analysis of the dry gas.

[illegible] example, assume the following analyses of fuel and exhaust gases from a gas engine using producer gas:

PRODUCER GAS.

	Per Cent.
CO	[illegible]
H	[illegible]
CH_4	[illegible]
C_2H_4	[illegible]
CO_2	[illegible]
O	[illegible]
N	[illegible]

EXHAUST GAS.

	Per Cent.
CO_2	[illegible]
O	[illegible]
N	[illegible]

The heat value of the gas is computed as follows:

CO, 0.27 x 320.6	86.5
H, 0.12 x 324.7	38.9
CH_4, 0.025x 990.7	24.8
C_2H_4, 0.004x1579.4	6.3
Total heat value, B.t.u. per cubic foot	156.5

In the combustion of the producer gas, oxygen is required in the following proportions:

(1). One cubic foot of CO + ½ cubic foot of O makes one cubic foot of CO_2.

(2). One cubic foot of H + ½ cubic foot of O makes one cubic foot of H_2O.

(3). One cubic foot of CH_4 + 2 cubic feet of O makes one cubic foot of CO_2 + two cubic feet of H_2O.

(4). One cubic foot of C_2H_4 + 3 cubic feet of O makes two cubic feet of CO_2 + two cubic feet of H_2O.

The CO_2 contained in the exhaust gases comes from items (1), (3) and (4), together with the CO_2 contained in the producer gas. Furthermore, in case of items (1) and (3), the volumes of CO_2 produced by combustion are the same as the volumes of CO_2 and CH_4, while in case of item (4) the volume is double. To determine the volume of CO_2 resulting from the combustion of one cubic foot of the gas, therefore, it is necessary only to add the proportions of CO, CH_4, and CO_2, and double the C_2H_4. In the case assumed, $0.27 + 0.025 + 0.025 + 2 \times 0.004 = 0.328$ cubic foot. From the analysis of dry gas in the exhaust, there is 0.139 cubic foot of CO_2 per cubic foot of exhaust. Dividing 0.328 by 0.139 gives 2.36 as the number of cubic feet of dry exhaust gas per cubic foot of producer gas burned.

The air supplied per cubic foot of gas may be computed from the nitrogen in the exhaust gases. The proportion of nitrogen in the present case is 81.5 per cent.; $0.815 \times 2.36 = 1.92$ cubic feet of nitrogen per cubic foot of gas burned.

The gas carries 55.3 per cent. of nitrogen, and the quantity of nitrogen in air supplied per cubic foot of gas is, therefore, $1.92 - 0.553 = 1.367$ cubic feet. Since air is composed of 79 parts nitrogen and 21 parts oxygen, the quantity of air supplied per cubic foot of gas was $1.367 \div 0.79 = 1.73$ cubic feet. The air required for combustion was as follows:

		Cu. Ft.
CO	$\frac{0.27}{2} \times \frac{1}{0.21}$	= 0.643
H	$\frac{0.12}{2} \times \frac{1}{0.21}$	= 0.286
CH_4	$0.025 \times 2 \times \frac{1}{0.21}$	= 0.238
C_2H_4	$0.004 \times 3 \times \frac{1}{0.21}$	= 0.057
Total		1.224

The excess air, therefore, is $1.73 - 1.224 = 0.506$ cubic foot per cubic foot of gas taken in by the engine.

Heat Rejected in Exhaust

From Table 2 the specific heat of the dry exhaust gas may be computed. The

TABLE 2. SPECIFIC HEATS OF EXHAUST GAS CONSTITUENTS AT 62° F.

Gas.	Symbol.	Specific Heat, B.t.u. Per Pound.	Weight Per Cubic Foot.	Specific Heat, B.t.u. Per Cubic Foot.
Oxygen	O	0.2175	0.0840	0.0183
Nitrogen	N	0.2438	0.0737	0.0180
Carbon dioxide	CO_2	0.2170	0.1156	0.0251

foregoing computations gave 1.92 cubic feet of N, 0.328 cubic foot of CO_2 and $0.046 \times 2.36 = 0.108$ cubic foot of O per cubic foot of gas consumed. The heat required to raise the temperature of one cubic foot of the dry exhaust gas one degree, therefore, is as follows:

N, 1.92 x0.0180	0.0345	B.t.u.
O, 0.108x0.0183	0.00197	B.t.u.
CO_2, 0.328x0.0251	0.0082	B.t.u.
Total	0.04467	B.t.u.

The heat carried off by steam is determined from the following considerations: One pound of hydrogen plus eight pounds of oxygen produce nine pounds of water vapor or steam. Also, in methane one-fourth of the entire weight is hydrogen; that is, one pound of hydrogen unites with three pounds of carbon to make four pounds of marsh gas. Similarly, one-seventh of the weight of ethylene gas is due to hydrogen.

Referring to Table 1 for the weights per cubic foot, and to the assumed analysis of producer gas for the proportions of these constituents, the steam produced per cubic foot of producer gas is computed thus:

From		Pound.
Hydrogen	$0.12 \times 9 \times 0.00527 \times 9$	= 0.00569
Methane	$0.025 \times \frac{9}{4} \times 0.04205 \times \frac{9}{4}$	= 0.00236
Ethylene	$0.004 \times \frac{9}{7} \times 0.07356$	= 0.00038
Total weight of steam		0.00843

The pressure of the exhaust being assumed as that of the atmosphere, the heat contained in the steam at the temperature of saturation, above 62 degrees, is:

Heat of vaporization 966x0.00843	8.14
Heat of liquid (212—62)x0.00843	1.26
Total heat, B.t.u	9.40

The heat per degree of superheat above 212 degrees is $0.00843 \times 0.48 = 0.00405$ B.t.u., 0.48 being taken as the specific heat of superheated steam.

Suppose the temperature of the exhaust is 600 degrees. The heat rejected per cubic foot of gas is:

	B.t.u.
In dry gases, 0.04467 × (600—62)	24.03
In steam, heat of liquid + vaporization at 212°	9.40
In steam, superheat, 0.0405 (600—212)	1.57
Total heat in the exhaust per cubic foot	35.00

The percentage of the heat supplied in the producer gas that is rejected in the exhaust, therefore, is

$$\frac{35}{156.5} \times 100 = 22.4 \textit{ per cent.}$$

Should Sine or Cosine be Used in Computing the Discharge Area of Bevel-seated Valves?

By F. R. Low

There was some disagreement in the discussion upon safety valves by the mechanical engineers a short time ago as to whether the lift should be multi-

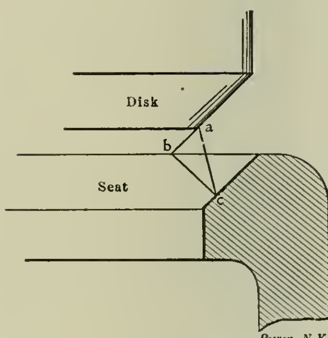


FIG. 1

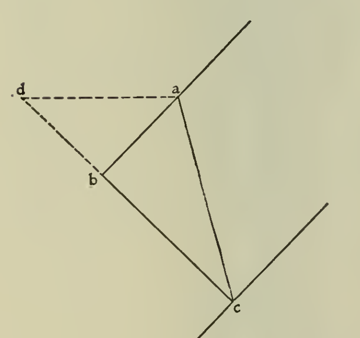
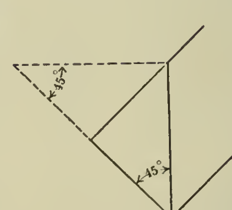


FIG. 2



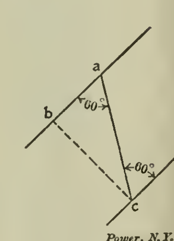


FIG. 3 FIG. 4

plied by the sine or by the cosine of the angle of the seat in order to get the area of the opening available for the discharge of steam.

There could, of course, be no such confusion about so simple a matter if everybody understood the problem alike and meant the same thing when speaking of it.

It all depends upon whether the angle taken is that which the bevel of the seat makes with the vertical or with the horizontal; with the axis through the spindle or with a line at right angles thereto.

In Fig. 1 the valve is shown lifted

vertically from its seat the distance a c but the width of the passage opened for the escape of steam is only b c. Now, b c is the sine of the angle at a and the cosine of the angle at c. In Fig. 2 this triangle is reproduced upon a larger scale and the dotted portion added. The little triangle a b d is similar to the larger triangle a b c, and in it the angle at a is the same as that at c in the larger triangle. But this is the angle which the seat makes with the horizontal and b c is the cosine of this angle.

When the rule says "multiply by the sine," the angle made by the lines a b and a c meeting at a is meant, i.e., the acute

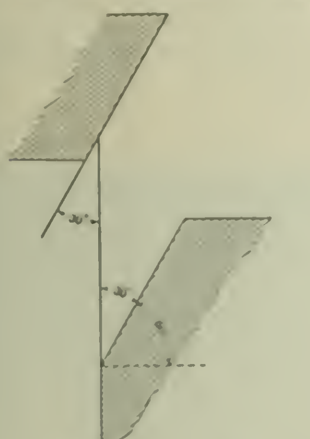


FIG. 5

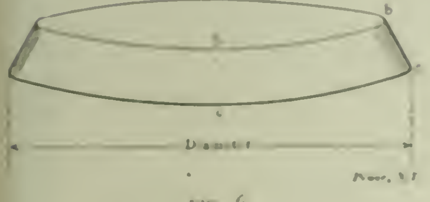


FIG. 6

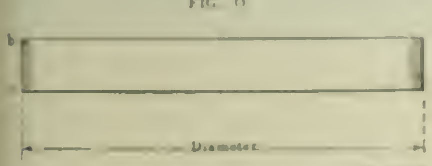


FIG. 7

angle between the line of the seat or the face of the valve and a vertical drawn across it.

When the rule says "multiply by the cosine," the angle made by the lines b c and b a, Fig. 2, meeting at c is meant, i.e., the acute angle made by the line of the seat with the horizontal or by a line b c at right angles to the seat with the vertical. With the common 45-degree bevel it does not make any difference, for both these angles are equal and the sine and cosine are the same. See Fig. 3.

Practically the only other angle used for a beveled seat is 60 degrees, and this is made with the seat 60 degrees to the vertical, as in Fig. 4, and the width of the passage b c is the lift multiplied by 0.866, the sine of 60 degrees.

It would avoid confusion always to speak of the bevel as of that angle which it makes with a vertical. If, for example, a seat were beveled as in Fig. 5, it should be called a 30-degree seat and not a 60-degree, the 60-degree angle being with the horizontal.

The smallest area for the escape of steam is the surface of a frustrated cone made by carrying the line b c around the circle, as shown in Fig. 6. This area will not be found exactly by multiplying b c, found as just described, by the circumference of the inner edge of the seat, which would give the surface of a cylinder of that diameter and of the length b c, Fig. 7. To be accurate, half the side b c should be multiplied by the sum of the circumferences at b and at c. The difference is too small, however, to bother with in so imprecise a problem as the discharge of a safety valve.

Preparation of Boilers for Inspection

By J. E. Terman

Engineers are vitally interested in the safety of the boilers under their charge, for in the average plant the engine room is located so that the engineer's exposure to personal danger from an explosion is almost as great as that of the boiler attendant, and if no other reason existed, this should make him cautious.

One of the most important requirements conducive to a safe boiler, aside from a few very necessary rules of operation, is that thorough expert inspections, both internally and externally, be made periodically to determine if injury has resulted from use. It is best to have such expert inspection at least once a year, but regardless of who examines the boilers, it is the moral duty of the engineer-in-charge to know by actual observation just what condition his boilers are in. For average conditions of operation, about three inspections should be made by the engineer each year. The purpose of the writer is to describe how boilers may be prepared for inspection.

Cooling Down a Boiler

The time that may be taken to cool a boiler varies with the equipment of each plant; in some instances one or more boilers being always idle, there is no need of hastening the cooling-off. When conditions require that a boiler be cooled off quickly for any purpose, it can be accomplished without injury by going at the job in a systematic manner. The first step is to find how the heat to be dissipated is distributed.

Assuming that we have an ordinary 72-inch horizontal return-tubular boiler, running at 150 pounds pressure, to be cooled to 100 degrees Fahrenheit for satisfactory inspection work, the heat to be dispelled in accomplishing this cooling will be about as follows:

The setting will be composed of approximately 75,000 brick, and it can be assumed that the average temperature of the setting walls, running at 500 degrees Fahrenheit, and to reduce it to 100 degrees Fahrenheit would require the extracting of about 7,500,000 B.t.u., using 0.2 as the specific heat of brickwork. The water and steam in the boiler will contain approximately 2,000,000 B.t.u., and the material of which the boiler is constructed 10,000 B.t.u. above the amount contained at 100 degrees Fahrenheit.

Assuming these figures to be approximately correct, it is readily seen that the setting is a very large reservoir of the heat that is to be expelled. The only practical way of dissipating the heat contained in the setting walls with fair speed and without injury, is by means of the stack; that is, by passing large quantities of relatively cool air over the surfaces to conduct the heat away. To accomplish this rapidly all openings in the setting and flue doors should be closed and the damper and fire doors left open, or, in other words, the boiler left just as it would be in operation, with the exception of the fire doors.

While this seems too a simple and obvious requirement, it would be surprising to many, who have not had experience in this line, to know how many boiler attendants imagine that the greater the number of doors left open in a setting the more rapidly the heat will escape, while the reverse is true.

Although the air passing through the setting and boiler carries away the heat from the boiler and contained water, as well as from the setting walls, there is another means of dissipating the heat contained in the water and boiler, if it may be at hand, for accelerating the flow of feed water. For this purpose cool water should be fed in very slowly and the blowoff valve opened just enough to maintain the water level at some point in the gage glass, and not until the setting has properly cooled should the water be let out of the boiler. It is not likely that serious strains will be set up in a boiler in cooling down, as long as the water level is kept up in the ordinary working scale. In some plants it is practice to make a blowing out the water as soon as the pressure has fallen as low as possible, regardless of the temperature of the brickwork, subsequently cooling the boiler and shell by a stream of cold water from a hose. This is very bad practice and frequently leads to leaky tubes and seams.

Cleaning the Combustion Chamber

When the setting has cooled sufficiently the ashes should be raked out of the combustion chamber. Some engineers, instead of raking them out, make a practice of wetting them down with a hose. This should not be done as it dampens the ting walls and it is dangerous for the inspector.

Many a serious burn has been received by crawling into a combustion chamber which has been treated in this manner and sinking through a cold crust of 6 or more inches into red-hot ashes. Inspectors soon become wary of these conditions. It is really surprising how long heat may be retained beneath ashes in a combustion chamber. The writer has seen sawmill boilers, where wood was burned, which had been idle a week, and although everything was apparently stone cold, red-hot ashes could be found a foot below the surface in the chamber back of the bridge-wall.

For proper inspection the grates of a boiler should be raked clean of ash and clinker, for it is extremely unpleasant, and painful, to crawl through a bed of clinkers, as anyone who has tried it can testify.

In the vertical or locomotive type of boiler the grate bars should be removed entirely, for corrosion is extremely liable to occur on the furnace sheets at the grate level, and a proper inspection can rarely be made with the grate bars in place.

Cleaning the External Surfaces

The external surfaces of water-tube boilers cannot be too well cleaned to aid inspection, unless it is at the tube ends, where accumulations caused by leaks may be present. These should be left to be cleaned by the person making the inspection. Such accumulations attract attention to the leaks, and the amount and nature of the accumulations assist the inspector in forming a correct opinion of the importance of the leaks. The foregoing reasoning applies to evidences of leaks at any point along the seams, shell or tube ends of all types of boiler. The blowoff pipes should be exposed for examination, as rapid corrosion frequently occurs on the piping to this attachment, and if it is not arranged so that it can be easily inspected, the equipment is defective, and proper changes should be made. The same reasoning applies to mud drums, where such devices are used, and while it is advisable to protect them from the heat and ashes, the protection should be readily removed to permit proper inspection.

Cleaning Internal Surfaces

If the inspection is for the purpose of determining the cause of a bag, or a leak at a seam, or tube end, or any similar defect, the interior surfaces should not be disturbed until after the inspection has been made, for convincing evidence of the cause of such defects may be removed in cleaning. However, the boiler should be opened, to permit drying out. If no defects as mentioned are known to exist, the boiler should be scaled and thoroughly washed out. This applies especially to the bottom of the return-tubular type, where accumulations of scale make it difficult to detect grooving at the seams, and other types of corrosion.

A necessary condition to permit comfortable and thorough internal inspection, where other boilers are being operated at the time of the examination, is that the valves connecting the boiler with the steam main and feed line be tight. An excellent precaution is to have all the valves to these connections locked shut during the cleaning and inspection of a boiler.

With the agitation for enactment of laws to prevent loss of life by boiler accidents, it would not seem amiss that such a requirement as locking the valves on a boiler during inspection and cleaning be added. This precaution also applies to the blowoff valve, where several boilers are connected to a single blowoff line, for doubtless the greater number of accidents due to scalding have been caused from this connection, owing to its apparent harmless nature, being on an open line. The experienced inspector soon learns to make it a fast rule, in plants where other boilers are in operation, to see that the blowoff valve on a boiler he is about to enter is closed, and he never takes anyone's word for it.

Attachments

Where safety valves are equipped with discharge pipes, they should be arranged so that a section next to the valve can be easily removed, to permit examination of the springs and moving parts. The steam gage should be removed from the boiler, so it may be compared with a test gage, and any necessary connections made.

Except in rare instances, there is no justification for placing in a boiler any apparatus which will interfere with easy access through the manholes, or proper inspection of the interior surfaces; if such conditions do exist, the attachment should be arranged so that it can be removed when an inspection is to be made.

The points here given are only some of the main features for the average plant; numerous other details for each specific case will suggest themselves to the progressive engineer, who is endeavoring to obtain the maximum benefit from such examinations.

The United States Civil Service Commission announces an examination on May 5 to secure eligibles from which to fill a vacancy in the position of mechanical assistant, at a salary of from $900 to $1200 per annum, in field investigations, Bureau of Plant Industry, Department of Agriculture. Applicants should have a knowledge of refrigerating machinery, and it will be necessary that the appointee be of slender physique on account of the limited space available in which some of the work must be done. Application form 1093 should be secured. Apply to the commission, at Washington, D. C.

Catechism of Electricity

Installation of Induction Motors

1017. *What consideration should govern the location of an induction motor?*

It should be placed where it is easily accessible for inspection, oiling or cleaning, and repairs. It must not be exposed to moisture, leaky steam pipes or dirt and coal dust. It should receive proper ventilation and should be mounted so that there is sufficient distance between its pulley and the pulley on the machine driven by it to permit the belt to drive efficiently and without excessive tension.

1018. *What kind of foundation is most desirable?*

A heavy timber or a concrete foundation as shown in Fig. 286 is best. It should be sufficiently heavy and so well bonded that there will not be any vibration. The foundation of the motor and of the driven machine should set with respect to each other so that the two shafts are parallel, in order that the rotor or rotating parts of the induction motor may "float" in its bearings.

1019. *In lining up a belted induction motor with the driven pulley what special precautions should be observed?*

The position of the motor with respect to the driven machine should be such that the belt will be tight enough to run without slipping, but not so tight that the bearings become unduly heated. The crowns of the two pulleys should be as nearly as possible alike to prevent the belt from wabbling; the greatest diameter should be at the center of the pulleys so that the belt will travel true and allow the rotor shaft to float. The belt must be free from grease and dirt, else it is likely to slip and flap, and the edges of the belt must stretch equally or there will be an objectionable sidewise movement of the belt on the pulleys.

1020. *In alining a direct-connected induction motor, what special precautions should be observed?*

The shafts of the machines to be coupled must be in perfect alinement with each other, and this alinement must be maintained by building the foundations so that they will not settle or vibrate.

1021. *If the motor is to be geared to its load, what points should be considered?*

The shafts must be carefully adjusted to parallelism and set the specified distance apart. The pinion should fit securely on the motor shaft, but not so tightly that it cannot be forced on or off with moderate pressure. If the pinion is driven on by heavy blows with a ram or sledge the rotor conductors are liable to be jarred out of place and damaged.

1022. If it is desired to use the motor in other than an upright position, what changes are necessary?

Ordinarily induction motors are made so that the only change necessary for operating them in other than an upright position is the shifting of the bearing brackets either 90 degrees or 180 degrees, as the case may be, in order that the oil wells shall remain in their proper position.

1023. Are there any special precautions to be observed when shifting the bearing brackets?

Care must be taken to replace them so that the rotor is properly centered. The air gap between the rotor and the pole faces must be the same at all points.

1026. What should be the capacity of the conductors and fuses in the motor circuit with respect to the full-load motor current?

For ordinary service the conductors and fuses should have a capacity 1½ times the full-load current. Where elevators or hoists are operated by the motors or wherever heavy starting duty is required of them, the capacity of the fuses should be 2½ times the full-load current.

1027. What size of conductor would be necessary for wiring up a two-phase induction motor, requiring 43 amperes, for ordinary service?

The capacity of the conductor, according to answer No. 1026, should be 1½ × 43 amperes = 64.5 amperes. Referring to the table under [illegible] No. [illegible] showing the carrying capacities of copper wires, it will be found that [illegible] work a No. 5 B. & S. gage conductor is the smallest size that will safely carry this current.

1028. What size fuse should be employed in a three-phase motor circuit if the motor requires 43 amperes at full load and is to be used at a hoist?

For hoist work the fuses should be rated at 2½ times 43 amperes; that is, they should be capable of carrying 2½ × 43 = 107.5 amperes without melting. Referring to answers Nos. [illegible] and [illegible], a [illegible] fuse of [illegible] amperes in either the open or inclosed [illegible] type would serve the purpose.

OPERATION OF INDUCTION MOTORS

1029. Are the starting conditions of different induction motors about the same?

No, they differ widely. Some start with full-load current and full-load torque, while others require two or more times their full-load current in starting under similar conditions. Two-phase and three-phase induction motors start with a higher torque and lower current than do single-phase induction motors.

1030. What is objectionable about a large starting current?

It is highly inductive and has very bad effects on the regulation of the supply circuit.

1031. In the operation of an induction motor how may the starting current be kept down?

By inserting resistance in the rotor circuit at the time of starting or by starting the motor on a voltage lower than the normal line voltage.

FIG. 286. SUBSTANTIAL FORM OF FOUNDATION FOR AN INDUCTION MOTOR

1024. In assembling an induction motor just received from the factory, what points should be observed?

The bearings and oil wells must be carefully wiped clean and the shaft rubbed with oil before being put into place. Only the highest grade of dynamo oil should be used in the bearings and they must be filled to such a hight that the surface of the oil comes above the lowest edges of the oil rings. The oil rings must revolve freely and carry sufficient oil to flood the bearings.

1025. In wiring up an induction motor how is one to know what size conductor to use?

The size of conductor to use is, of course, determined by the amount of current the motor requires. The full-load current for an induction motor is usually stamped on the nameplate. When it is not, the builder should be asked to specify it.

Washington Meeting of the A. S. M. E.

The announced program for the Washington meeting of the American Society of Mechanical Engineers is as follows:

TUESDAY, MAY 4, 8:15 P.M.

Informal reception at the New Willard hotel.

Address of welcome by Hon. Henry B. F. Macfarland, president of the Board of District Commissioners.

Response by President Jesse M. Smith.

WEDNESDAY, MAY 5

Professional session at 9:30 a.m.

Sight-seeing automobile trips about the city, at 10 a.m., for the ladies.

Reception of members and guests by the President of the United States in the East Room of the White House at 2:30 p.m.

Trips to nearby points of interest at 3 p.m.

Illustrated lecture by F. H. Newell, director of the Reclamation Service, on "Home-Making in the Arid Regions," at 8:15 p.m.

THURSDAY, MAY 6

Short professional session at 9:15 a.m.

Trips for ladies to points of interest in and about the city at 9:45 a.m.

Special [illegible] to Mount Vernon at 2 p.m.

Social session. Address by Rear Admiral Melville on "The Engineer in the Navy," at 8:15 p.m., to be followed by presentation to the National Gallery of a portrait of Rear Admiral Melville, with acceptance by Dr. C. D. Walcott, accepting the portrait.

FRIDAY, MAY 7

Professional session at 9:30 a.m.

It is possible that during the convention there will be [illegible] of a [illegible] [illegible] to which members and guests have be invited.

POWER AND THE ENGINEER

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Contents PAGE

Handling the Peak Load

If a flexible expanding and contracting grate could be designed, by means of which the correct relation of grate area to generator output could be maintained, a measurable reduction in the coal cost per kilowatt-hour would result. In power plants where the peak load for a short time amounts to three or four times the average load, the economical handling of this peak becomes a serious problem.

Generating units which may be operated without a marked loss in efficiency over a range of output from three-fourths load to an overload of fifty per cent. are common, and when not in operation do not eat into the coal pile.

When the average, the maximum and the minimum demands and their probable duration are known, generating units may be selected of such capacity that the entire range may be covered by two or three, and the steam cost per kilowatt-hour vary but little from the average, whether operating on the peak or on the lightest run.

But it is somewhat different in the boiler plant. Here an area of grate surface sufficient for the utmost needs of the service must be kept in readiness for use all of the time. Banked fires cost money in more ways than one, and not the least cost is in the investment involved in boilers where this method is followed; and in various directions designers are working to increase the output of boilers without appreciably reducing the efficiency.

Experiments with this end in view have been numerous. In one instance the grate area under a boiler was doubled by the installation of an additional stoker at the rear end of the boiler, on the grates of which the fire was banked during part of the day. Whatever this combination lacks of realizing the highest efficiency in operation and the loss that obtains in a banked fire at one end of the boiler during a part of the time, it probably costs less in investment and in operation than two boilers, each equipped with one stoker.

In another attempt along the same line oil burners were installed under a portion of the boilers, to be used on the peak load. Oil is a more expensive fuel than coal in most localities, but the fire does not need banking when not in use, and it was thought that the cost of using some oil fuel part of the time would be less expensive than using coal for all of the fires.

In still another case oil burners were installed above the coal fires, with the intention of burning all of the coal possible on the grate, and with the oil burners so designed that the necessary air for their operation would enter the furnace with the oil, thus increasing the volume of hot gases, if not also the temperature of the furnace.

In the first and last of these three experiments to make an efficient and elastic boiler-room equipment the investment in boilers is reduced to the lowest practicable amount, while in the second, although the boiler investment is not reduced, the waste attending the slow, inefficient burning of coal in banked fires is avoided.

The Progress in Marine Engineering

From September 25 to October 9 of this year the State of New York will commemorate the three hundredth anniversary of the discovery of the Hudson river and the one hundredth anniversary of the successful introduction thereon of steam navigation. For nearly twenty centuries the river flowed on undisturbed by man, save when the savage propelled himself from shore to shore on a floating log, or when later he burned a hollow in a log, in semblance of a boat, or, as his mental capacity broadened, built his canoe of the bark of trees and propelled it by crude paddles. Thus as recently as a hundred years ago the motive power for boat propulsion was human muscle.

It is difficult to realize this now. The gigantic steamships of today are so common that they attract slight attention; yet they had a beginning. Fulton did not construct a modern seamship, but he applied the power of steam to the paddle-wheel of a boat and revolutionized the then existing method of ship propulsion. The history of invention contains almost countless instances of great discoveries which were the outgrowth of small beginnings. There were steam engines in crude forms long before Robert Fulton was born; and men had attempted the propulsion of ships by steam, but they had not grasped the requirements necessary for commercial success.

Today, when it is announced that a valuable discovery has been made, or a new invention has been perfected, the inventor finds scores of capitalists ready to back him with their money, provided it is worth while. Not so with Fulton, however, for while he was at work upon the "Clermont," which the disbelieving public called "Fulton's Folly," tokens of encouragement were few and far between. It was only after the run from New York to Albany, one hundred and fifty miles in thirty-two hours, the entire run having been performed by the power of steam, that the significance of his achievements was realized. The old Hudson river had not witnessed a sight even approaching this since the "Half Moon" sailed over the same course nearly two hundred years before.

The advancement in steam navigation during one hundred years has been marvelous. Today the Hudson river is the pathway of thousands of steamships. The run to Albany is made day and night by steamers of types unequaled throughout the world; the waters of the river are cleaved by the prows of the "Lusitania" and "Mauretania," the largest and fastest steamships in the world—magnificent monuments to the growth of marine engineering in one hundred years.

While it is true that Fulton did not build the first boat propelled by steam, he inaugurated the great movement of steam navigation, and he has justly been called "the father of American steamboating."

Safety for Boiler Attendants

An article on another page of this issue suggests that the valves leading to the steam main and other lines on a boiler which is being cleaned, inspected, or repaired, be locked shut, to prevent accidental opening of them while someone is inside the boiler. Such a requirement added to municipal or State boiler laws would apparently be a step in the right direction.

As has been previously stated in these columns, the only excuse for the existence of laws licensing engineers and firemen, and supervising boiler construction, is the avowed purpose of throwing safeguards around human life. Should not the lives of the boiler attendant or inspector, or the boiler repairman, be safeguarded with as much zeal as those of other employees, or the casual passer-by or lounger around the plant?

We frequently read of some frightful accident in a plant, where a boiler attendant has been imprisoned in a boiler and scalding steam or water turned on, the general cause being an ignorant fellow operative, who has opened some valve without knowing the fearful consequences that would result, and the accident is soon forgotten, the general opinion being that until more intelligent operatives are demanded, such accidents will occur with more or less frequency. Such reasoning is without foundation, for only a few men in a plant should have authority to open and close valves, and to prevent accidents due to their forgetfulness or from the zeal of the fool meddler, a lock would be very effective.

It is, without doubt, desirable to prevent making any rules governing boiler operation or construction that are not absolutely essential to safety. For regardless of how complete rules may be made, conditions not contemplated will arise, and in such cases, with a few simple rules the judgment of the individual inspector can be relied upon to adjust the details to suit each case. Notwithstanding this recognized need of brevity, we think such a rule as here advocated would be a very proper addition, and, if enforced, it would be as certain of accomplishing the purpose for which it was intended as any of the rules with which we are familiar.

Characteristics of the Turbine Pump

The article published under the above title by Frederick Ray in our issue of March 23 has attracted a great deal of attention from practical engineers and possible users of pumps of this class as well as from pump designers. In fact, it was at the user of the pump that the article was directed, the curves indicating possibilities and performances of given pumps under varying conditions, rather than the effect of varying factors in the pump itself.

It was only a few years since the centrifugal pump was restricted to a comparatively narrow field and served only a few purposes, as where large quantities of liquid had to be lifted against low heads. For such purposes, especially for the handling of sewage, the pumping out of excavations, etc., the valveless and pistonless centrifugal offered particular advantages, and it has become so associated in the public mind with this class of work that it has been difficult to secure an appreciation upon the part of pump users of the progress which has been made in the development of this type of pump and the extension of the field to which it is applicable.

Today there is hardly a service for which the centrifugal or turbine type of pump is not ready to compete with the piston variety. In several of the large power plants of the country they are successfully used to handle the boiler feed against high boiler pressures. Mr. Ray's article shows in a simple and easily understandable way the real merits, capabilities and limitations of the type. The relations of head, horsepower required, efficiency and capacity are admirably brought out in the diagrams which he furnishes, and a little study of the article will put the engineer or power user into possession of the latest and best information attainable as to what is available and capable of accomplishment in this line.

Turbine versus Reciprocating Engines

We have several times referred to the three scout cruisers in which the United States Navy is trying out the comparative merits of the turbine and the reciprocating engine. These are the "Birmingham," with reciprocating engines, the "Chester," with Parsons turbines, and the "Salem," with Curtis turbines.

The vessels are built to the same model, having a trial displacement of [illegible] tons and designed for something like [illegible] horse horsepower.

Trial runs at 10 and 15 knots have been made with the following results, in tons of coal consumed:

	At 10 Knots	At 15 Knots
"Birmingham" (Engines)	[illegible] tons	[illegible] tons
"Chester" (Parsons)	[illegible] tons	[illegible] tons
"Salem" (Curtis)	[illegible] tons	[illegible] tons

These results are unofficial and interesting only for comparison. At the lowest speed the reciprocating engine is at a decided advantage, requiring only three-quarters as much coal as the Parsons turbine and about three-fifths as much as the Curtis. The "Chester" is a four-screw boat, while the others have but two screws each. Our advices do not say whether all of the turbines were used on the slower trial. If they were not the Parsons turbine had the advantage of working more nearly to its capacity.

The turbine, depending for its operation upon the "interaction" between jet and blade, is much more sensitive to departure from the speed for which it is designed than the piston engine, and its improved showing at the 15-knot speed is very apparent. Calling the consumption of the "Birmingham" 1, that of the "Chester" is [illegible] at the lowest and [illegible] at the 15-knot trials, while that of the "Salem" is [illegible] and [illegible] respectively.

It will be very interesting to see how the results will compare at the 25-knot speed which the vessels are expected to make.

A License and Inspection Bill for Wyoming

There is before the legislature of the State of Wyoming an act to constitute a State Board of Inspection for Steam Boilers and for the examination and licensing of engineers. The bill, curiously, [illegible] its title and notwithstanding [illegible] in the text it provides that "there" shall be one and [illegible] authorizes the appointment of but one inspector. All boilers, with the usual exceptions, are to be inspected annually and tested by hydrostatic pressure to exceed the working pressure allowed in the ratio of one to [illegible]. A fee of [illegible] for each boiler is required when there is but one boiler and [illegible] for each additional boiler when there is more than one in a plant.

The fee for the examination of applicants for license is [illegible] for first-class engineers, [illegible] for second-class engineers and [illegible] for third-class engineers. The license must be renewed each year, the renewal being [illegible]. If an engineer feels that he has been unjustly refused a license, [illegible] an engineer holding a license of the grade of that for which he is applying and the engineer with the inspector are to select another, these two with the inspector to give the man another examination, which shall be final.

The relative proportions of different expenses in power generation in the electric stations of Massachusetts have been found to average as follows: For each dollar received from the consumer [illegible] cents is spent for fuel, [illegible] cents for wages at the station, [illegible] cents for maintenance, repairs and [illegible] cents for [illegible].

Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

Telescope Ash Elevator

For steam plants such as are usually located in a basement or subbasement, and not a few of which are without access even to an alley, the problem of ash disposal becomes a matter of considerable moment. In the photographs reproduced herewith is shown a device well adapted to this purpose.

This elevator, which is of the "telescopic" type, has been especially designed by the Chain Belt Company, Milwaukee, Wis., for elevating ashes from a basement and discharging them directly into a wagon drawn up at the curb. See Figs. 1

FIG. 1. TELESCOPIC ASH ELEVATOR EXTENDED THROUGH SIDEWALK READY TO DISCHARGE INTO WAGON

and 2. When not in use, it can be let down again through the opening in the sidewalk and left standing in its corner, where but little space is occupied. See Fig. 3.

The elevator frame, head and boot are of all-steel construction, well braced and stiffened. The buckets are of malleable iron, carried on an interlocking-chain belt particularly adapted to service of this character and placed at such intervals as to give satisfactory capacity at a minimum of power for operation, it is said.

By means of the special links, the elevator is locked at every point, thereby eliminating the possibility of an accident

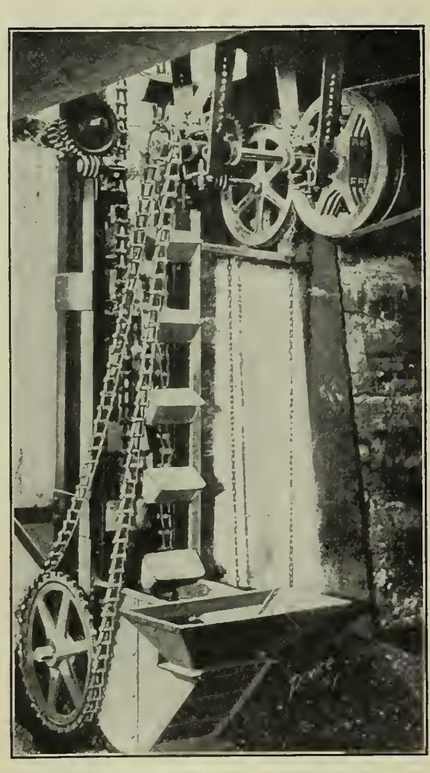


FIG. 2. TELESCOPIC SIDEWALK ASH ELEVATOR EXTENDED

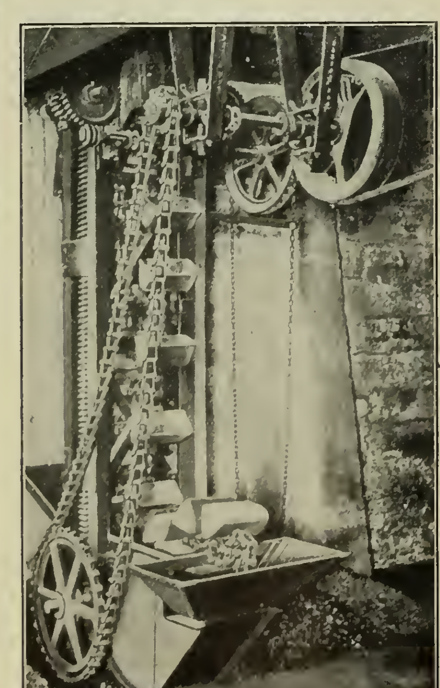


FIG. 3. TELESCOPIC SIDEWALK ASH ELEVATOR LOWERED

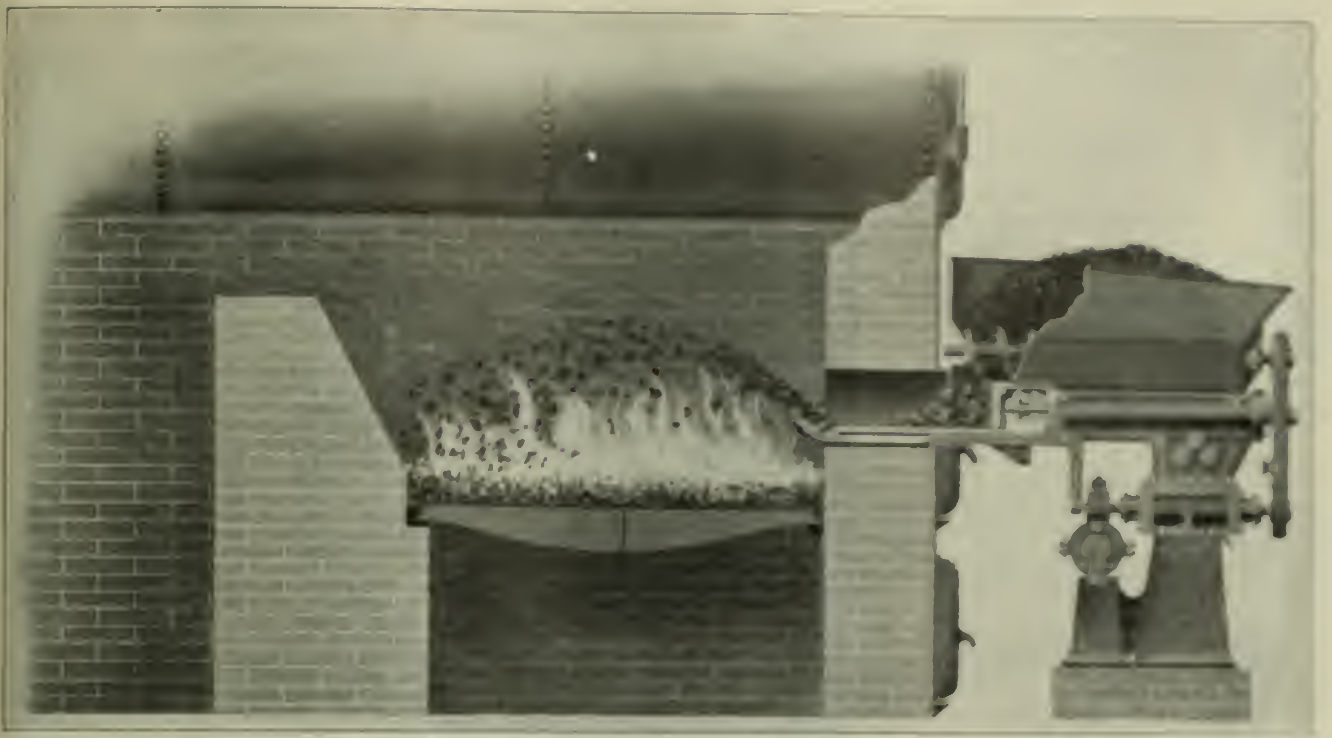
and telescoping the apparatus, which would cause considerable damage.

The mechanism for raising and lowering the elevator consists of racks and pinions operated by a worm-gear drive which takes its motion from the same countershaft that operates the elevator belt. Where convenient, a small electric motor may be used to transmit power to the apparatus, but the intermittent character of the service will, in most cases, make connection to shafting more economical.

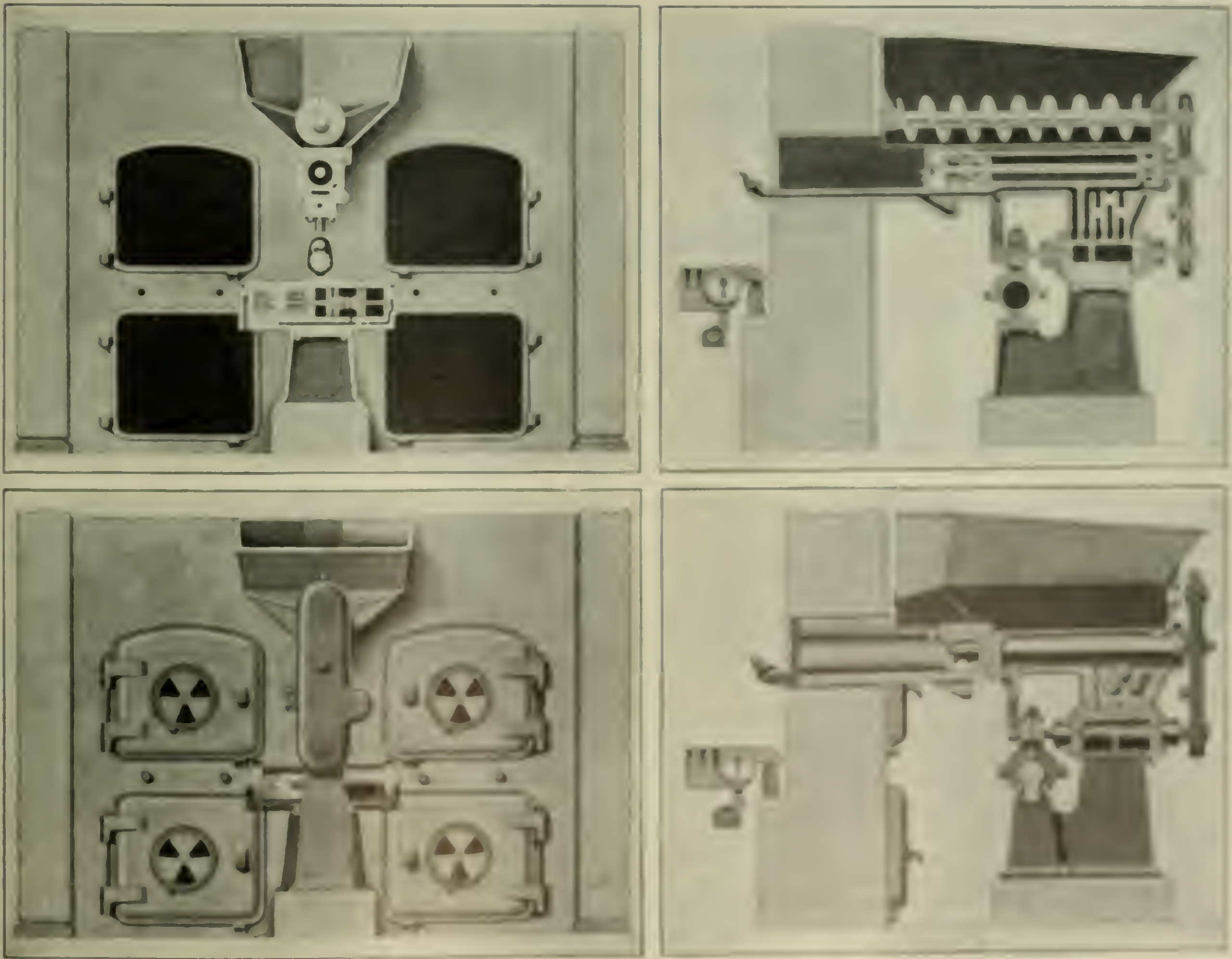
Erie Foundry Company's Stoker

The Erie stoker is of the overfeed plunger or shovel type. It consists essentially of a coal hopper, with an opening in the bottom at the end nearest the boiler; a conveyer for agitating or carrying the coal from the rear of the hopper to an opening at the front, where it falls by gravity in front of the plunger; a main cylinder and trough in which reciprocates a plunger piston which, with variable stroke, throws the coal to the different parts of the firebox. The variable stroke is given to the plunger by means of a rotary valve, from which three separate steam ports lead to the rear end of the cylinder, and three choke plugs, one for each of the steam ports. The office of the choke plugs is to vary the amount of steam reaching the rear end of the cylinder through the various ports. As the valve operates, the ports stop full open in front of their corresponding steam passages in regular succession. By choking down the steam with the choke plug nearest the rear of the stoker until that port is almost closed, there is obtained a very light stroke of the plunger, thereby distributing the coal over the grate near the fire door. The other two choke plugs operate in turn in the same manner, only they are so adjusted that more steam is admitted on the second stroke than on the first, thus distributing coal over the middle portion of the grate, and more on the third stroke than on the second, thereby scattering the coal over the rear end of the grate. By adjustment of the choke plugs any desired arrangement of distribution may be obtained.

The conveyer is controlled by a small reciprocating steam motor, which also operates the valve that controls the speed of the plunger to provide a uniform



THE ERIE FOUNDRY COMPANY'S STOKER



FRONT AND SIDE ELEVATIONS OF THE ERIE STOKER amount of coal for each stroke. A deflector attached to the front of the trough is designed to spread the coal to the sides of the furnace as it is delivered by the plunger. This deflector is the only part of the stoker exposed to the fire, and it depends for protection upon exhaust steam from the stoker, which passes through it. By having the stoker located outside of the firebox, if anything goes wrong it can be repaired without inconvenience; and being between the two fire doors, if there is a breakdown it is a simple matter to hand-fire until repairs are made. It is also to be noted that practically no change is necessary in the construction of the firebox.

The stoker may be used with either natural or forced draft, no change to the grate bars being necessary, and any operating engineer can install it without the services of an expert. It is built by the Erie Foundry Company, Erie, Penn.

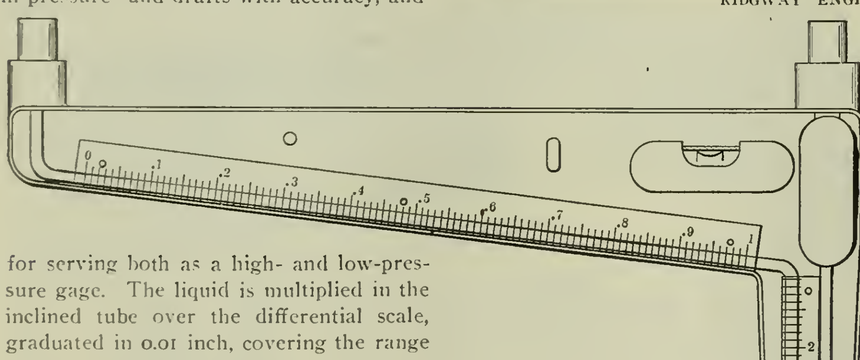
Ellison Differential-Direct Draft Gage

In this draft gage a combination of a differential and direct draft gages in one simple instrument has been made. It is intended for measuring high fluctuations in pressures and drafts with accuracy, and for serving both as a high- and low-pressure gage. The liquid is multiplied in the inclined tube over the differential scale, graduated in 0.01 inch, covering the range of low intensities of drafts and pressures, beyond which the percentage of error becomes too small to be of importance to be multiplied and the liquid turns downward into the vertical tube over the direct scale, of 5-inch equivalent water head, graduated equivalent to 0.1 inch and easily subdivided into small fractions by reason of the small diameter of the bore of the indicating tube and the wider spacing of the graduations for oil to represent water.

The liquid used is 39-degree Baumé oil, having a constant capillary attraction for which the gages are corrected, the rise of the liquid in the chamber and the specific gravity are compensated for in the design and arrangement of the scales, so that the indications represent the equivalent of distilled water directly on the single reading scales without any corrections or calculations whatsoever.

The gage is made in four capacities, comprising a 6-inch, a 6½-inch, a 7-inch and an 8-inch. In the 6-inch gage, the first inch of equivalent water head is multiplied ten times, having a scale 10 inches long; and in the 6½-inch gage, the first 1½-inch equivalent head is multiplied ten times, having a scale 15 inches long. In the 7-inch gage, the first 2 inches of equivalent water head are multiplied five times, having a scale 10 inches long; and in the 8-inch gage, the first 3 inches of equivalent head are multiplied five times, having a scale 15 inches long.

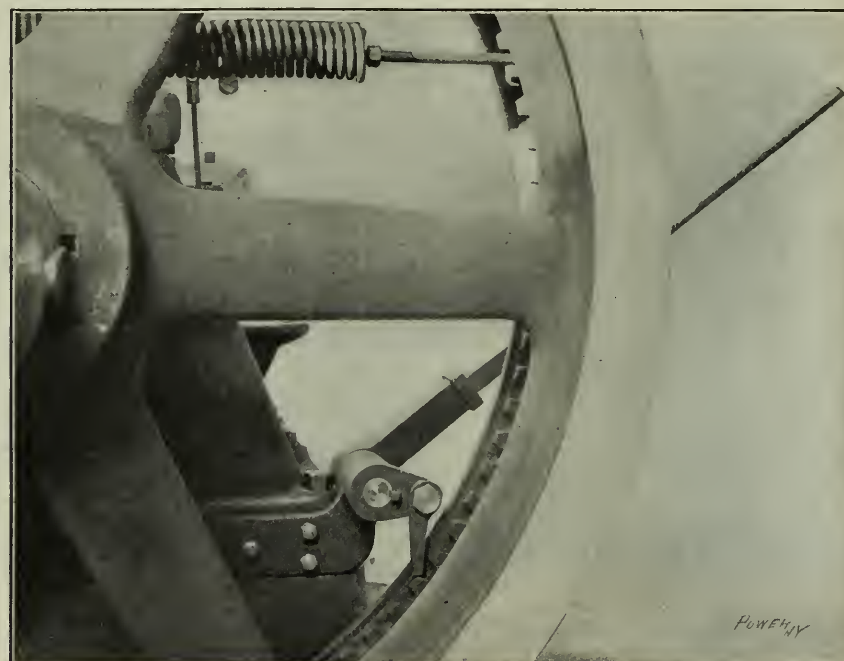
The frames are of aluminum, polished and buffed on the outside; and the scales are of a special, noncorrosive german silver. This instrument is manufactured by Lewis M. Ellison, 6238 Princeton avenue, Chicago, Ill.



ELLISON DIFFERENTIAL-DIRECT DRAFT GAGE

Engine Turning Device

An engine-turning device that will appeal to engineers and others interested in Ridgway engines is shown herewith. The device is bolted to the frame of the engine and consists of a ratchet attachment which engages in teeth on the rim of the flywheel. By this means the largest engine made by the Ridgway Dynamo and Engine Company, Ridgway, Penn., which also makes the device, can be moved from its center. When not in operation the handle bar is removed and the ratchet part thrown back out of engagement.


RIDGWAY ENGINE-TURNING DEVICE

A. I. E. E. Annual Meeting

The annual convention of the American Institute of Electrical Engineers will be held at the Hotel Frontenac, Thousand Islands, Frontenac, N. Y., beginning Monday, June 28, next. A tentative list of papers to be presented includes the following:

"Split-Pole Converters and Storage-Battery Regulation at Gary, Ind." By J. L. Woodbridge.

"The Reduction in Capacity of Induction Motors Due to Unbalancing in Voltage." By S. B. Chartres and W. A. Hillebrand.

"The Heating of Induction Motors." By Alexander M. Gray.

"Generators for 100,000 Cycles." By E. F. Alexanderson.

There will also be three power papers, by D. B. Rushmore, and two educational papers, by H. H. Norris.

Inquiries

Questions are not answered unless they are of general interest and are accompanied by the name and address of the inquirer

Steam Superheats when Expanding in a Receiver

In a pamphlet on "Compound Engines" I read the following: "It is said that drop cannot be detrimental to economy because steam expanding freely in this way (in a receiver) loses no heat but becomes superheated, and at the lower pressure contains every unit of heat it contained at the high."

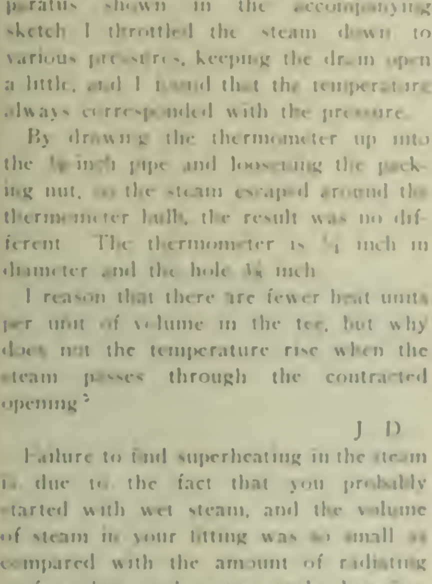
To prove that this is a fact I tried the following experiment. With the apparatus shown in the accompanying sketch I throttled the steam down to various pressures, keeping the drain open a little, and I found that the temperature always corresponded with the pressure.

By drawing the thermometer up into the ⅛-inch pipe and loosening the packing nut, so the steam escaped around the thermometer bulb, the result was no different. The thermometer is ¼ inch in diameter and the hole ⅜ inch.

I reason that there are fewer heat units per unit of volume in the tee, but why does not the temperature rise when the steam passes through the contracted opening?

J. D.

Failure to find superheating in the steam is due to the fact that you probably started with wet steam, and the volume of steam in your fitting was so small as compared with the amount of radiating surface that condensation took place faster than superheating, and the heat generated by expansion was absorbed in the evaporation of the moisture at the temperature due to the pressure rather than in elevating the temperature of the mass. In order to make the experiment effective you should have the surfaces abundantly protected by nonconducting material and assure yourself that the steam is dry when it reaches the apparatus. A demonstration of the fact that steam superheats when expanded under these circumstances is found in the throttling calorimeter, which is very much along the line of the apparatus that you have devised.



APPARATUS USED IN THE EFFORT TO PROVE THAT STEAM SUPERHEATS WHEN EXPANDING IN A RECEIVER

Lumps of Scale in Boiler Tubes

When we run the flue scraper through the boiler tubes we sometimes strike lumps of hard scale. What causes these lumps?

E. F.

Some of the tubes are leaking at the back end and the water is drawn into the tube and there evaporated, leaving behind all of the dissolved solid matter, which sticks to the tube in the form of scale.

Cause of Pound in Check Valve

Every time a certain plunger of our duplex feed pump sends water into the boiler the check valve in the feed line pounds. What is the probable cause?

F. G.

The motion of the plungers may be uneven, allowing the water in the pipe to come to rest. Every time the moving water stops, the check valve will seat with more or less noise. Or the discharge valves in the pump may be in such shape that they do not close promptly and the water flows back into the pump cylinder until the closing of the check valve in the feed line stops it.

Angle of Deflection, etc., of Crank Shafts

I am anxious to know a few things about crank shafts:

(1) What is meant by the angle of deflection? I have read that for a double-throw shaft of a compound steam engine it is between 0.000270 and 0.000412 second.

(2) How can I determine the equivalent twisting moment, or the angle of twist on, for instance, one of the double compound engines in the Interborough station in New York? The high-pressure cylinder is 42 inches in diameter, the low-pressure cylinder 86 inches, the stroke 5 feet, the revolutions per minute 75, the steam pressure 175 pounds per square inch, the crank shaft 34 inches in diameter at the bearings, the length of the shaft 25 feet 3½ inches, and the flywheel generator weighs 370,000 pounds.

(3) What is the strength of that shaft, and how is it calculated against the bending by the weight of the generator and for the twisting strain produced by the crank effort?

H. H.

(1) Deflections are not usually measured in angles and you probably mean angle of torsion. This term means the angle of twist in the shaft between any two points.

This angle is

$$\theta = \frac{M\,s}{C\,I},$$

where

θ is in radians $\left(\text{radian} = \frac{180}{\pi}\ \text{degrees}\right)$

M = Twisting moment on this length of shaft (foot-pounds);

s = Length of section of shaft in feet;

C = Shear modulus of elasticity, for steel = 12,000,000;

I = Moment of inertia of the shaft section = $\frac{\pi r^4}{2}$ for solid shaft and $\frac{\pi r^4}{2} - \frac{\pi r_1^4}{2}$ for hollow.

(2) The angle of twist is found as already explained under question (1).

To find the equivalent bending moment proceed as follows:

Find the maximum bending moment (M_b) between the bearings by the usual method of beams.

$$M_x \text{ at } X = R_1 \times a$$
$$M_y \text{ at } Y = R_1 b - X (b - a)$$
$$M_z \text{ at } Z = R_1 c - X (c - a) - Y (c - b)$$

The greatest of these moments will be the maximum bending moment.

Maximum twisting moment (M_t) = *Maximum crank thrust* × *Crank arm*.

To combine these moments to get the equivalent bending moment, the most reliable formula is Grashof's

$$f = \frac{r}{I_1}\left\{\tfrac{3}{8} M_b + \tfrac{5}{8}\sqrt{M_b^2 + M_t^2}\right\},$$

where I_1 is the bending moment of inertia $= \frac{\pi r^4}{4} - \frac{\pi r_1^4}{4}$ for a hollow shaft such as the Interborough engines [illegible] and r is the outside radius of the shaft and r_1 the inside radius.

Therefore the combined moment is equivalent to a bending moment

$$M_e = \tfrac{3}{8} M_b + \tfrac{5}{8}\sqrt{M_b^2 + M_t^2}$$

(3) Grashof's formula gives a value for the maximum fiber stress f due to the combined moment. This value should not exceed the tensile strength of the steel divided by a suitable factor of safety, usually 5 or 6.

Hence,

$$f = \frac{[illegible]}{6} = [illegible]$$

pounds per square inch. If

$$\frac{r}{I_1}\left\{\tfrac{3}{8} M_b + \tfrac{5}{8}\sqrt{M_b^2 + M_t^2}\right\} = f,$$

the shaft is safe.

Book Reviews

THE GAS ENGINE. By Forrest R. Jones. Published by John Wiley & Sons, New York, 1909. Cloth; 455 pages 6x9 inches; 142 illustrations. Price, $4.

This book has the merit of presenting a treatment of the subject which differs from the usual testbook routine, as well as some material not ordinarily found in such books. The author devotes a rather disproportionate amount of space to automobile practice and a correspondingly meager quantity to stationary engines. The discussions of ignition systems, the physical properties of gases, combustion, fuels and gas producers are especially clear and satisfying and the tables compiled from the Geological Survey coal-test report will be found of immense convenience by anyone practically interested in gas producers.

NOTES ON HYDROELECTRIC DEVELOPMENT. By Preston Player. McGraw Publishing Company, New York. Cloth; 68 pages, 4¾x7 inches. Price, $1.

This little work is intended to indicate general lines along which investigation should be made to afford a basis for forming a correct opinion of the merits of any proposed undertaking in the line of hydroelectric power-plant development from the investor's viewpoint. Generating electric energy has reached such a degree of perfection that what competition means must be thoroughly understood before hydroelectric enterprises are taken up. The author has divided the work into two basic inquiries: "What will be the cost of making any development?" and "What receipts may be expected from the undertaking?" and he has presented an intelligent method of seeking correct answers to the inquiries.

HEAT ENERGY AND FUELS. By Hanns von Jüptner. Translated into English by Oskar Nagel. McGraw Publishing Company, New York, 1908. Cloth; 310 pages, 6x9 inches; 118 illustrations; 137 tables. Price, $3.

Barring Chapter II, on Forms of Energy, Professor von Jüptner has produced a remarkably clear-cut and useful textbook. The title is somewhat a misnomer and the confused and abstruse discussion in the chapter mentioned could have been omitted with distinct advantage. The author's attempt to explain work in terms of distance, surface and volume is not clear and might easily be misleading to a student.

The remainder of the book deals with fuels, their analysis, their utilization by combustion and partial combustion, and the measurement of high temperatures. This part, constituting the bulk of the work, is excellent. The tables giving the composition of various grades of the different fuels could have been made more convenient for general reference by grouping them together in an appendix, but as the book was written for college use, the location of each table in the text referring to it is but logical.

The discussions of peat and lignite, which usually receive scanty attention in a book of general character, are most satisfying and the chapters on producer gas and water gas and the means of making them are particularly complete and clear.

ALTERNATING CURRENT MACHINES. By Samuel Sheldon, Hobart Mason and Erich Hausmann. Published by D. Van Nostrand Company, New York, 1908. Cloth; 360 pages, 5½x8 inches; 236 illustrations. Price, $2.50.

This is the seventh edition of Dr. Sheldon's excellent textbook, and it shows the effects of extensive revision. The original edition of the book impressed the reviewer as being a conspicuously fine example of college textbook, and an honest opinion of the present edition might be regarded as fulsome eulogy, so the reviewer will refrain. It may be well to inform those who are unfamiliar with the work that it is intended for use in technical colleges and not for unassisted study by beginners. It is remarkably clear in exposition, but a knowledge of mathematics as far as elementary calculus is necessary for the student to derive the proper degree of learning from its contents.

WASHING AND COKING TESTS OF COAL. By A. W. Belden, G. R. Delamater and J. W. Groves. Issued by the United States Geological Survey, being Bulletin 368. Paper; 54 pages, 6x9 inches; illustrated. Gratis upon application.

The investigations described in this report were undertaken by the Government for the general purpose of increasing efficiency in the utilization of the fuel supply of the United States by devising improvements in washing and coking coals. The washing tests of coal were made to determine the possibility of so improving the quality of the coal as to render it available for the production of coke. The coking tests were made to determine the possibility of utilizing the various coals in this way or to devise improvements in coking practice. The washing tests have demonstrated the fact that many coals which are too high in ash and sulphur for economical use under the steam boiler, or for coking, may be rendered of commercial value by proper treatment in the washery. The coking tests have demonstrated that many coals which were not supposed to be of economical value for coking purposes may be so rendered by proper treatment in the washery and coke oven. The bulletin describes the washery plant established by the Survey at Denver, Colo., and gives the analyses of and the results obtained with numerous coal samples.

Books Received

"The Internal Combustion Engine." By H. E. Wimperis. D. Van Nostrand Company, New York. Cloth; 326 pages, 5¼x8½ inches; 114 illustrations; tables. Price, $3.

"Heavy Electrical Engineering." By H. M. Hobart. D. Van Nostrand Company, New York. Cloth; 338 pages, 5½x9 inches; 188 illustrations; 19 plates; tables; indexed. Price, $4.50.

"The Theory of Electric Cables and Networks." By Alexander Russell. D. Van Nostrand Company, New York. Cloth; 269 pages, 5¼x8½ inches; 71 illustrations; indexed. Price, $3.

"The Mechanical Appliances of the Chemical and Metallurgical Industries." By Dr. Oscar Nagel. Published by the author. Cloth; 307 pages, 5¾x9¼ inches; 292 illustrations; indexed. Price, $2.

"Steam Pipes, Their Design and Construction." By William H. Booth. The Norman W. Henley Publishing Company, New York. Cloth; 183 pages, 5¼x8½ inches; 62 illustrations; tables; indexed.

Obituary

Jasper R. Rand, vice-president and director of the Ingersoll-Rand Company, died of pneumonia in Salt Lake City on March 30. Mr. Rand was the son of Jasper Raymond Rand, one of the founders of the Rand Drill Company, and was born in Montclair, N. J., September 3, 1874. He was graduated from Cornell University in 1898 with the degree of mechanical engineer, and served in Porto Rico in the Spanish-American war as a member of the first New York Volunteer Engineers. During 1899-1900 he was president of the Imperial Engine Company, at Painted Post, N. Y., leaving that position to take the presidency of the Rand Drill Company, which he held until 1905. In that year he was elected vice-president and director of the Ingersoll-Rand Company, which was his chief interest until the last. Mr. Rand was a member of Alpha Delta Phi fraternity, of the Spanish War Veterans, of the American Institute of Mining Engineers, of the American Society of Mechanical Engineers, of the Engineers' Club, of the Cornell Club and of the Alpha Delta Phi Club of New York.

Personal

E. Whitaker, formerly chief engineer of the Weil & Mayer buildings, New York City, has become an inspector for the Engineering Supervision Company, also of New York.

Harnessing Power in Greater New York

The Work of the Boiler Inspection Bureau; How Engineers and Firemen Are Licensed, and How Life and Property Are Safeguarded

BY A. C. ROWSEY

Deep-rooted in the mind of the average New Yorker was a thought that filled his soul with peace as he read of the devastation of San Francisco and Messina. It was the thought that his city, his "Great New York," is not likely to be visited by such upheavals; his is a city upon a rock, against which the might of the elements would unavail. But he was unaware, and he does not today realize, that mightier than the force of any earthquake, the heat-and-power channels of his city, honeycomb its rock foundation and the city is really resting upon a many-mouthed volcano roaring with millions of units of power capable of causing a cataclysm

[illegible] HANSON, THIRD DEPUTY POLICE COMMISSIONER, NEW YORK

almost greater than the mind of man can conceive.

Fettered and guarded by sleepless eyes, this titan force throbs and struggles in stupendous potentiality under the very sidewalks of the city, upon which the New Yorker, blissfully unconscious of danger, treads to and from his affairs. From the subcellar of his office building it threatens death and destruction. And as he sleeps in contented ignorance, the monster in the basement is struggling frantically to shatter the house and rend its tenants.

Three times in forty-six years it has broken some of its manacles. It may break another any day. But twenty-eight men, the staff of the Boiler Inspection Bureau of the police department, hold with a tight grip the reins of a living harness made up of the interwoven responsibilities of 1400 firemen, 12,716 engineers and 7000 patrolmen. A flaw in a fetter may not release the giant, but if traceable to the neglect of any man in the harness it means the ending of that man's connection with the organization, be he engineer, fireman or patrolman.

No city in the Union is without its subterranean monster of heat and power, but New York is peculiar in that the control of it is so nearly perfect. In less than twenty-four hours it can be strangled to death and every engineer and crew mobilized at police headquarters.

A cursory reading of the annual reports of Police Commissioner Bingham, or of his predecessors, gives but a faint idea of the importance and varied activities of the work and the system of the boiler inspection bureau under Third Deputy Commissioner Hanson's direction. Still less does it yield clean-cut outlines of boundaries of responsibilities of the bureau, engineers and owners in the enforcement of the so-called "Engineers' License Law." For this reason, inspectors and examining engineers from nearly every State are frequent visitors to the bureau to form a closer acquaintance with the system.

Wherever a new system of State or municipal supervision of heat and power is organized its model has been found in the New York bureau. That its adoption has not been more general is due to the estimated cost of operation. Yet in New York its maintenance is only slightly in excess of its income, while its income is a very welcome contribution to the city's police-pension fund.

Incidentally, the maintenance cost is absurdly small compared to the tremendous supervision for which a staff of only twenty-eight men can, with accuracy and precision, reach every boiler, yield engineer or fireman to every boiler room in the city within a day, and [illegible] down any or all plants in [illegible].

Cost of Administration and [illegible]

The entire cost of administration is [illegible] annually. The income during [illegible] was [illegible]. Old debts collected [illegible] this sum to [illegible]. The cost of administration is distributed as follows:

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
Total	[illegible]

The [illegible] of the bureau is derived from the annual compulsory inspection of every boiler in the greater city. For this inspection a fee of $[illegible] per boiler is charged, if a boiler is found in good condition. If the boiler is condemned, ordered repaired or shut down for any cause, no license to operate is issued and no fee is collected. Thus, in [illegible] there were 17,[illegible] boilers in New York. If they had all been found in good working order

[illegible]

the revenue would have been $[illegible] and the [illegible] would have been within $[illegible] of the [illegible]. But of the total number only [illegible] were found to be in good working order and licensed for a year. [illegible] of the [illegible] not licensed were [illegible] the boilers and had been removed out of the city, some going to [illegible].

It may be interesting to [illegible] how these boilers are distributed:

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

Portable, for scows	119
Portable, for barges	255
Portable, for schooners	5
Portable, for elevators	5
Portable, for steam carriages	7
Portable, for floating baths	1

Inspectors and Inspection Districts

To facilitate the inspection of these boilers the city is divided into nine inspection districts, and one inspector detailed to each district. Seven of the inspectors are patrolmen, who were formerly boilermakers, engineers or machinists;

JOHN LYNCH, EXAMINING ENGINEER N. Y. BOILER SQUAD

two are Civil Service appointees. Each is provided a horse and wagon, a driver and a hydrostatic pump. The inspectors are assigned as follows: One to Staten island, borough of Richmond; one to the borough of Queens and precincts 160 and 161; two to the borough of Brooklyn and Coney island; one to the borough of the Bronx; four to the borough of Manhattan (four districts).

Upon the inspectors' reports licenses are made out in duplicate. One copy is sent to the owner of the plant and the other is given to the engineer. The law declares that the license must be paid for within twenty-four hours. City departments, however, have a habit of holding up payments for their licenses two or three months, and while bad debts against private boiler owners may be turned over to the corporation counsel for collection, it is impossible to sue city departments.

As soon as a license is made out Lieut. Henry Breen, who is in command of the bureau, becomes personally responsible to the police department for the fee or the license; he must have either one or the other. Recently, in clearing up the books, he discovered a debt, against a boiler in Brooklyn, incurred thirteen years ago, before the consolidation. The corporation counsel collected the fee for him.

Incidentally, owing to the more intensive service demanded of boilers, the vigilance of the inspectors has been increased, it having been found that the modern boiler deteriorates more rapidly than the old-style, and that the standard of life—twenty years—of a boiler is fast being lowered.

The fee of $2 a year paid by the owner entitles him to three distinct guarantees upon his plant: (1) That his boiler is safe; (2) the privilege of ascertaining the ability of his engineer to take care of his plant; (3) the privilege of ascertaining the qualifications of the firemen to do their work. Thus, for $2 paid for the annual inspection of a boiler, the boiler-inspection bureau undertakes, when it issues a license, all the responsibility of the boiler room where the licenses will hang. This brings us to the supervision of the boiler-room crews of the city:

Supervision of Boiler-room Crews

A coal passer, oiler or general assistant to an engineer, who is a citizen of the United States either by birth or adoption, and has served his two years, may be promoted to fireman, if the owner of a plant in a communication to the bureau signifies his desire to have the employee examined as to his qualification for such a position, the chief engineer under whom the man works at the same time certifying the time of employment in his room and that he is a person of good character, both of which statements must be sworn to.

According to the law the apprenticeship "on a building or buildings in the city of New York or on any steamboat, steamship or locomotive" must be "for a period of not less than two years;" but unless the owner states in the letter with the application that he wishes to employ the man at a certain plant, the applicant will be refused the examination for a license. The formalities being O. K., however, the board of examiners of the bureau will give the applicant a practical test in the care of a boiler, and if he is found competent he will be granted a license, within six days, good for one year, but at any time revokable by the police commissioner or the board of examiners appointed by him, upon proof of deficiency in a trial before the bureau's examiners who issued the license. Should an owner or lessee employ a man as a fireman or engineer who is not licensed for the particular plant at which he is at work a week's notice to quit is given. If the man is not supplanted, the owner or lessee may be arrested for "endangering life and property."

Requisites for Third-grade Applicants

Should a fireman, oiler or general assistant to a licensed engineer of New York City wish to take an examination for the position of third-grade engineer, the first requisite is a letter from an owner asking that the man be examined as to his capacity to handle the plant (stating the full equipment of the plant) as a third-grade engineer. The second requisite provides for verified statements from three licensed engineers in good standing in New York City, who must state where and when the applicant put in a total of five years' working time in boiler rooms. One of these statements must be rendered by the chief engineer under whom he put in the last part of his time, and all the statements must be verified before notaries.

An application blank is then given the applicant. In this he must state that he is at least twenty-one years of age, a citizen by birth or naturalization, and if the latter the date and place of his naturalization, his weight, hight, the color of his hair and eyes, and the dates, addresses and numbers of the boilers upon which he has put in his time. He is required to swear to the accuracy of these statements, which must be in his own hand-writing. The bureau then gives him three vouchers, to be filled out by the engineers who have already certified for him, these vouchers being in affidavit form and de-

MICHAEL FITZPATRICK, EXAMINING ENGINEER STEAM BOILER BUREAU, N. Y.

claring that the statements made by the candidate in the application are true to the endorsers' own knowledge. The vouchers must be sworn to, also. When he hands in the signed vouchers the applicant is slated to take the examination for third-grade engineer.

The Bureau Busy in the Meantime

While the candidate has been busy getting his vouchers signed a searching inquiry has been going on in the bureau.

Every boiler that has ever been in New York is represented by a card in an elaborate card-index system. A boiler can be located by its means in two minutes, either by knowing the name of its owner, or its license or serial number, location (past or present), or by the name of any engineer or fireman who has ever worked upon it.

In like manner, every licensed engineer and fireman can be located in an equally short time, every room they ever worked in and the number of the boiler in each place can be ascertained. A glance at a few cards gives an accurate description of the personal appearance of each engineer and fireman and a detailed itemization of plants they have handled. There is no guesswork, the information is compiled every day.

More than this, the signature of every engineer or licensed fireman can be found by looking at the date of his last visit to the bureau, which is recorded on his card, and glancing under that date down the alphabetically arranged pages of the "Signature Book" which every engineer and licensed fireman signs when he calls for the renewal of his license, or for a transfer to another plant.

Thus, when the applicant for examination for third grade engineer appears and says he is a licensed fireman, and shows a license issued to "John Doe," fireman on boiler No. —, the card for Fireman John Doe is taken out. If it says that John Doe has red hair and the candidate for engineer's license has black hair, he is known to be a "ringer" sent by the red-haired one to take an examination for him. Trouble gathers for him with the red hair, while he with the black hair is arrested and the vouchers are summoned to the bureau to explain.

Again, the chief engineer who swears that John Doe worked for him five years on boiler No. —, may be discovered by the index cards to have been less than five years in charge of that boiler. His card may show that he has been either out of work, out of town, or working at another plant part of the time. Trouble starts for him, for he has perjured himself twice, once in the voucher verifying John Doe's statement and once in his preliminary certification.

Then, too, the cards of all of the certifying engineers may show that they did work on the boilers for the time they stated, and as stated by John Doe, but the signatures to their statements and vouchers may bear no resemblance to their signatures in the "Signature Book." John Doe is then in hot water. He has committed forgery. It will be seen that the system effectually checks fraud before an examination takes place.

THE EXAMINATION

When the papers are found to be correct the candidate is taken in hand by Patrolmen Michael Fitzpatrick and John Lynch, both licensed engineers. Their examination is wholly oral. It does not pretend to follow the model of the Civil Service. The examiners must be satisfied that the candidate will not endanger life and property if placed in charge of a plant. To this end they examine him upon the following subjects: Construction of boilers, connections to boilers, care of boilers, construction of pumps, operation of pumps, construction of engines, operation of engines.

There is a large slate on the table before the candidate. He may figure and rub out as much as he chooses, all under the eyes of the examiners. As the subjects are covered, a rating is given on the back of the application. There is no point system; the terms used are "Excellent," "Good," "Fair," "Poor." If he gets "Poor" on the first five subjects he is bound to be "Poor" on the balance and will be rejected. "Good" on the first five will counterbalance "Poor" on the last two.

Assuming that the applicant passes for the grade, he is then put through a second examination, this time upon the handling of the equipment to which he is going. If the plant consists of a tubular boiler and a pump, 80 pounds pressure allowed, and he shows himself able to handle it, he is given a license, but it will read that he is a third-grade engineer, licensed to operate "one tubular boiler, No. —, and a pump with 80 pounds pressure," at that one plant only.

A card is prepared for the index file and the number of the boiler, the equipment of the plant, his examination rating, his address, the address of the plant and the date of his examination for the grade are recorded on the card. He is then ordered, under pain of having his license suspended or revoked if he violates the order, to make an absolutely truthful report of the condition of his plant every month. He is told that the bureau reserves the right to inspect his plant any time of the day or night, and if he is caught with defects not reported, or exceeding the pressure allowed, he will be taken into custody for endangering life and property.

If he goes on strike after beginning the day's work and leaves the plant unguarded, he is liable to arrest for misdemeanor. If he is caught intoxicated the mildest penalty will be a year "on the shelf," the severest, denial of the right to work in New York at all. And he is given an exact history of the boiler, its age, repairs, defects and peculiar danger points.

By this it can be seen that the [illegible] of the administrative work of twenty-eight in the bureau is, by license, [illegible] through the virtual appointment of every engineer in charge of a plant an inspector without pay but with full burden of the responsibility of his particular plant upon his shoulders.

MONTHLY REPORTS

The monthly reports, which are printed, are made upon blank forms. Their questions must be answered clearly and they cover the entire plant. If a defect is noted an inspector from the bureau makes an official test. Upon his report the bureau has power to compel repairs or to shut down plants.

Thus a full detailed inspection of the 17,464 boilers of New York takes place every month and, with the annual official test, there are really thirteen actual inspections a year at the cost of only $2 per boiler. Incidentally, making the engineer an inspector by virtue of his license means the stationing of an attaché of the bureau in every boiler room in the city.

In addition to this supervision, there is at the service of the bureau the entire force of 7000 patrolmen of Greater New York, to enforce its regulations on owners and lessees, engineers and firemen, to insist upon repairs, to prevent the operation of condemned plants or boilers and to prevent the employment of unlicensed crews.

Is a complaint received that an unlicensed engineer is operating a boiler? By telephone the complaint is transmitted to the nearest police station. A man from the reserve force hurries to the boiler room and demands to see the engineer's license. If he has none, he takes the engineer back to the station house together with the owner or lessee, if he can find him. The bureau prepares the prosecution.

Is an unlicensed boiler installed somewhere? Again, the station house is notified and the man on reserve [illegible] to arrest the man in charge, be he licensed or not.

Is a boiler going into a building? The patrolman on post notifies the bureau. If the bureau has no information of the plant, it will send an inspector to find out why the boiler is [illegible].

Is there a drunken fireman or engineer in a boiler room? The man on post arrests the unfortunate. The plant is closed down and a report is made to the bureau, [illegible] of that boiler room [illegible]. Charges are made against the guilty man and he is given a trial before the examiners who licensed him. On that [illegible] he is [illegible] of his license [illegible] for good and all. The index card records his fate.

[illegible]

No. 163-08 (B) 5,000

Boiler No.	Serial No.	Owner's Name	Location of Plant
4399	3 1 to 3	WILLIAM L. SMITH & CO.	1262 BROADWAY

Style of Boilers	Size of Boilers, When and Where Built	Location of Boilers
HOR. TUB	16′6″L. x 5′6″D. 3/8 SH. D.R. 56,000 1908.	BASEMENT

Date of Test			Amount of Test	Pressure Allowed	Pressure Carried	No. of Gage Cocks	No. of Steam Gages	No. of Safety Valves	Inspected by	REMARKS
MAR.	15	1909	150	100	100	3	1	1	LANAGAN	#1 - 2 - 3.

Power, N. Y.

BOILER-TEST CARD

but one responsibility, that of making prompt repairs when notified.

Neglect on the part of the owner results in the bureau reaching out with that long arm, the uniformed force, and taking actual control of the plant, even, as the law states, "in cases deemed necessary, the appliances, apparatus or attachment for the limitation of pressure may be taken under its control."

Others Eligible for Third-grade Licenses

The fireman, oiler or general assistant for five years to a licensed engineer of New York City, heretofore referred to, are not the only persons eligible for examination for a third-grade engineer's license. Those equally eligible are a fireman, oiler or general assistant to the engineer on any steamship or steamboat, or any locomotive engineer, for five years, who shall have been employed for two years under a licensed engineer in a building in New York City; a fireman, oiler or general assistant to the engineer on any steamship or steamboat, for the period of five years, who shall have been employed for two years under a licensed engineer in a building in New York City; or a fireman, oiler or general assistant who has served as a marine or locomotive engineer or fireman to a locomotive engineer for a period of five years and has been a resident of the State of New York for a period of two years; or a person who has learned the trade of machinist or boilermaker or steamfitter and has worked at such trade for three years, exclusive of time served as apprentice, or while learning such trade; and also any person who has graduated as a mechanical engineer from a duly established school of technology, after such person has had two years' experience in the engineering department of any building or buildings in charge of a licensed engineer of New York City.

Unless the stranger in New York can show a certificate as engineer issued to him by a duly qualified board of examining engineers existing in pursuance to law in a State or Territory of the United States, and can prove that he is the identical person to whom the certificate was issued, he will not be permitted to take an examination for an engineer's license.

In some States and Territories there are no legal boards of examiners of engineers; men from those States, although they may be experts and may have served twenty years in boiler rooms, are absolutely debarred from the supervision of boilers in this city. Their local union cards are not received as credentials.

After the license is granted it lies with the examiners whether the engineer shall do the work he wants to do or not. Although the owner of a portable hoisting engine requests the examination of a man who has come out of an office building and is willing that he shall run his engine, the board may and does decline to permit him to undertake the place, on the ground that an office-building man, never having worked on hoisting machinery, is liable to kill someone. So they exercise discretion in permitting men to work on different classes of work.

Three Grades of Engineer

The bureau recognizes three grades of engineer, third, second and first. The third grade alone is compulsory for the care of a plant. The second grade may be obtained after two years in the third grade. The examination takes in the operation and care of dynamos. The first-grade examination may be had at the request of an owner, as in every other case, after one year in the second grade. The subjects are operation and care of ice machines, use of the steam engine and indicator.

The owner of a building, whose candidate for fireman or any grade of engineer fails to pass his examination, has the right to send two licensed engineers to the bureau to examine the candidate upon the subjects given. The bureau reserves the right to instruct its examiners to interrogate the candidate on the same subjects where they find the visitors were not sufficiently painstaking.

In Boston and a few other large cities, the horsepower and steam pressure regulate the grade of an engineer. In New York, however, a third-grade engineer may be found operating a huge plant. There is no legal provision against this.

No. 159

Boiler No.	Owner's Name	Office	Boiler Where Located
13220	GENERAL CONTRACTING CO.	43 JOHN ST.	PILE DRIVER # 117

Engineer	Date of Exam.	Renewal	Renewal	Renewal	Renewal	Remarks
EDWARD J. DUNN	MAR. 15/09					

Power, N. Y.

PORTABLE ENGINEERS' PLANT CARD

it has been pointed out as a weakness in the system. But it is only fair to say that although men in charge of some of the largest plants in the city have only third grade licenses, they are invariably men of superior ability, and often graduates and post graduates of technological institutes, who could pass with ease almost any kind of an examination in mechanics.

Restrictions of Licenses

Although the engineer's license is good for one year, it is only theoretically so. Practically, the license is good for one year provided the engineer remains in charge of the particular plant it covers for a year. A system of transfer examinations prevents him from "free-lancing" about the city on his one year's license and brings him to headquarters as soon as he leaves his job, for examination, at the request of the next prospective employer, upon his ability to handle his new plant.

For, pursuing its actuating principle, the safeguarding of life and property, the bureau has divided engineering into five distinct classes as follows:

(1) Portable, double drum.
(2) Hoisting.
(3) Steam shovel.
(4) Engineer in charge of shafting.
(4) Engineer in charge of office building.

If a man leaves an office building and is sent by the owner of a hoisting plant to the bureau for examination as to his fitness to run his plant, he will be rejected unless his index card shows that he has had experience in running a hoisting engine previous to his last place in the office building. If he insists that he has had experience not on the card, he is given an examination on running a hoisting outfit. If he cannot satisfy the examiners that he will not kill anyone, he is refused a transfer to the new job. His place in the office plant being filled, his license is of no value to him, for he cannot, although licensed for a year, run any boiler in the city until he has been transferred to it by the bureau.

So through each of the divisions of engineering. If experience is shown, the transfer is granted.

It can easily be seen that this system of licensing, for particular plants, examination on the floor, transfers and examinations for transfer and the practical suspension of the license during periods of idleness, all recorded on the card index, give the bureau an absolute measure of the ability of every fireman and engineer in the city, their movements and past performances day by day and their whereabouts at all times. They can never get away from the supervision of the bureau once they are licensed.

Establishment of the Card-Index System

Previous to the appointment of Deputy Commissioner Hanson, about three years ago, all these records of the bureau were kept in huge books. They were awkward to handle, their pages were torn and dirty and some of the writing had become illegible from many causes. The information they conveyed was incomplete.

After looking over the work of the bureau, the deputy commissioner decided to bring it up to date. To that end he installed Lieutenant [illegible] and half a dozen young patrolmen, and proceeded to reduce the records to card-index form. It took [illegible] nearly a year before the task was completed. At the end of that time the heavy books were closed. [illegible] synopses on the reverse of each card [illegible] back to the books but rarely, [illegible] assertion, but the synopses on the cards are found generally to be sufficient.

At that time the headquarters of the bureau were located in Manhattan and a branch was maintained, with separate records and files, at Brooklyn police headquarters. Shortly after the cards were completed, the deputy commissioner closed the Brooklyn branch and centralized the activities in the Manhattan bureau. This has necessitated a renumbering of all the cards into one general index covering all boroughs. The consolidation created an immense amount of labor, but the result in increased efficiency and economy of administration is more than compensating.

The index is arranged under the following subject heads: "Boilers," "Portable Boilers," "Stationary Boilers," "Idle Boilers," "Boiler Tests," "Engineers," "Portable Engineers," "Stationary Engineers," "Firemen," "Portable Firemen," "Stationary Firemen."

For permission to copy the engineers' cards a donation of $500 to the police pension fund was offered Commissioner Bingham. The offer was rejected.

The steps of certain of these cards, reproduced herewith, illustrate the contents of the cards. They are back-checked by a second series under the following heads: "Street and Number Address of Plants," "Boilers in the Bronx," "Boilers in Queens," "Boilers in Richmond," "Boilers in Manhattan," "Street Numbers of Plants in Greater New York," "Owners of Plants in Greater New York."

The illustrations are of the "Engineer's Card," "Stationary Engineer's Plant Card," "Portable Engineer's Plant Card" and "Boiler Test Card." The fireman's cards are similar. The engineers' and firemen's cards as well as the owners' plant cards are good for [illegible]

No. 161

Engineer's Name SMITH, JOHN T   From Page No. 160   Book No. 2

Date of First Examination MARCH 15th 1909

Date of Exam.	Boiler No.	Date of Exam.	Boiler No.	Date of Exam.	Boiler No.	Date of Exam.	Boiler No.	Date of Exam.	Boiler No.	Date of Exam.	Boiler No.
MAR 15/09	4399										

ENGINEERS' CARD

No. 130

Owner's Name	No.	Street	Boiler No.
WILLIAM L. SMITH & CO	1363	BROADWAY	4399

Engineer	Date of Exam.	Removed	Removed	Removed	Removed	Remarks
JOHN T. SMITH	MAR 15/09					

STATIONARY ENGINEERS' PLANT CARD

records. All the cards are 7x9¾ inches in size, ruled front and back, and each is of a color different from the others.

The boiler cards are reviewed every day and those due for the annual inspection are listed. Ten days before the day the inspection is due, a notice is sent to the engineer. He is required to be ready for the hydrostatic-pressure test. So as to delay and inconvenience the owner or lessee as little as possible, the day and hour of the inspector's call are given.

Inspectors' Reports

The bureau then routes its inspectors overnight and knows just where they are working. Pressure one-third more than that allowed is the standard test. On their return every day to the bureau, the inspectors' reports are compiled, and where licenses are issued entries are made in full in the boiler accountbook. The license is made out and the following day it is on its way to the plant by messenger, a patrolman. He is charged with so many specified, numbered licenses and must bring back the license or the fee. City departments alone receive credit. Others must pay on delivery.

Payment for Licenses

Upon receipt of a couple of hundred dollars, entries of which are made in a boiler cashbook and checked off with a date stamp on the boiler accountbook, the money is sent to the bookkeeping department of the police department, where the custodian of the pension fund, under bond, certifies to receiving payment for licenses whose numbers are given, together with the serial numbers of the boilers. He has a full set of the serial numbers so that at a glance he can see whether all the listed boilers have been licensed. If they have been licensed and there is no fee, it is up to the bureau to explain. If there is no license issued to a boiler it shows plainly in the blank space opposite the unchangeable number of the boiler.

Boilers condemned retain their numbers, but are assorted as "Idle Boilers," until new boilers are installed. The numbers are then given to the new boilers. Where plants go out of business after the condemnation of a boiler and take power from some other source, the fact is noticed on the boiler card.

The Guiding Principle of the Bureau

In all its operation the bureau is guided by the one principle, the saving of life and property, to which it owes its creation. In 1862 the number of boiler explosions in New York became alarming. It was rumored that there was a plot to blow up the city. A committee of citizens was appointed to investigate. Unable to perform the task, they called in the police. Patrolmen were placed on guard in the boiler rooms of the city.

Gradually the work drifted into the hands of the police, and the bureau, the first of its kind in the world, was organized as part of the police department's supervision of life and property.

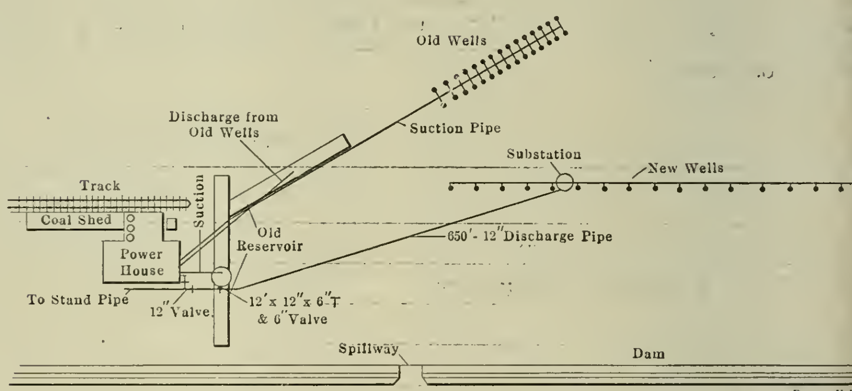
There have been several unsuccessful attempts to remove the bureau from police-department supervision.

Municipal Plant at Marshfield, Wisconsin

By Louis B. Carl

In 1904 the city of Marshfield, Wis., purchased the local electric-light plant and water works for $150,000. The power house was 1½ stories, the engine room, 36x84 feet, containing two 12x15-inch high-speed McEwen engines operating at 270 revolutions per minute, belted to two 50-kilowatt 1100-volt 133-cycle Westinghouse and Fort Wayne alternators; a No. 8 Wood arc machine; a 20 and 12 by 15-inch Worthington and a 16 and 8 by 15-inch Smedley duplex steam pumps, used to pump water into a standpipe 15 feet in diameter by 120 feet high, located about two miles from the plant. The Smedley pump was so connected as to be able to pump from thirty-two 2-inch driven wells into the standpipe or into the reservoir, or from the reservoir into the standpipe. The Worthington could pump only from the reservoir into the standpipe. With the exception of a small spring in the reservoir, the thirty-two wells constituted the entire water supply for a city of about 7000 people. The wells were driven about 22 feet and when working at their best did not give over 75 gallons per minute. The switchboard was of wood, and was equipped with the necessary meters, switches, etc.

The boiler room adjoins the engine room on the east, being a 35x40-foot 1½-story brick building containing two 60-inch by 18-foot return-tubular boilers, an "Excelsior" feed-water heater, a 6 and 4 by 6-inch Fairbanks-Morse duplex boiler-feed pump and a "Metropolitan" injector. The uptakes were connected to a brick chimney 88 feet high, with an internal diameter of 4 feet and an external diameter of 8 feet at the base and 6 feet at the top. There were also a 70-kilowatt Wood alternator and a No. 8 arc machine located in a factory and used to carry the load part of the time.



PLAN OF GROUNDS, MARSHFIELD (WIS.) PLANT

The outside work consisted of about 5 miles of transmission lines, with 38 arc lamps, and about 7½ miles of 12-, 10-, 8-, 6- and 4-inch cast-iron water pipe. One hundred and twenty acres of second-growth timber, on which the plant was situated, went with the purchase. In 1907 the people voted $35,000 of improvement bonds for the purpose of rebuilding the plant and obtaining a reliable water supply.

The Remodeled Plant

In the engine room, as remodeled, are two generating sets, one consisting of a 14x30-inch Corliss engine running at 120 revolutions per minute, and driving with a 15-inch double leather belt a 100-kilowatt 2300-volt 60-cycle alternator running at 900 revolutions per minute, and the other unit comprising an 18x42-inch Corliss engine running at 100 revolutions per minute, and driving with a 30-inch double leather belt a 225-kilowatt 2300-volt 60-cycle alternator running at 600 revolutions per minute. The exciters are direct-mounted on the generator shafts.

The generators and engines are of the Allis-Chalmers standard make. The engine cylinders are lubricated by Manzel automatic force-feed lubricators and the bearings are supplied from a gravity-oiling system, consisting of a 100-gallon tank located near the roof and connected to the different bearings by brass pipe. The eccentrics are lubricated with Albany grease. All the drains lead to a three-section Turner oil filter, having a capacity of 75 gallons per twenty-four hours, located in a basement between the engine cylinders. The oil is elevated to the tank by a small rotary hand pump.

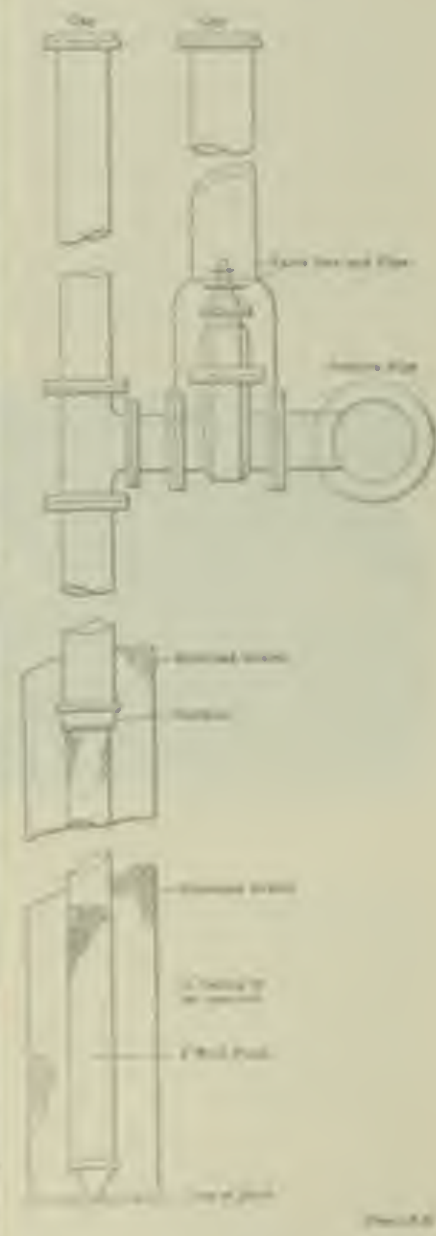
The switchboard consists of four 30x90-inch Vermont blue-marble panels, of which two are generator panels containing three ammeters, one voltmeter, one 3-pole 3000-volt automatic oil switch, one field switch and a ground-detector lamp, with the necessary plugs. There is a swinging bracket located on the 100-kilowatt generator board containing a synchroscope and exciter voltmeter. There is one feeder panel containing three ammeters and three oil switches, also a 3-phase wattmeter.

The remaining panel is for the arc system and contains one ammeter, one oil switch, three stab switches for each of two circuits and one 3-phase wattmeter. At the right of the switchboard is located the arc-lighting apparatus, consisting of two Fort Wayne 35-light tub transformers, with regulators supplying 52 arc lamps. All leads from the generators to the switchboard are lead-covered cables laid in conduit. The lightning arresters are mounted outside of the building. There is also located in this room a motor-starting panel of slate, 24x60 inches, containing one automatic 3000-volt 20-ampere double-throw oil switch and one three-phase wattmeter. In the back of this board are mounted two 200-horsepower auto transformers.

In the boiler room there are three 18-foot by 72-inch return-tubular boilers, containing seventy 4-inch tubes and having 30 square feet of grate surface. The boilers have "American" pop safety valves and steam gages. There is a separate stack to each boiler, 36 inches in diameter and 100 feet above the ground. The feed-water apparatus consists of a 200-horsepower Cochrane open heater, which heats the water to 208 degrees Fahrenheit, a 6 and 4 by 6-inch Gardner duplex feed pump and an 8 and 5 by 10-inch Marsh pump. The feed pipe from the pumps to the front of the boilers is 2-inch brass, to which each boiler is connected by a 1½-inch brass pipe having two gate and one check valves. The blowoff is 1½ inches in diameter and contains a gate valve and a blowoff valve with renewable disk. Wilmington lump coal is used, having a heating value of about 11,000 B.t.u. and costing $2.50 per ton in the bin. The coal is weighed and brought into the boiler room in a car holding 1000 pounds. The storage capacity is 250 tons.

The piping consists of standard wrought-

TWO VIEWS IN THE ENGINE ROOM OF THE MUNICIPAL PLANT AT MARSHFIELD, WIS.



ELEVATION OF WELL AND CONNECTIONS

iron pipe with extra-heavy cast-iron flanges and fittings; all bends are made with long-sweep elbows. Crane valves are used throughout the plant. The leads from the boilers, which are 6-inch and contain two valves, are connected to the top of an 8-inch header which is 60 feet long and has a drop leg at each end drained by traps discharging into the heater. The connections for the engines and the water-works pumps are all taken from the top of the header. Separators above the engine throttles are drained by traps located in the basement and discharging into the heater. A 5-inch header at right angles to and connected with the 8-inch header supplies steam for the feed pumps and whistle. All steam pipes are covered with air-cell asbestos covering.

New Wells for the Water Works

After a thorough test covering considerable territory it was decided to locate sixteen new wells about 600 feet south of the power house, spaced 45 feet apart.

Water-works Substation

At about the center of the line of wells a substation was built of brick, laid in cement and made water-tight. The substation is 18 feet below the surface and 10 feet above, having an inside diameter of 12 feet. In this station is located a vertical 3-stage DeLaval centrifugal pump running at 1120 revolutions per minute, with a capacity of 600 gallons per minute under a head of 120 pounds. A Westinghouse 75-horsepower 3-phase 2300-volt induction motor is located 14 feet above and direct-connected to the pump. This set is started by an auto-starting switch located in the engine room. As soon as the pump is started the pressure in the pump casing acts on a diaphragm and opens a valve, allowing oil to run into a gang feed, whence it is carried to the different bearings by brass pipe.

As the average pressure carried on this pump is 70 pounds, it was tested at that pressure and delivered 750 gallons of water per minute. To keep the wells sup-

SWITCHBOARD IN MARSHFIELD PLANT

VIEW OF MARSHFIELD PLANT

plied it was decided to build an impounding reservoir covering eight acres and holding approximately 25,000,000 gallons. A dam was constructed across a valley through which a ditch ran. This ditch drains about 1200 acres of land. After finding the direction of the underground flow, which is about 8 inches in twenty-four hours, two intake wells, 12 inches in diameter, were drilled to bedrock and filled with gravel, through which the water filters to feed the other wells.

They were drilled with a 12-inch drill which was followed up with a 12-inch steel casing until rock was reached, when a 4-inch point from 16 to 26 feet long was connected to a 4-inch pipe and lowered in the casing. The space between the point and casing was then filled with screened gravel to within 14 feet of the surface, where a tee was located in the well pipe which was connected to the suction pipe through a gate valve. The suction pipe varied from 6-inch at the extreme end to 10-inch at the pump. These are all flowing wells at the depth of the suction pipe which keeps the pump primed.

After the gravel was placed in the casing the casing was withdrawn. For pulling this casing, a heavy cast-iron collar, with an internal diameter of 15 inches, was slipped over the casing. Wedges having teeth on one side similar to a pipe wrench were then driven between the casing and collar. With the aid of two 30-ton hydraulic jacks the casing was pulled about 12 feet per hour.

In General

When the city purchased the plant there were about 4500 lights, whereas now there are 9500. The water connections have also been increased from 180 to 315. Nearly all the services were on a flat rate, but have now been changed to meter rates, for both light and water.

The city has also replaced all 4-inch mains with 6-inch pipe, besides having laid about 5000 feet of new 6-inch mains. There have also been installed 12 new hydrants and four arc lights. Although the average pressure carried is 70 pounds, in case of a large fire the standpipe can be shut off, when 110 pounds can be maintained at the hydrants by direct pressure.

The plant operates twenty-four hours per day with four men, two on each shift of 12 hours. The day load consists of about 75 horsepower in motors, besides the pumping.

Operating Expense

Although no exact records are available, the following will give a general idea of the operating expenses for November and December, 1908. As the steam pump uses about 650 pounds of coal per hour, that amount will be deducted. The pump operated 208 hours, therefore it used $208 \times 650 = 135{,}200$ pounds, which, deducted from the 626,000 pounds used during November and December, leaves 490,800 pounds to be credited to the rest of the plant; and 490,800 pounds at $3.50 per ton equals $860.30. Supplies and repairs cost $73.96, and labor cost $530, making a total of $1464.26. As there were 74,800 kilowatts generated,

$$\$1464.26 \div 74{,}800 = \$0.019$$

per kilowatt at the switchboard.

O. L. Dorschel is superintendent of the plant and had charge of rebuilding the system.

Proposed License Law for Philadelphia

There is an act before the legislature of Pennsylvania providing for the better protection of life and property by the competent operation of steam boilers and engines, and for the examination and licensing of engineers in charge thereof. It appoints a chief engineer and twelve assistants, one for each of the twelve districts into which the State is divided. Engineers holding licenses of cities of the first, second or third class, which are already provided for, shall be granted a license without examination. The fee is $3 when the license is granted and $1 for each renewal.

Danger from Water Hammer in Steam Pipes

Cases in which Water Hammer Damaged Piping and Valves; with Hints as to How These Conditions Might Have Been Avoided

BY HOWARD S. KNOWLTON

The importance of preventing water hammer in steam pipes is not always fully appreciated by operating engineers. The study of steam-plant accidents shows that every year lives are lost and property damaged through the fracture of pipes or valves by water hammer. A number of cases occurring recently are presented in the following paragraphs in the hope that engineers working with steam mains, valves and drains will be able to avoid similar troubles:

Case 1—The initial conditions were pipes 250 feet long, newly erected and uncovered. The drain to the trap, Fig. 1, was blocked by cement jointing material and rust. The stop valve A, cutting off steam from a boiler other than that shown, and the boiler shutoff valve B were closed in order to enable the joint at E to be repaired. The valve C was left open. Water accumulated in the pipe before the stoppage of the valves and cooled during the time of closure. When the valve B was opened a fracture occurred at the point shown. The steam pipe was of cast iron 6 inches in diameter, and the boiler pressure was 65 pounds per square inch. The cause of the fracture was the opening of the steam valve B, the mistake being to rely on a steam trap for draining a new pipe. A large drain cock, without a waste pipe, should have been fitted close to the pipe. The arrangement of the pipe was also bad, and it should have been fitted with a drain pipe provided with a small test cock, or a float telltale, and a large drain cock to be subsequently connected to a steam trap. The test cock or float would have enabled the engineer to ascertain if the water were below the horizontal length of pipe before he opened the drain cock or the valve B. Test cocks used in such cases should be very small, and opened for a short time only; otherwise the discharge from them may be sufficient to disturb the surface of the water in the horizontal length of pipe, and thus start the water hammer they are intended to prevent.

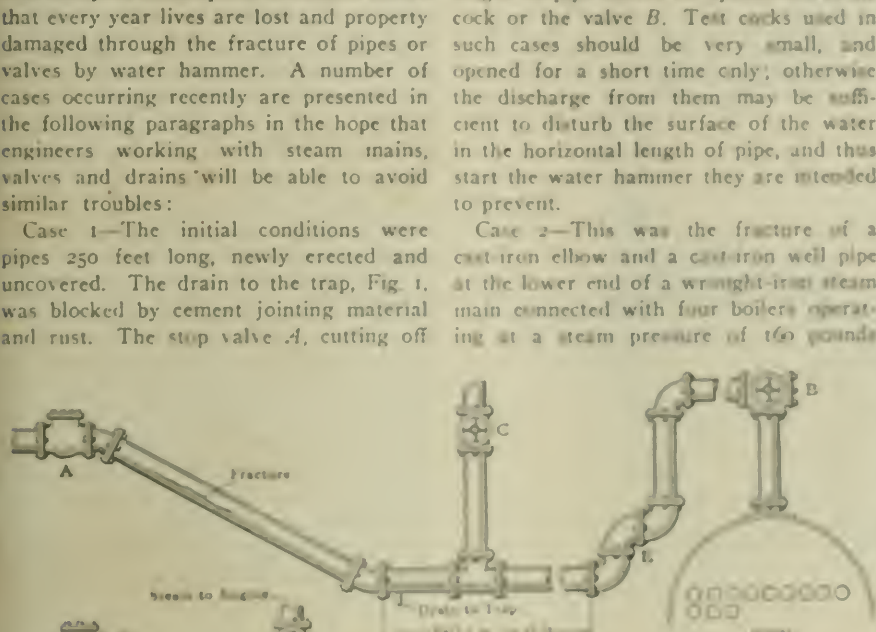


FIG. 1

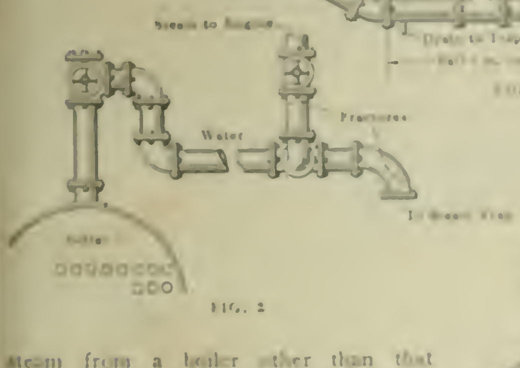


FIG. 2

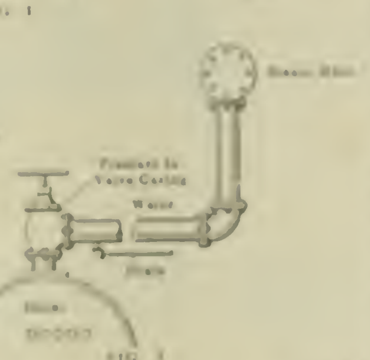


FIG. 3

Case 2—This was the fracture of a cast-iron elbow and a cast-iron well pipe at the lower end of a wrought-iron steam main connected with four boilers operating at a steam pressure of 160 pounds per square inch. The well pipe was drained by a steam trap and a drain cock. The stop valves on the boilers were left open during the shutdown of the plant on Sunday, and the lever or valve in the steam trap appeared to have stuck, so the trap failed to drain the lower end of the steam main. Fig. 2 shows the piping arrangement. On the opening of the drain cock to clear the pipes preparatory to starting the engine, a water hammer was set up which broke the bend and well pipe. The horizontal length of the pipe was filled with condensed steam. The fault was in assuming that the steam trap was keeping the system quite clear, and opening the valve to the engine without shutting the boiler stop valve. A well pipe fitted with a small test cock or a float telltale would have enabled the operating engineer to see if the pipe were clear.

Case 3—This was the fracture of a valve casing of the boiler valve by water hammer. The branch pipe connecting the boiler valve to the steam main, Fig. 3, which was similarly connected to twelve other boilers, was carried horizontally from the valve casing to an elbow, and thence vertically to join the main. The horizontal length was provided with a drain cock, which was usually left slightly open when the boiler valve was closed, as it had been for two days before the accident while the boiler was being cleaned, in order to keep the valve free from water. On this occasion the cock had either not been opened or had become closed by dirt, for a considerable quantity of water collected in the branch pipe. To clear the latter the cock was opened wide without shutting down the junction valves on the other boilers; the vertical part of the pipe was emptied and a considerable surface in the horizontal section exposed to the steam, when water hammer of sufficient force to break the valve casing occurred. The fault lay in opening the cock without first shutting the junction valves of all the boilers.

Where there is room over one boiler the pipes can better be installed as at A, in Fig. 4, or if this is impossible on account of head room, all the branches should be drained by large pipes without cocks or valves leading into an auxiliary pipe across the boilers, with a connection controlled by a cock to each boiler, so that when one boiler is opened its branch pipe will drain into the other boilers, as at B, in Fig. 4.

Case 4—This was the fracture of a cast-iron junction valve casing on a boiler, caused by admitting steam into a horizontal length of pipe half filled with water. There was a drain cock on the valve casing, but it was placed so high that no discharge took place until the pipe was half filled. The conditions, Fig. 5, were that one boiler was out of service for three weeks. The junction valve B was closed and the stop valve C, [illegible] boiler, was open at the time of the explosion. The drain to valve B was open and the stop valve A leading to the other boilers was shut 15 hours before the explosion. The construction [illegible] tained water, and possibly also the 7-inch pipe up to the level of the drain. The water hammer was produced when the stop valve *A* was opened to give steam to the engine, the fault being in opening the valve *A* before closing the valve *C*.

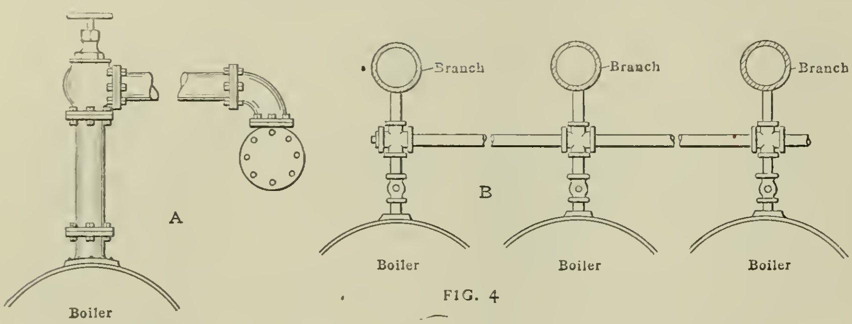


FIG. 4

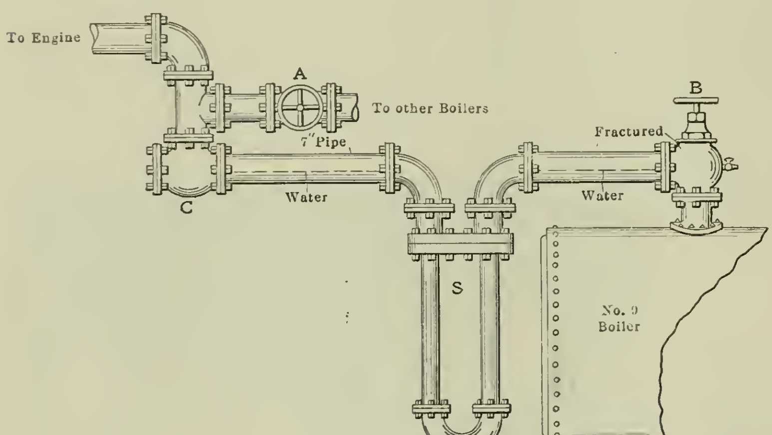


FIG. 5

Power, N.Y.

The engineer should have known that unless the valves *B* and *C* were absolutely tight there would probably be water in the superheater. He should have shut off the valve *C* before opening valve *A*, and left it closed, with the water in the superheater, until the fire was lighted in No. 9 boiler to evaporate it. The drain *d* should have been located at the lowest point of the pipe.

Case 5—This accident was the fracture of a cast-iron reducing valve by water hammer. The valve was placed at one end of the main steam pipe crossing a group of four boilers, Fig. 6, and could be shut off from the pipe by a wedge-shaped valve near to it. The steam main had a fall of about 3 inches toward the wedge-shaped valve, and at the time of the explosion the stop valve on the boiler next the wedge valve was shut, and the stop valves on the other three boilers open. The explosion occurred early in the morning and was caused by the night watchman's opening the wedge valve to admit steam to the reducing valve, and through it to the heating system in the mill. The steam main being partly filled with water, a violent water hammer was at once set up. If the drain had been cross-connected to the other boilers the steam main might have been kept free from water.

Case 6—This was the fracture of a cast-iron steam pipe by water hammer. Steam had been left to condense in 90 feet of new uncovered pipe varying from 9 to 6 inches in diameter. The engine valve *A*, Fig. 7, was shut, and the drain was shut. Water hammer occurred when the engine stop valve was opened. The pipes were new and well designed, having been in use but a week. The boiler-junction valves were shut at the nightly closure of the plant, but were left open during the stops for meals, and the condensation during the dinner hour on the day of the accident must have been sufficient to fill the well pipe and partially fill the 36-foot length of nearly horizontal pipe leading to it. The fault was in opening the engine stop valve before closing the boiler-junction valves and opening the drain. With the well pipe overflowing into the steam main, it would have been dangerous to open the drain without first shutting the boiler-junction valves. A try cock or a telltale float would have shown the conditions. The drain should have been opened when the engine was stopped, and left open until the engine was started again, or if left shut the junction valves on the boilers should have been closed before reopening it.

Case 7—This accident was the fracture of the cast-iron casing of the junction valve on a boiler line. The boiler, Fig. 8, was one of a group of nine, and the steam was conveyed from the junction valve to the steam main by a 7-inch branch pipe about 16 feet long, which was joined by a bend to the under side of the steam main, so that when the junction valve was shut, not only the steam condensed in the branch, but also water from the main would accumulate in this pipe. To prevent the accumulation of water a ½-inch drain pipe and valve were fitted to the lowest part of the branch near the junction valve. The pipe had originally been connected to a ¾-inch pipe leading to a drain in front of the boilers, but this was later disconnected and shortened to about 18 inches, so that when the valve on it was open it discharged upon the top of the side flue of the boiler. On a certain day the junction valve was shut down, and on the next day the water was run out and four men sent into the

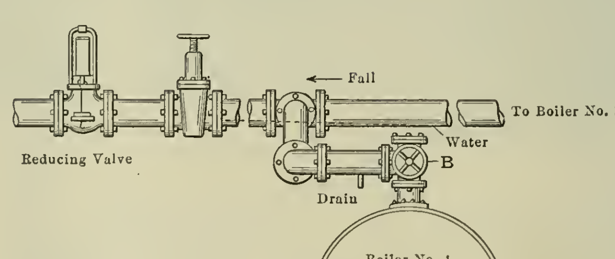


FIG. 6

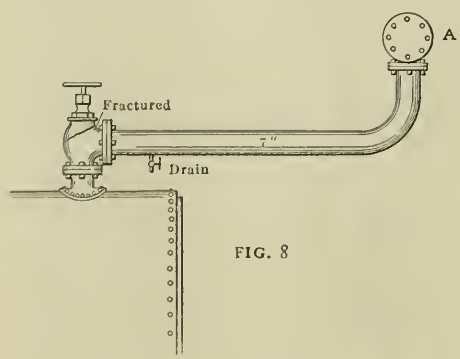


FIG. 8

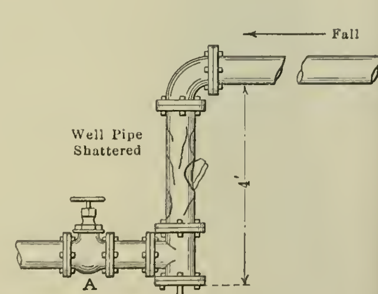


FIG. 7

Power, N.Y.

boiler to scale it, and four others into the external flues to sweep them preparatory to the annual examination. It was customary at this plant, when a boiler was laid off for cleaning, to insert a blank flange at the joint of the 7-inch branch pipe with the steam main, to prevent the men in the boiler being annoyed by the leakage of steam and hot water past the junction valve. On this occasion the precaution was omitted, but the ½-inch drain above referred to was opened to keep the branch clear of water. The discharge from this drain, running upon the brickwork, percolated through into the flue and annoyed the men sweeping it. The evidence was that someone shut the drain and later obtained an iron plate to lay upon the boiler top to lead the water away from the brickwork, had then opened the ½-inch drain and thus disturbed the surface of the water which had in the meantime accumulated in the branch pipe, and so caused the water hammer which broke the casing. The pressure in the pipe was 95 pounds per square inch.

At the investigation of the accident it was decided that the chief engineer and the foreman of the company were to blame for the explosion. They should have been aware that the ½-inch drain pipe had been shortened and was discharging water upon the brickwork, and so into one of the flues, and that the flue cleaners were adopting the clumsy expedient of using sheets of iron to divert the water, and also that it was highly probable that laborers of this class might temporarily close the valve of a drain pipe which was causing them annoyance through dripping. The drain pipe had remained in defective condition for over a year. It was clearly dangerous to allow

FIG. 10

men inside the boiler under the circumstances, for the main steam pipe should have been disconnected and a blank flange put on. The drain should have been cross-connected to at least one of the other boilers.

Case 8—This was the fracture of a steam stop valve, Fig. 9. The initial conditions were: Stop valve B shut, drain shut, and the 7-inch pipe full of condensed steam at low temperature. The water hammer was caused by opening the drain two turns, giving an opening of about ⅛ square inch for two minutes, or if this did not lower the water level in the 7-inch pipe to A A, opening the stop valve B after the drain had been open two minutes. Whichever of these acts lowered the water level in the 7-inch pipe to A A caused the water hammer. The fault was

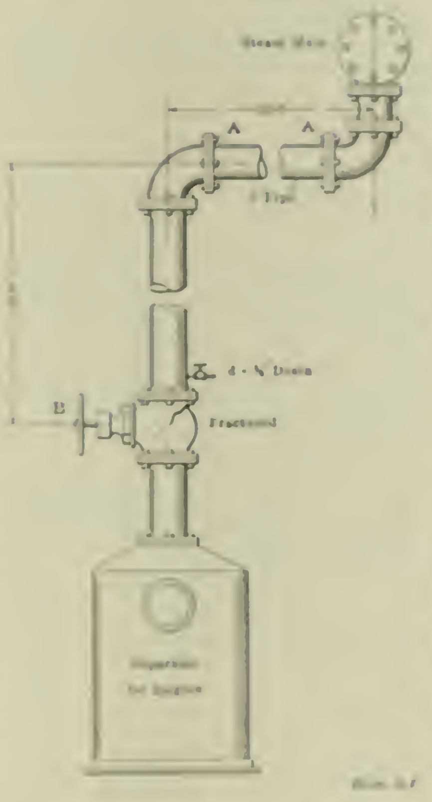


FIG. 9

in opening the drain or the valve without shutting off the steam main. The drain could have been trapped and left open, but the better plan would have been to place the stop valve B close under the steam main.

Case 9—This was the breaking of a cast-iron flange off the screwed end of a 7-inch wrought-iron pipe and knocking it by water hammer under a steam pressure of 95 pounds per square inch. Initially the stop valve C was shut, and D was open. The engine stop valve A was open and the drain shut. Condensed steam had accumulated and cooled in pipe E F. Water hammer was caused by closing valve D, opening the drain and valve C. The fault was in opening the valve C before closing the junction valves on the top boilers. To avoid the necessity of closing these valves before opening valve C, the pipe E F should have been fitted with a large drain leading to a steam trap, which would have kept the pipe clear as long as the trap acted. A still better plan would have been to have installed a well or tank pipe close to C, drained by a trap and fitted with a float telltale or small test cock to enable the engineer in charge to see that the pipe was free from water before opening the valve C, and to warn him that the junction valves on the boilers should be shut.

Museum of Safety Election

Announcement has just been made of the election of the following officers of the Museum of Safety and Sanitation: Acting president, Philip T. Dodge; vice-presidents, Charles Kirchhoff, T. C. Martin, Prof. F. R. Hutton, R. W. Gilder; treasurer, Robert A. Franks; plan and scope committee, Prof. F. R. Hutton, William J. Moran, Dr. Thomas Darlington, H. D. Whitfield, P. T. Dodge; director, William H. Tolman. Among the charter members are C. H. Dodge, Elbert H. Gary, Richard Watson Gilder, Dr. Thomas Darlington, Charles Kirchhoff, T. Commerford Martin, Philip T. Dodge, Prof. E. R. A. Seligman, Irving Fisher, William J. Moran, Henry D. Whitfield, A. R. Shattuck and Prof. F. R. Hutton.

The Museum of Safety and Sanitation has its office in the Engineering Societies' building, 29 West Thirty-ninth street, New York City. The objects of the museum are to study and promote means and methods of safety and sanitation and the application thereof to any and all public or private occupational environment; and of advancing knowledge of kindred subjects; and to that end to establish and maintain expositions, libraries and laboratories and their branches, wherein all devices, methods and means for improving the general condition of the people as to their safety and health may be studied, tested and promoted, with a view to lessening the number of casualties.

At the Greenwich station of the London County Council Tramways the external surface of the [illegible] was considered to be about [illegible] square feet, or about [illegible] square feet per kilowatt of normal capacity.

Three-phase Transformer Connections and Resulting Voltages

By A. D. Williams, Jr.

The accompanying Table 1 gives the voltage between the line and the neutral,

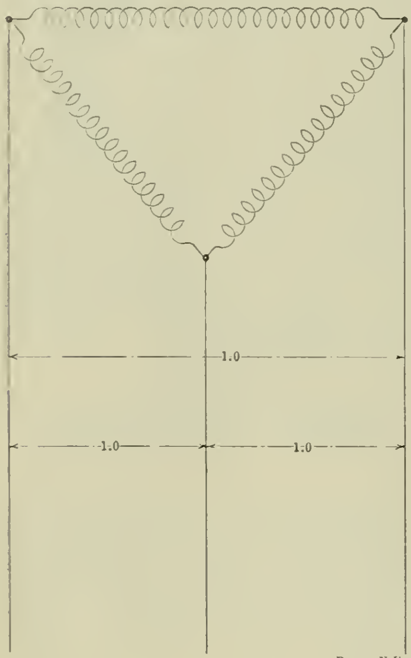


FIG. 1. THREE-PHASE DELTA-CONNECTED GENERATOR

TABLE 1. VOLTAGE OF THREE-PHASE CIRCUITS.

Voltage Between Phases.	Voltage Between Line and Neutral.	Voltage Between Phases.	Voltage Between Line and Neutral.	Voltage Between Phases.	Voltage Between Line and Neutral.
1	0.6	100	57.8	10,000	5,773.5
2	1.2	200	115.5	20,000	11,547.0
3	1.7	300	173.2	30,000	17,320.5
4	2.3	400	230.9	40,000	23,094.0
5	2.9	500	288.7	50,000	28,867.5
6	3.5	600	346.4	60,000	34,641.0
7	4.0	700	404.1	70,000	40,414.5
8	4.6	800	461.9	80,000	46,188.0
9	5.2	900	519.6	90,000	51,961.5
10	5.8	1000	577.4	100,000	57,735.0
20	11.6	2000	1154.7		
30	17.3	3000	1732.0		
40	23.0	4000	2309.4		
50	28.9	5000	2886.8		
60	34.6	6000	3464.1		
70	40.4	7000	4041.4		
80	46.2	8000	4618.8		
90	52.0	9000	5196.2		

or ground, on a three-phase star-connected circuit, and by simple addition will give the voltage to the neutral or ground for any potential not included in the table.

Example—To find the potential between the ground and any phase of an 11,000-volt circuit:

$$5773.5 + 577.4 = 6350.9 \textit{ volts.}$$

The diagram of a three-phase, star-connected generator is shown in Fig. 2. The neutral wire makes this a three-phase, four-wire system. The usual method connects the neutral to the ground, and this is the three-phase, three-wire system used for most transmission lines. The neutral point of the star-connected circuit is not necessarily grounded, but where it is desired to operate without a ground connection or to ground one phase, a condition that occurs in three-phase railway work, the delta connection shown in Fig. 1 is more often used.

The method of connecting the transformers for delta, or triangle, circuits is shown in Fig. 3, and for star connection in Fig. 4; in the latter the neutral is shown dotted. These two methods are the usual three-phase connections and require three transformers or a three-phase transformer. This latter differs only from three single-phase transformers in having a magnetic circuit, certain portions of which are in common. Figs. 5 and 6 illustrate two forms of three-phase connection for transformers which are rarely

TABLE 2. TRANSFORMATION RATIOS; PRIMARY AS IN FIG. 7, SECONDARY AS IN FIG. 9.

Primary Voltage.	Proportion of Primary Coil in Use, Per Cent.	Ratio of Transformation, Secondary Coils In: Multiple.	Series-Mult.	Series.
Normal....	100	40	20	10
	95	38	19	9.5
	90	36	18	9
	85	34	17	8.5
95 per cent. of normal	100	42	21	10.5
	95	40	20	10
	90	38	19	9.5
	85	36	18	9
90 per cent. of normal	100	44.5	22.25	11.13
	95	42	21	10.5
	90	40	20	10
	85	38	19	9.5
85 per cent. of normal	100	47	23.5	11.75
	95	45	22.5	11.25
	90	42.5	21.25	10.63
	85	40	20	10
50 per cent. of normal	100 per Cent. Coils in Mult.	20	10	5

used, but which may be found of service in emergencies.

The three-phase V-connection, Fig. 5, is sometimes called an open-delta connection. This connection would result if one of the transformers shown in Fig. 3 were removed for some cause or other. This property of the three-phase delta circuit is of advantage in permitting continuous operation under practically any emergency that may arise, and is one of the reasons why the delta-connected circuit has been used in some transmission lines. In the three-phase V-connection, if the amount of current per phase be represented by 1, the current flowing through each transformer winding will be $\sqrt{3} = 1.73$, from which it can be seen that the copper loss of the transformers will be increased. The objection to this connection arises from the tendency of the transformer impedance to produce an unbalanced secondary voltage, which also produces unbalancing in the primary circuit.

The T-connection, Fig. 6, overcomes the disadvantage of the V-connection. The unbalancing is not as serious. The ratios given between the transformer taps on this diagram are the theoretical values. In practice the transformer marked with the ratio 0.867 may have the ratio 0.85 or 0.90 and will then operate satisfactorily.

Nearly all transformers made have taps taken out from the primary winding so

TABLE 3. TRANSFORMATION RATIOS; PRIMARY AS IN FIG. 8, SECONDARY AS IN FIG. 7.

Primary Voltage.	Proportion of Primary Coil in Use, Per Cent.	Ratio of Transformation, Secondary Coils In: Multiple.	Series-Mult.	Series.
Normal....	100	40	20	10
	95	38	19	9.5
	90	36	18	9
95 per cent. of normal	100	42	21	10.5
	95	40	20	10
	90	38	19	9.5
90 per cent. of normal	100	44.5	22.25	11.13
	95	42	21	10.5
	90	40	20	10
50 per cent. of normal	Coils in Multiple			
	100	20	10	5
	90	18	9	4.5
45 per cent. of normal	100	22	11	5.5
	90	20	10	5

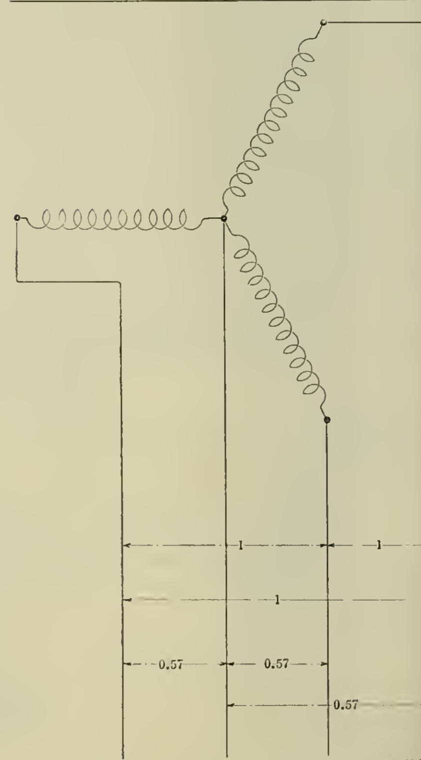


FIG. 2. THREE-PHASE STAR OR Y-CONNECTED GENERATOR

that they may be operated with 100, 95, 90 or 85 per cent. of the primary coils in service; and a top is usually connected to the middle of the primary winding. Occasionally they are arranged to operate with only 100, 95 or 90 per cent. of the primary in service. The schematic arrangements of these two cases are shown in Figs. 7 and 8, respectively. The percentage values given are the ratios between the total number of turns in the primary coils and the number of turns between the various taps.

If the ratio across the entire primary winding be taken to represent the potential in volts for which the primary winding is normally designed, the ratios given represent the various primary potentials upon which this winding can be connected to deliver the full secondary voltage. Thus the winding shown in Fig. 7 will deliver the normal secondary voltage when the primary voltage is 100, 95, 90, 85 or 50 per cent. of the normal or, with normal primary voltage, secondary voltages of

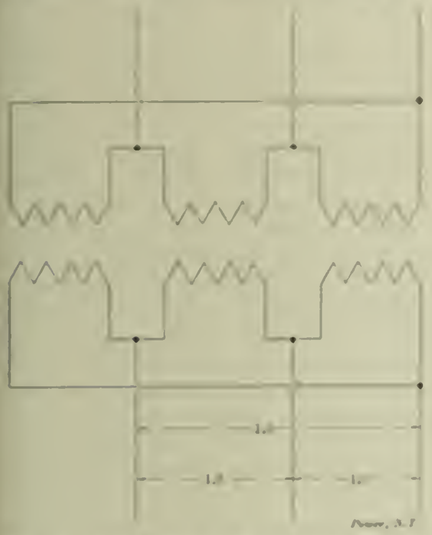


FIG. 3. THREE-PHASE DELTA CONNECTION OF TRANSFORMERS

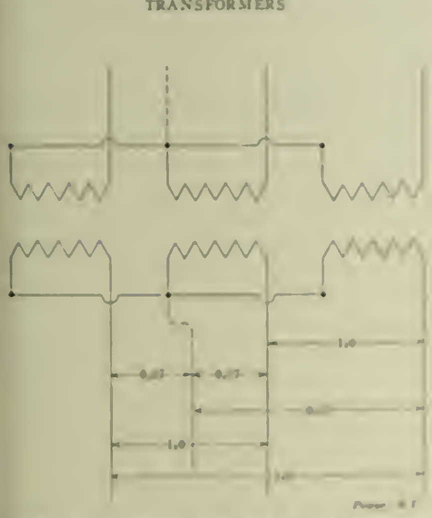


FIG. 4. THREE-PHASE STAR CONNECTION, NEUTRAL [illegible]

100, 105, 111 or 117 per cent. of normal voltage can be obtained. The winding shown in Fig. 8 will deliver the normal secondary voltage when the primary voltage is 100, 95, 90, 50 or 45 per cent. of normal or, with the normal primary voltage, can deliver a secondary voltage of 100, 105 or 111 per cent. of normal. The primary connections shown are those usual for distributing transformers and transmission transformers.

The secondary or low-tension winding usually found in distributing transformers is shown schematically in Fig. [illegible] and the four coils can be connected in series, multiple-series or multiple, giving secondary potentials of 100, 50 or 25 per cent. of the normal, or they can be used to operate two-, three- or five-wire circuits. As any of these combinations may be made in connection with any desired primary connection, it can be seen that a wide variety of transformation ratios can be obtained between the primary and the secondary voltages. Assuming that the normal ratio of the transformer from primary to secondary is 10 to 1, a common ratio in distributing transformers,

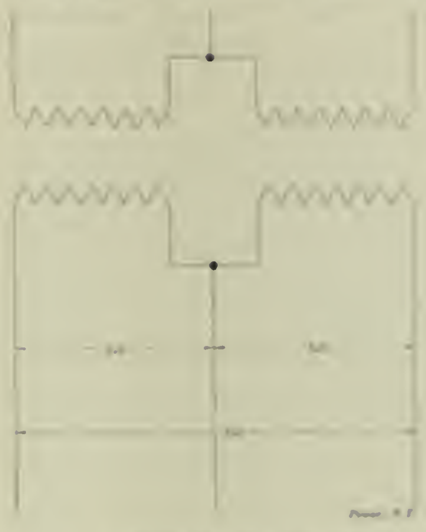


FIG. 5. THREE-PHASE V-CONNECTION

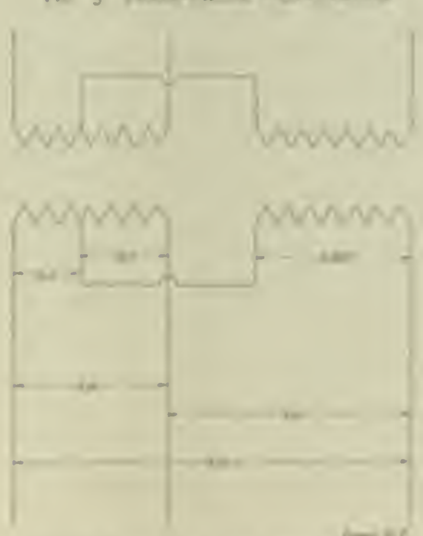


FIG. 6. THREE-PHASE T-CONNECTION

the following transformation ratios can be obtained, when the secondary shown in Fig. [illegible] is used in connection with the primary shown in Fig. 7: [illegible] and [illegible] to 1. Table [illegible] gives the ratios for various primary voltages using different taps of the primary. Table [illegible] gives the ratios obtainable when the primary shown in Fig. 8 is used in combination with the secondary shown in Fig. [illegible], the desired ratio between the primary and secondary winding being [illegible]

In some cases intermediary taps are brought out of the secondary winding similar in [illegible] to those shown in Figs. 7 and 8, but these are unusual. When taps are [illegible] in both, a wider variety of ratios can be obtained, as a greater number of combinations of connections can be made.

In the perfect transformer, that is, one in which no losses occurred, the primary amperes multiplied by the number of turns in the primary coil would be equal to the secondary amperes multiplied by the number of turns in the secondary coil. The watts drawn from the line would equal

FIG. 7. SCHEMATIC ARRANGEMENT OF PRIMARY WINDINGS

FIG. 8. ANOTHER ARRANGEMENT OF PRIMARY WINDINGS

FIG. 9. SCHEMATIC ARRANGEMENT OF SECONDARY WINDINGS

the number of watts delivered at the secondary circuit. In practice, the design of transformers is complicated by the [illegible] losses, due to hysteresis and eddy currents and the copper losses, due to [illegible] [illegible] and resistance, the latter being [illegible] [illegible] but [illegible] may be neglected. Transformers are rated on their kilowatt output [illegible] at some given [illegible] [illegible] that value. The [illegible] [illegible] practice. The [illegible] [illegible] to allow a margin for [illegible]

The Use of Indicators in Refrigeration

Limitations of the Diagram in Work of This Character; Its Meaning in Compression; Analogy to and Comparison with the Steam Diagram*

BY SAMUEL K. PATTESON

The indicator in steam-engine design and operation is in common use today in valve setting and in the determination of the efficiency of steam engines, and its value in this connection is well known. Its application to the steam engine and the details of its use are familiar facts, but its application to the compressor in refrigerating plants is not so common. In fact, ammonia-refrigerating machine manufacturers themselves advocate the use of a thermometer with their installations. Most engineers, however, who are thoroughly familiar with the workings of the indicator recognize its applicability to both cases.

Limitations of the Indicator Diagram

That the indicator diagram is just as useful in refrigeration as in steam-engine work is beyond doubt. In the steam engine it merely records the pressure in the cylinder depending on the cylinder stroke, and it acts in the same way in the ammonia compressor. Its limitations here are the same as in steam work. In steam work nothing can be learned from it about the degree of superheat in the steam, the amount of moisture in it, or the quantity of steam which passes through the cylinder at each stroke of the piston. In fact, it takes no account of the temperature of the steam. This can only be deduced from the pressure and the volume as shown on the diagram. These limitations hold in refrigeration work as well, and no record can be obtained by its use of the degree of superheat in the ammonia gas or its temperature, or the amount of liquid or vapor carried over in the gas or evaporated in the compressor itself. As to these points many of them can be obtained from the thermometer in both of these installations. The fact that these latter points have more influence in refrigeration work than in steam work is responsible for the opinion that the indicator is not applicable to this development. Steam should never enter the cylinder partially condensed and effort is made to avoid this condition. However, in refrigeration work, especially in wet compression, it is desirable that a part of the liquid should enter the cylinder in order to permit its further evaporation in the cylinder. These variations are due to the fact that in steam work the heat is desirable in the cylinder, while in refrigeration it must be gotten out as completely and as rapidly as possible. These conditions, of course, give an entirely different conception of the indicator work and its relative importance in the two developments.

Thus work is the end sought after with steam and the presence of heat is not of such importance. In the case of the refrigerating machine, heat, or rather the removal of it, is the object in view. The indicator performs the same duty in the one case as in the other. It is invaluable in both steam-engine practice and ammonia compression and it would be difficult to obtain adequate data in regard to these machines without it. Adequate data in regard to pressure and total work done in expansion and compression can be gotten in no other way. Of course, if no account is taken of the quantity of work done by the compressor in refrigeration, or of the amount of steam used, the indicator is not particularly useful in this development, and the thermometer answers very well, if the refrigeration alone is considered. The same may be said, however, of steam work. In the refrigeration machine the same information can be obtained by the use of the thermometer and metering the ammonia as can be gotten in steam work by the use of the thermometer and measuring the water consumed. The metering of the ammonia is done practically by measuring the refrigeration produced in the cooling coils. The refrigerating-machine manufacturers, as a general thing, have not considered the compressor as an efficient machine from a work point of view, and hence the low estimate placed upon the usefulness of the indicator in this field. There can be no doubt that a wider use of the indicator would result in showing where improvements are desirable and practicable.

Analogy of the Steam Diagram

A study of the steam diagram in its analogy and contrasts with the indicator diagram as used in refrigeration work, will aid in making more clear a description of the latter. The general shapes of the diagrams are the same. In both they should consist of horizontal lines, one above the other, the lower always being longer than the upper and the two connected on one side by a vertical line and on the other by a line curving toward the lower straight line. In steam work the object in view is to get the greatest amount of work with the least steam consumption. In compression the object is to get the greatest amount of compression with the least work. The upper straight line in the steam diagram represents the portion of the stroke during which steam enters the cylinder, and its distance from the lower line represents its pressure above that of the exhaust. Hence, the distance between the two lines must be as great as possible, or the pressure of the steam as it enters must be as high as possible, in order to get the maximum amount of work obtainable. Then, too, the line must be as short as possible, as its length is always proportional to the amount of steam that enters the cylinder per stroke of the piston. The area of the diagram being equal to the pressure times the change in volume represents work, and by making the upper line longer a larger area is secured and therefore more work done per stroke of the piston, but more steam is used, and the object here is to get the greatest possible proportionate amount of work from a given quantity of steam. In overloads, of course, the time of cutoff is extended and we have varying lengths of cutoff, in many cases automatically regulated by the governor. In these cases the engine does more work, but it uses a larger proportion of steam, and its efficiency is lowered.

In the best engines the cutoff is made to operate under normal circumstances, so that the greatest proportionate amount of work is accomplished at the best efficiency from a steam-consumption viewpoint. This is equivalent to stating that the rest of the curves in the diagram are so proportionate and have such relations that with this particular length of upper line, or steam consumption, the greatest area, or work done relatively, is obtained. After the cutoff is made, that portion of the expansion remaining should be adiabatic for most efficient work, or, in other words, the remainder of the upper line in the indicator diagram should be part of an adiabatic curve. An adiabatic curve is steeper than an isothermal one, and hence the latter would give a larger area to the diagram and, therefore, more work, but in this case heat would have to be added while the change was taking place, and this extra heat would not be made use of at its highest efficiency. On account of cylinder condensation and the accompanying loss of heat, this curve, in practice, is even steeper than an adiabatic. To eliminate the cylinder condensation, recourse is had to steam-jacketing the cylinder and this tends to make the curve isothermal as well.

The Standard Diagram and Its Meaning in Compression

In compression the upper half of the diagram represents the compression part of the stroke. The ammonia gas or air is compressed adiabatically. This compression continues until the valve opens and during the remainder of the stroke, while the gas is leaving the compressor and entering the condenser, the line should be horizontal. Now, the amount of refrigeration produced is proportional to the quantity of ammonia gas leaving the compressor. The amount of work done on the gas by the compressor is, of course, represented by the area of the diagram, and hence the object here is to get the upper line as long as possible. The area of the diagram, or the work done, becomes less the nearer the suction pressure is to the condensing pressure. The colder the condensing water and the larger the condenser the less will be this pressure; hence follows the great effect which the temperature has on the efficiency of a given plant and the amount of work required. If the condenser is too small to take the extra charge from the compressor without extra work, the upper straight line will not be horizontal, but will continue to rise with further compression; and this represents a loss in efficiency also, since the pressure at which the valve opens is the pressure at which the condenser can work if its capacity is not overcrowded. All this work done on the gas up to this time appears as heat, and the compression, therefore, is adiabatic.

As the adiabatic curve is steeper than the isothermal, the compression should be isothermal and the temperature of the ammonia gas should be kept down during the compression, in order that the area in the diagram, which represents the work done, shall be as little as possible. Water jacketing is resorted to to obtain this result, and the efficiency of this device is readily shown from the curve on the indicator diagram. This line is also affected by the speed of the compressor. The heat cannot escape from the gas to the water jacket fast enough if the compressor is operated too rapidly, and the curve becomes adiabatic and more work is done. Again, under these circumstances the entering cold gas on the next stroke reabsorbs this heat very rapidly from the cylinder walls and expands back into the cooling coils before the closing of the valves. This reduces the capacity of the condenser with a consequent loss in refrigeration produced. An analogous situation exists in the steam engine, which explains the fact that an increase in speed results in an increased efficiency in the steam engine, while in the ammonia compressor the reverse effect is in evidence. Thus, the indicator diagram becomes invaluable in showing the speed at which the best results can be obtained from the compressor.

In practice, however, an ammonia compressor is run at its maximum operating speed. This is often done without regard to the efficiency of the operation, but in order to secure the highest possible returns on the first cost investment. The excess refrigeration, however, is sometimes produced at a loss even when the first cost factor is given full consideration, and the point at which the loss begins should be positively known by the operator, and this point can only be obtained by intelligent use of the indicator diagram.

Dry versus Wet Compression

The conditions considered so far have been those which in refrigeration are similar to steam work, assuming a dry gas as the working substance and not a condensable one or one containing liquid which enters the cylinder with the gas. A consideration of these factors materially alters the conditions to be considered and also alters the indicator diagram. What has been considered thus far has dealt with dry compression. In what is known as wet compression an amount of water, varying with different conditions, is sucked into the cylinder. Under these conditions the cylinder volume available for gas to be compressed has been diminished by the presence of the water in the cylinder. The upper horizontal line in the indicator diagram, understood as being proportional to the quantity of gas compressed in the cylinder per stroke, can no longer be so considered, if this gas is measured in volumes as in the case of the previous gas with the existence of constant condensing pressure.

In dry compression the reheating effects in the cylinder walls constitute a very objectionable feature, and to eliminate these effects small quantities of liquid are injected into the compressor. This elimination, however, is not accomplished and it is present in both cases, probably even to a greater extent in the wet compression than in the dry. These reheating effects may cut the capacity of the compressor 40 per cent. This effect is present in the cylinder in the form of a rise in temperature followed by a diminution in density at constant pressure, and cannot be detected on the indicator card. On the other hand, in wet compression, when liquid enters the cylinder a portion of it is immediately evaporated, and the gas which results tends to diminish still further the capacity of the cylinder for the gas coming from the cooling coils. However, this evaporation takes place at a lower temperature and consequently with an increased amount of gas. The relative efficiency of these two methods is a much-mooted question, as the extent to which the two opposing tendencies counterbalance each other is not known. In dry compression the reheating effects sometimes become cumulative with high speeds if the water jacket does not act very efficiently in performing its duty of removing the heat from the cylinder. This factor is not present in wet compression, and if the proper amount of liquid for cooling is injected with each stroke of the piston, much higher speeds can be obtained, at least theoretically. The compression curve even in the wet compression is approximately an isothermal one, being below the adiabatic. Less work should be done per stroke by this method, and the only question is the relative efficiency of this work in the two cases.

The Suction Part of the Cycle

This brings us to the lower limb of the cycle, or in other words, the lower line of the diagram. In refrigeration it consists of the suction part of the cycle and the effect of clearance on the lowering of the pressure in the cylinder to that in the cooling coils. In the steam work it corresponds to the exhaust stroke and the return to the boiler pressure. In steam the lower line should be as far as possible from the upper, in order that the area inclosed in the diagram may be as large as possible. This merely means that the pressure at the exhaust should be as low as possible and the lower line should be horizontal in order that there may be no loss in area or a diminution in the available work, resulting from a rise in that line. This rise may be the effect of a number of different causes, such as insufficient condenser capacity, or the water may not be cold enough to counteract the tendency to increased pressure from the advent of additional steam, or a variety of other defects in the size of the exhaust ports or pipes, or the operation of the valves. All these defects can be recognized with facility by the form of that line with relation to the remainder of the diagram. The line should be vertical for the remainder of its length, and should appear only at the end of the stroke, when the pressure is again raised to boiler pressure. Any variation in this line from the normal means a loss in efficiency due to a variety of causes, such as errors in the proper size of ports, leakages or improper closing of the exhaust valves. All these causes can be easily diagnosed as variations and combinations of variations in the form of the diagram.

In compression, on the other hand, the lower line involves in its vertical component the expansion of the gas which remains in the cylinder after the compression is finished, and is known as clearance gas. Then comes the condensation of the suction valve and the horizontal line of suction pressure. This line should be such close to the upper line for greatest efficiency, since under these conditions the area is smallest or the work done is at a minimum. This result is obtained first when the suction pressure is high. This pressure, however, depends on the temperature of the boiling ammonia in the cooling coils and hence it may be seen why the temperature required in the refrigerator affects so greatly the efficiency, and also why the lower the temperature required the less efficient will be its production. The lower line should be horizontal. Any lowering of this line means increased work on account of stiff valves, too small ports or pipes, or a leak of sufficient extent in the cooling coils to produce this effect. A vertical clearance denotes the complete absence of ammonia remaining in the cylinder from the compression stroke, and this, of course, is desirable. Leaky valves or abnormal clearance on the pressure side causes this line to curve over. This results in less work being done in a cycle, since the area inclosed is smaller. However, some of the work done in this case is repeated work, and the efficiency is thus diminished. Clearance in the cylinder has the same effect that a spring would have if inserted between the piston and piston head. Work is lost here, resulting in extra heat in both cases.

The usefulness of the indicator extends over a wide range, and a large amount of knowledge thus becomes available in regard to the internal behavior of the ammonia compressor and of the conditions governing its efficiency. The chief value of the indicator is in valve setting, as a slight change in the position of the eccentric produces variations in the times of operation of the valves which very materially affect the efficiency. By means of the diagram a complete study of the valve mechanism is possible, and in addition it is the principal, as well as the best, method for getting the best efficiency and proper operation in this department.

An Interesting Low Pressure Pumping Installation

By Albert E. Guy

There has lately been completed by a large steel company a pump installation of considerable interest, particularly so as it is the first of its kind in this country. It consists of a combination high- and low-pressure steam turbine of 150 horsepower capacity driving two 16-inch single-stage pumps connected in series, Fig. 1. This installation is quite noticeable in view of the extremely difficult conditions that the turbine was required to meet, as it was necessary that this machine operate continuously without attention, on the failure of the low-pressure steam supply.

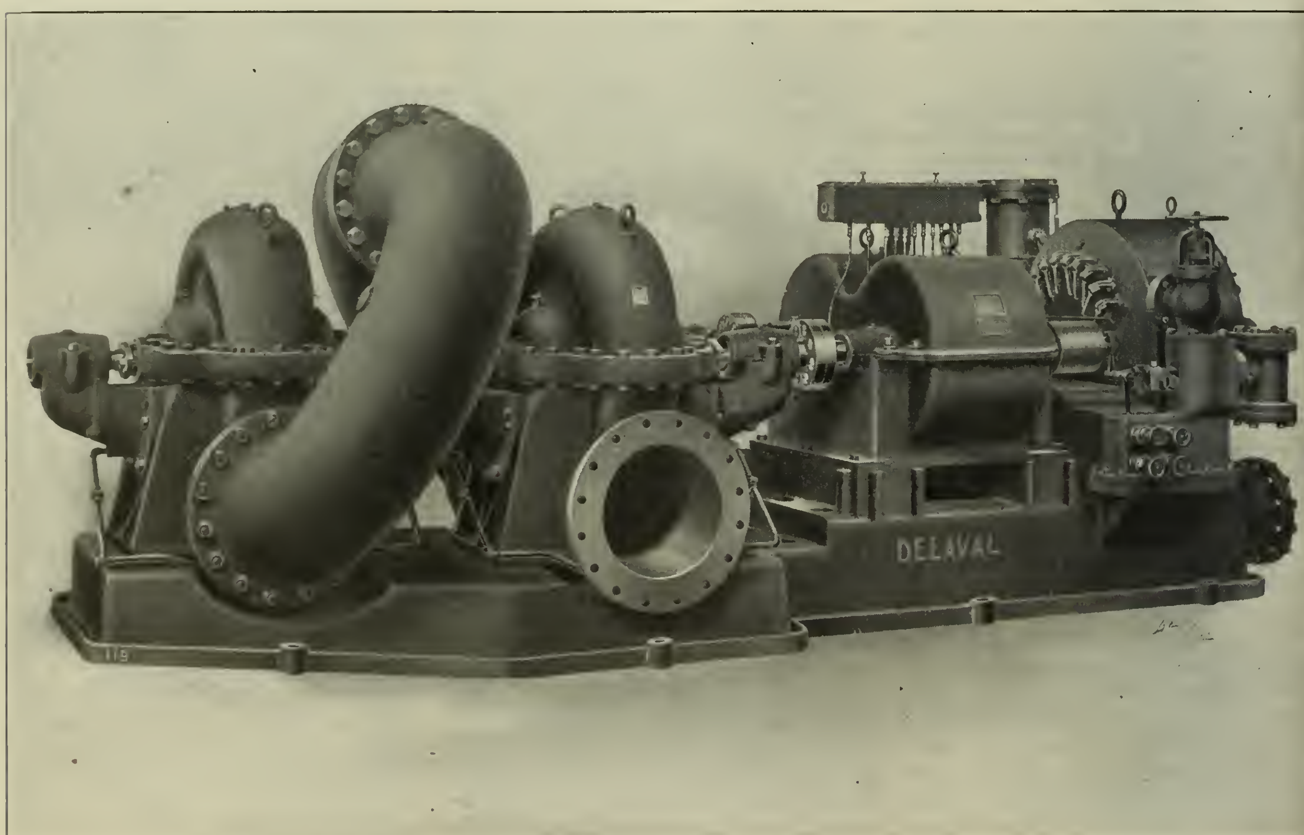


FIG. 1. COMBINATION HIGH- AND LOW-PRESSURE TURBINE DRIVING TWO 16-INCH PUMPS IN SERIES

The steam for the turbine is collected from a number of hydraulic pumps, air pumps and other auxiliary machines, all of which exhaust into a common header from which the turbine draws its supply. No large receiver was installed in the header, the capacity of the header being deemed sufficient for the needs of the turbine. Neither was there any heat accumulator installed, as on failure of the low-pressure steam supply the machine is arranged to operate on steam at boiler pressure.

In view of obtaining continuous operation it was necessary to devise a machine that would operate under a number of conditions. The turbine was to be located near and in connection with a large central condensing plant in use for numerous engines, a number of which were reversing rolling-mill engines, so that the vacuum was very irregular, varying from 18 to 27 inches and averaging about 22 inches. The vacuum was also lost at times due to trouble on the engines or air leaks, making it necessary to operate the turbine noncondensing as an emergency. The turbine was accordingly purchased to meet the following conditions: To carry full load when using steam at atmospheric pressure, exhausting into a vacuum of 22 inches; also to carry full load when operating with steam at 120 pounds, exhausting into a vacuum of 22 inches; also to operate condensing with steam at 90 pounds pressure, exhausting into a vacuum of 22 inches. In case of emergency it must operate noncondensing with steam at 90 pounds pressure; all of these variations to be handled automatically, with the exception of the emergency noncondensing condition.

The machine is used for pumping water from the hotwell of a central condensing plant to the purifying tanks of a large water-purification system, supplying all the boilers of the steel plant with purified water. The conditions for this work are to deliver 5000 gallons of water per minute against a total head of 65 feet. However, as the water-purification plant requires but one hour of work out of three, if used for this service only, a pump would have been in operation only one-third of the time. In order to keep the machine in continuous operation to obtain the greatest returns from the investment, and also to assist in obtaining lower costs on the main water-supply system, it was determined to use this pump, for the two thirds of the time that it was not supplying the purifying system, on the main standpipe system. The total water consumption of the plant is so large that the small amount of heat contained in the hotwell water handled by the turbine pump was of no importance.

The machine was accordingly connected to the main water works system in the following manner: The total head for the purifying tanks is 65 feet, as stated above. The total head of the standpipe system is 95 feet. The purifying system was at a considerable distance from the pump so that it would be impossible for an attendant to go from the purifying system to the pumping plant. The machine was piped into both systems with a check valve between the standpipe system and the pump, and a gate valve directly at the purifying plant in charge of the purifying-plant attendant. As the purifying-plant head was less than the standpipe head, when it was desired to fill one of the tanks, the attendant simply opened the valve and the water from the turbine would at once flow into the purifying system. During this period the check valve of the standpipe system would close, but on closing the purifying-system valve the pressure in the pump would at once increase and as soon as it exceeded 95 feet the water would flow into the standpipe through the check valve. In order that the pump would work automatically on both systems, the impellers were so designed that they would give practically the same efficiency when pumping against either 65 or 95 feet, in one case delivering 5000 and in the other case 4000 gallons per minute.

The machine was most carefully tested by representatives of the steel company before leaving the factory, and later tested after installation at the plant. The results of these tests were very interesting in showing the number of conditions that can be successfully handled by a De Laval turbine. Fig. 2 shows characteristic curves for a 10-inch turbine centrifugal pump designed to deliver 5000 gallons per minute against a head of 65 feet when making 2900 revolutions per minute. On test the turbine operated on steam at atmospheric pressure, exhausting into a vacuum of 26 to 28 inches. It also operated with steam at 5 inches of vacuum below atmosphere, exhausting into a vacuum of 26 inches. It also operated on steam at 150 pounds pressure exhausting into a vacuum of 26 inches and steam at 150 pounds pressure, exhausting into the atmosphere. The alternative noncondensing condition was successfully carried with 50 pounds of steam. The resulting economies of all the conditions were nearly equal to the economy of a turbine designed for each one of these particular conditions.

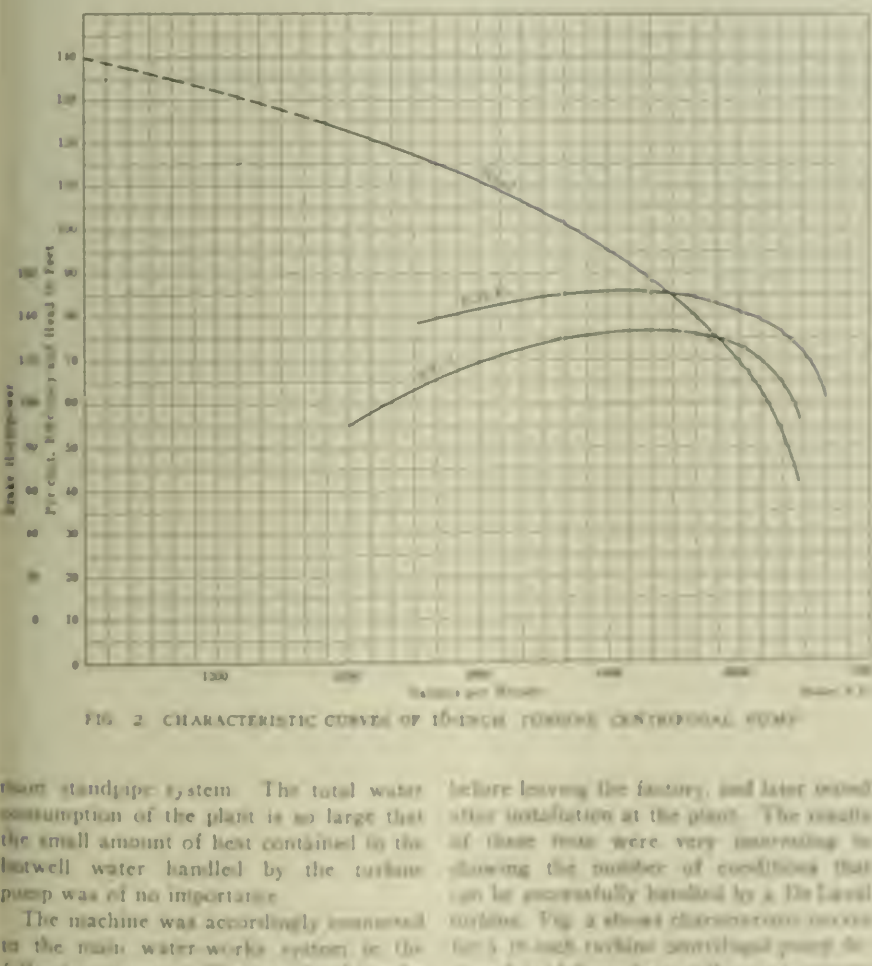


FIG. 2. CHARACTERISTIC CURVES OF 10-INCH TURBINE CENTRIFUGAL PUMP

The arrangement of the turbine is as follows: It is supplied with two governor valves and two governors, one for high-pressure steam and the other for low-pressure steam. The high-pressure governor is set at a few revolutions below normal speed and at this point keeps the high-pressure governor valve tightly closed. The low-pressure governor is set for normal speed and regulates the turbine by means of the low-pressure governor valve. On the failure of the low-pressure steam supply the machine drops a few revolutions in speed, thus releasing the high-pressure governor valve and admitting steam at boiler pressure into the turbine. The steam nozzles in the turbine for the high- and low-pressure conditions are in separate compartments and each nozzle is correct for the ratio of expansion of the conditions it has to meet, thus allowing of good economy with the variable conditions. The noncondensing condition being for emergency only was not made automatic, and to operate the turbine noncondensing it was necessary to open a bypass valve admitting steam from the high-pressure steam compartment to the low-pressure nozzles. The ratio of expansion in the nozzle with steam at atmospheric pressure exhausting into a vacuum of 26 inches is practically the same as steam entering the nozzle at 150 pounds pressure and exhausting at atmosphere, thus giving very good results under either condition. The speed regulation obtained when changing from one steam supply to the other was less than 2 per cent.

In operation there is a very considerable fluctuation of the exhaust steam pressure due to the large hydraulic pumps running rather slowly and exhausting heavily when they do exhaust. The exhaust steam pressure varies from 2 pounds above atmosphere to 5 inches of vacuum, but the regulating mechanism of the turbine handles this variation without trouble.

A bill has been introduced into the Pennsylvania legislature prohibiting the emission of smoke. One thickness of gray glass of sufficient opacity to cut off 80 per cent. of the light from a flame having the diffuse power of 16 candles is taken as the basis on this basis, and four thicknesses of such glass are designated as No. 4 of the scale. It is forbidden and declared to be nuisance to emit or permit the emission or escape of smoke of a greater degree of darkness than No. 2 of the scale, and is the darkness produced by the passage of light through two glasses of the said density.

TABLE FOR CONVERTING HORSEPOWER INTO WATTS.

1 Horsepower = 745.65 Watts.

H. P.	Additional Tenths of One Horsepower.									
	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1	746	820	895	969	1,044	1,118	1,193	1,268	1,342	1,417
2	1,491	1,566	1,640	1,715	1,790	1,864	1,939	2,013	2,088	2,162
3	2,237	2,312	2,386	2,461	2,535	2,610	2,681	2,759	2,833	2,908
4	2,983	3,057	3,132	3,206	3,281	3,355	3,430	3,505	3,579	3,654
5	3,728	3,803	3,877	3,952	4,027	4,101	4,176	4,250	4,325	4,399
6	4,474	4,548	4,623	4,698	4,772	4,847	4,921	4,996	5,070	5,145
7	5,220	5,294	5,369	5,443	5,518	5,592	5,667	5,742	5,816	5,891
8	5,965	6,040	6,114	6,189	6,263	6,338	6,413	6,487	6,562	6,636
9	6,711	6,785	6,860	6,935	7,009	7,084	7,158	7,233	7,307	7,382
10	7,456	7,531	7,606	7,680	7,755	7,829	7,904	7,978	8,053	8,128
11	8,202	8,277	8,351	8,426	8,500	8,575	8,650	8,724	8,799	8,873
12	8,948	9,022	9,097	9,171	9,246	9,321	9,395	9,470	9,544	9,619
13	9,693	9,768	9,843	9,917	9,992	10,066	10,141	10,215	10,290	10,365
14	10,439	10,514	10,588	10,663	10,737	10,812	10,886	10,961	11,036	11,110
15	11,185	11,259	11,334	11,408	11,483	11,558	11,632	11,707	11,781	11,856
16	11,930	12,005	12,080	12,154	12,229	12,303	12,378	12,452	12,527	12,601
17	12,676	12,751	12,825	12,900	12,974	13,049	13,123	13,198	13,273	13,347
18	13,422	13,496	13,571	13,645	13,720	13,795	13,869	13,944	14,018	14,093
19	14,167	14,242	14,316	14,391	14,466	14,540	14,615	14,689	14,764	14,838
20	14,913	14,988	15,062	15,137	15,211	15,286	15,360	15,435	15,510	15,584
21	15,659	15,733	15,808	15,882	15,957	16,031	16,106	16,181	16,255	16,330
22	16,404	16,479	16,553	16,628	16,703	16,777	16,852	16,926	17,001	17,075
23	17,150	17,225	17,299	17,374	17,448	17,523	17,597	17,672	17,746	17,821
24	17,896	17,970	18,045	18,119	18,194	18,268	18,343	18,418	18,492	18,567
25	18,641	18,716	18,790	18,865	18,940	19,014	19,089	19,163	19,238	19,312
26	19,387	19,461	19,536	19,611	19,685	19,760	19,634	19,909	19,983	20,058
27	20,133	20,207	20,282	20,356	20,431	20,505	20,580	20,655	20,729	20,804
28	20,878	20,953	21,027	21,102	21,176	21,251	21,326	21,400	21,475	21,549
29	21,624	21,698	21,773	21,848	21,922	21,997	22,071	22,146	22,220	22,295
30	22,369	22,444	22,519	22,593	22,668	22,742	22,817	22,891	22,966	23,041
31	23,115	23,190	23,264	23,339	23,413	23,488	23,563	23,637	23,712	23,786
32	23,861	23,935	24,010	24,084	24,159	24,234	24,308	24,383	24,457	24,532
33	24,606	24,681	24,756	24,830	24,905	24,979	25,054	25,128	25,203	25,278
34	25,352	25,427	25,501	25,576	25,650	25,725	25,799	25,874	25,949	26,023
35	26,098	26,172	26,247	26,321	26,396	26,471	26,545	26,620	26,694	26,769
36	26,843	26,918	26,993	27,067	27,142	27,216	27,291	27,365	27,440	27,514
37	27,589	27,664	27,738	27,813	27,887	27,962	28,036	28,111	28,186	28,260
38	28,335	28,409	28,484	28,558	28,633	28,708	28,782	28,857	28,931	29,006
39	29,080	29,155	29,229	29,304	29,379	29,453	29,528	29,602	29,677	29,751
40	29,826	29,901	29,975	30,050	30,124	30,199	30,273	30,348	30,423	30,497
41	30,572	30,646	30,721	30,795	30,870	30,944	31,019	31,094	31,168	31,243
42	31,317	31,392	31,466	31,541	31 616	31,690	31,765	31,839	31,914	31,988
43	32,063	32,138	32,212	32,287	32,361	32,436	32,510	32,585	32,659	32,734
44	32,809	32,883	32,958	33,032	33,107	33,181	33,256	33,331	33,405	33,480
45	33,554	33,629	33,703	33,778	33,853	33,927	34,002	34,076	34,151	34,225
46	34,300	34,374	34,449	34,524	34,598	34,673	34,747	34,822	34,896	34,971
47	35,046	35,120	35,195	35,269	35,344	35,418	35,493	35,568	35,642	35,717
48	35,791	35,866	35,940	36,015	36,089	36,164	36,239	36,313	36,388	36,462
49	36,537	36,611	36,686	36,761	36,835	36,910	36,984	37,059	37,133	37,208
50	37,282	37,357	37,432	37,506	37,581	37,655	37,730	37,804	37,879	37,954
51	38,028	38,103	38,177	38,252	38,326	38,401	38,476	38,550	38,625	38,699
52	38,774	38,848	38,923	38,997	39,072	39,147	39,221	39,296	39,370	39,445
53	39,519	39,594	39,669	39,743	39,818	39,892	39,967	40,041	40,116	40,191
54	40,265	40,340	40,414	40,489	40,563	40,638	40,712	40,787	40,862	40,936
55	41,011	41,085	41,160	41,234	41,309	41,384	41,458	41,533	41,607	41,682
56	41,756	41,831	41,906	41,980	42,055	42,129	42,204	42,278	42,353	42,427
57	42,502	42,577	42,651	42,726	42,800	42,875	42,949	43,024	43,099	43,173
58	43,248	43,322	43,397	43,471	43,546	43,621	43,695	43,770	43,844	43,919
59	43,993	44,068	44,142	44,217	44,292	44,366	44,441	44,515	44,590	44,664
60	44,739	44,814	44,888	44,963	45,037	45,112	45,186	45,261	45,336	45,410
61	45,485	45,559	45,634	45,708	45,783	45,857	45,932	46,007	46,081	46,156
62	46,230	46,305	46,379	46,454	46,529	46,603	46,678	46,752	46,827	46,901
63	46,976	47,051	47,125	47,200	47,274	47,349	47,423	47,498	47,572	47 647
64	47,722	47,796	47,871	47,945	48,020	48,094	48,169	48,244	48,318	48,393
65	48,467	48,542	48,616	48,691	48,766	48,840	48,915	48,989	49,064	49,138
66	49,213	49,287	49,362	49,437	49,511	49,586	49,660	49,735	49,809	49,884
67	49,959	50,033	50,108	50,182	50,257	50,331	50,406	50,481	50,555	50,630
68	50,704	50,779	50,853	50,928	51,002	51,077	51,152	51,226	51,301	51,375
69	51,450	51,524	51,599	51,674	51,748	51,823	51,897	51,972	52,046	52,121
70	52,195	52,270	52,345	52,419	52,494	52,568	52,643	52,717	52,792	52,867
71	52,941	53,016	53,090	53,165	53,239	53,314	53,389	53,463	53,538	53,612
72	53,687	53,761	53,836	53,910	53,985	54,060	54,134	54,209	54,283	54,358
73	54,432	54,507	54,582	54,656	54,731	54,805	54,880	54,954	55,029	55,104
74	55,178	55,253	55,327	55,402	55,476	55,551	55,625	55,700	55,775	55,849
75	55,924	55,998	56,073	56,147	56,222	56,297	56,371	56,446	56,520	56,595
76	56,669	56,744	56,819	56,893	56,968	57,042	57,117	57,191	57,266	57,340
77	57,415	57,490	57,564	57,639	57,713	57,788	57,862	57,937	58,012	58,086
78	58,161	58,235	58,310	58,384	58,459	58,534	58,608	58,683	58,757	58,832
79	58,906	58,981	59,055	59,130	59,205	59,279	59,354	59,428	59,503	59,577
80	59,652	59,727	59,801	59,876	59,950	60,025	60,099	60,174	60,249	60,323
81	60,398	60,472	60,547	60,621	60,696	60,770	60,845	60,920	60,994	61,069
82	61,143	61,218	61,292	61,367	61,442	61,516	61,591	61,665	61,740	61,814
83	61,889	61,964	62,038	62,113	62,187	62,262	62,336	62,411	62,485	62,560
84	62,635	62,709	62,784	62,858	62,933	63,007	63,082	63,157	63,231	63,306
85	63,380	63,455	63,527	63,604	63,679	63,753	63,828	63,902	63,977	64,051
86	64,126	64,200	64,275	64,350	64,424	64,499	64,573	64,648	64,722	64,797
87	64,872	64,946	65,021	65,095	65,170	65,244	65,319	65,394	65,468	65,543
88	65,617	65,692	65,766	65,841	65,915	65,990	66,065	66,139	66,214	66,288
89	66,363	66,437	66,512	66,587	66,661	66,736	66,810	66,885	66,959	67,034
90	67,108	67,183	67,258	67,332	67,407	67,481	67,556	67,630	67,705	67,780
91	67,854	67,929	68,003	68,078	68,152	68,227	68,302	68,376	68,451	68,525
92	68,600	68,674	68,749	68,823	68,898	68,973	69,017	69,122	69,196	69,271
93	69,345	69,420	69,495	69,569	69,644	69,718	69,793	69,867	69,942	70,017
94	70,091	70,166	70,240	70,315	70,389	70,464	70,538	70,613	70,688	70,762
95	70,837	70,911	70,986	71,060	71,135	71,210	71,284	71,359	71,433	71,508
96	71,582	71,657	71,732	71,806	71,881	71,955	72,030	72,104	72,179	72,253
97	72,328	72,403	72,477	72,552	72,626	72,701	72,775	72,850	72,925	72,999
98	73,074	73,148	73,223	73,297	73,372	73,447	73,521	73,596	73,670	73,745
99	73,819	73,894	73,968	74.043	74,118	74,192	74,267	74,341	74,416	74,490

TABLE FOR CONVERTING KILOWATTS INTO HORSEPOWER.

1 Kilowatt = 1.3411118 Horsepower.

Kw.	Additional Tenths of One Kilowatt.									
	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1	1.34	1.48	1.61	1.74	1.88	2.01	2.15	2.28	2.41	2.55
2	2.68	2.82	2.95	3.08	3.22	3.35	3.49	3.62	3.76	3.89
3	4.02	4.16	4.29	4.43	4.56	4.69	4.83	4.96	5.10	5.23
4	5.36	5.50	5.63	5.77	5.90	6.04	6.17	6.30	6.44	6.57
5	6.71	6.84	6.97	7.11	7.24	7.38	7.51	7.64	7.78	7.91
6	8.05	8.18	8.31	8.45	8.58	8.72	8.85	8.99	9.12	9.25
7	9.39	9.52	9.66	9.79	9.92	10.06	10.19	10.33	10.46	10.59
8	10.73	10.86	11.00	11.13	11.27	11.40	11.53	11.67	11.80	11.94
9	12.07	12.20	12.34	12.47	12.61	12.74	12.87	13.01	13.14	13.28
10	13.41	13.55	13.68	13.81	13.95	14.08	14.22	14.35	14.48	14.62
11	14.75	14.89	15.02	15.15	15.29	15.42	15.56	15.69	15.83	15.96
12	16.09	16.23	16.36	16.50	16.63	16.76	16.90	17.03	17.17	17.30
13	17.43	17.57	17.70	17.84	17.97	18.11	18.24	18.37	18.51	18.64
14	18.78	18.91	19.04	19.18	19.31	19.45	19.58	19.71	19.85	19.98
15	20.12	20.25	20.38	20.52	20.65	20.79	20.92	21.06	21.19	21.32
16	21.46	21.59	21.73	21.86	21.99	22.13	22.26	22.40	22.53	22.66
17	22.80	22.93	23.07	23.20	23.34	23.47	23.60	23.74	23.87	24.01
18	24.14	24.27	24.41	24.54	24.68	24.81	24.94	25.08	25.21	25.35
19	25.48	25.62	25.75	25.88	26.02	26.15	26.29	26.42	26.55	26.69
20	26.82	26.96	27.09	27.22	27.36	27.49	27.63	27.76	27.90	28.03
21	28.16	28.30	28.43	28.57	28.70	28.83	28.97	29.10	29.24	29.37
22	29.50	29.64	29.77	29.91	30.04	30.18	30.31	30.44	30.58	30.71
23	30.85	30.98	31.11	31.25	31.38	31.52	31.65	31.78	31.92	32.05
24	32.19	32.32	32.45	32.59	32.72	32.86	32.99	33.13	33.26	33.39
25	33.53	33.66	33.80	33.93	34.06	34.20	34.33	34.47	34.60	34.73
26	34.87	35.00	35.14	35.27	35.41	35.54	35.67	35.81	35.94	36.08
27	36.21	36.34	36.48	36.61	36.75	36.88	37.01	37.15	37.28	37.42
28	37.55	37.69	37.82	37.95	38.09	38.22	38.36	38.49	38.62	38.76
29	38.89	39.03	39.16	39.29	39.43	39.56	39.70	39.83	39.97	40.10
30	40.23	40.37	40.50	40.64	40.77	40.90	41.04	41.17	41.31	41.44
31	41.57	41.71	41.84	41.98	42.11	42.25	42.38	42.51	42.65	42.78
32	42.92	43.05	43.18	43.32	43.45	43.59	43.72	43.85	43.99	44.12
33	44.26	44.39	44.52	44.66	44.79	44.93	45.06	45.20	45.33	45.46
34	45.60	45.73	45.87	46.00	46.13	46.27	46.40	46.54	46.67	46.80
35	46.94	47.07	47.21	47.34	47.48	47.61	47.74	47.88	48.01	48.15
36	48.28	48.41	48.55	48.68	48.82	48.95	49.08	49.22	49.35	49.49
37	49.62	49.76	49.89	50.02	50.16	50.29	50.43	50.56	50.69	50.83
38	50.96	51.10	51.23	51.36	51.50	51.63	51.77	51.90	52.04	52.17
39	52.30	52.44	52.57	52.71	52.84	52.97	53.11	53.24	53.38	53.51
40	53.64	53.78	53.91	54.05	54.18	54.32	54.45	54.58	54.72	54.85
41	54.99	55.12	55.25	55.39	55.52	55.66	55.79	55.92	56.06	56.19
42	56.33	56.46	56.59	56.73	56.86	57.00	57.13	57.27	57.40	57.53
43	57.67	57.80	57.94	58.07	58.20	58.34	58.47	58.61	58.74	58.87
44	59.01	59.14	59.28	59.41	59.55	59.68	59.81	59.95	60.08	60.22
45	60.35	60.48	60.62	60.75	60.89	61.02	61.15	61.29	61.42	61.56
46	61.69	61.83	61.96	62.09	62.23	62.36	62.50	62.63	62.76	62.90
47	63.03	63.17	63.30	63.43	63.57	63.70	63.84	63.97	64.11	64.24
48	64.37	64.51	64.64	64.78	64.91	65.04	65.18	65.31	65.45	65.58
49	65.71	65.85	65.98	66.12	66.25	66.39	66.52	66.65	66.79	66.92
50	67.06	67.19	67.32	67.46	67.59	67.73	67.86	67.99	68.13	68.26
51	68.40	68.53	68.66	68.80	68.93	69.07	69.20	69.34	69.47	69.60
52	69.74	69.87	70.01	70.14	70.27	70.41	70.54	70.68	70.81	70.94
53	71.08	71.21	71.35	71.48	71.62	71.75	71.88	72.02	72.15	72.29
54	72.42	72.55	72.69	72.82	72.96	73.09	73.22	73.36	73.49	73.63
55	73.76	73.90	74.03	74.16	74.30	74.43	74.57	74.70	74.83	74.97
56	75.10	75.24	75.37	75.50	75.64	75.77	75.91	76.04	76.18	76.31
57	76.44	76.58	76.71	76.85	76.98	77.11	77.25	77.38	77.52	77.65
58	77.78	77.92	78.05	78.19	78.32	78.46	78.59	78.72	78.86	78.99
59	79.13	79.26	79.39	79.53	79.66	79.80	79.93	80.06	80.20	80.33
60	80.47	80.60	80.73	80.87	81.00	81.14	81.27	81.41	81.54	81.67
61	81.81	81.94	82.08	82.21	82.34	82.48	82.61	82.75	82.88	83.01
62	83.15	83.28	83.42	83.55	83.69	83.82	83.95	84.09	84.22	84.36
63	84.49	84.62	84.76	84.89	85.03	85.16	85.29	85.43	85.56	85.70
64	85.83	85.97	86.10	86.23	86.37	86.50	86.64	86.77	86.90	87.04
65	87.17	87.31	87.44	87.57	87.71	87.84	87.98	88.11	88.25	88.38
66	88.51	88.65	88.78	88.92	89.05	89.18	89.32	89.45	89.59	89.72
67	89.85	89.99	90.12	90.26	90.39	90.53	90.66	90.79	90.93	91.06
68	91.20	91.33	91.46	91.60	91.73	91.87	92.00	92.13	92.27	92.40
69	92.54	92.67	92.80	92.94	93.07	93.21	93.34	93.48	93.61	93.74
70	93.88	94.01	94.15	94.28	94.41	94.55	94.68	94.82	94.95	95.08
71	95.22	95.35	95.49	95.62	95.76	95.89	96.02	96.16	96.29	96.43
72	96.56	96.69	96.83	96.96	97.10	97.23	97.36	97.50	97.63	97.77
73	97.90	98.04	98.17	98.30	98.44	98.57	98.71	98.84	98.97	99.11
74	99.24	99.38	99.51	99.64	99.78	99.91	100.05	100.18	100.32	100.45
75	100.58	100.72	100.85	100.99	101.12	101.25	101.39	101.52	101.66	101.79
76	101.92	102.06	102.19	102.33	102.46	102.60	102.73	102.86	103.00	103.13
77	103.27	103.40	103.53	103.67	103.80	103.94	104.07	104.20	104.34	104.47
78	104.61	104.74	104.87	105.01	105.14	105.28	105.41	105.55	105.68	105.81
79	105.95	106.08	106.22	106.35	106.48	106.62	106.75	106.89	107.02	107.15
80	107.29	107.42	107.56	107.69	107.83	107.96	108.09	108.23	108.36	108.50
81	108.63	108.76	108.90	109.03	109.17	109.30	109.43	109.57	109.71	109.84
82	109.97	110.11	110.24	110.37	110.51	110.64	110.78	110.91	111.04	111.18
83	111 31	111.45	111.58	111.71	111.85	111.98	112.12	112.25	112.39	112.52
84	112.65	112.79	112.92	113.06	113.19	113.32	113.46	113.59	113.73	113.86
85	113.99	114.13	114.26	114.40	114.53	114.67	114.80	114.93	115.07	115.20
86	115.34	115.47	115.60	115.74	115.87	116.01	116.14	116.27	116.41	116.54
87	116.68	116.81	116.94	117.08	117.21	117.35	117.48	117.62	117.75	117.88
88	118.02	118.15	118.29	118.42	118.55	118.69	118.82	118.96	119.09	119.22
89	119.36	119.49	119.63	119.76	119.90	120.03	120.16	120.30	120.43	120.57
90	120.70	120.83	120.97	121.10	121.24	121.37	121.50	121.64	121.77	121.91
91	122.04	122.18	122.31	122.44	122.58	122.71	122.85	122.98	123.11	123.25
92	123.38	123.52	123.65	123.78	123.92	124.05	124.19	124.32	124.46	124.59
93	124.72	124.86	124.99	125.13	125.26	125.39	125.53	125.66	125.80	125.93
94	126.06	126.20	126.33	126.47	126.60	126.74	126.87	127.00	127.14	127.27
95	127.41	127.54	127.67	127.81	127.94	128.08	128.21	128.34	128.48	128.61
96	128.75	128.88	129.01	129.15	129.28	129.42	129.55	129.69	129.82	129.95
97	130.09	130.22	130.36	130.49	130.62	130.76	130.89	131.03	131.16	131 29
98	131.43	131.56	131.70	131.83	131.97	132.10	132.23	132.37	132.50	132.64
99	132.77	132.90	133.04	133.17	133.31	133.44	133.57	133.71	133.84	133.98

Horsepower and Kilowatts

One of the most frequent computations made in connection with electrical power-plant work is the conversion of kilowatts into horsepower, or the reverse. While the calculation is a very simple one, consisting of the division or multiplication of a given number by 746, it is sufficiently tedious to cause the average worker to use 750 watts as the horsepower equivalent in order to reduce the irksomeness of computation. In view of these well-known facts, the preparation of the labor-saving tables on the opposite page appeared to be worth while, and they are accordingly presented to our readers.

The exact equivalent of a horsepower is 745.65 watts, and this value has been used in computing the tables. While the equivalents in both tables are expressed in numbers of four and five figures, it is seldom advantageous to use more than three in ordinary practice.

By shifting the decimal point, the tables are applicable, of course, to numbers of any magnitude, and the "additional tenths" have been included to facilitate such applications and to insure the accuracy of conversions thus made. For example, the horsepower equivalent of 500 kilowatts could be easily determined by taking the equivalent of 50 kilowatts (67.06 horsepower) and moving the decimal point one figure to the right, giving 670.6 horsepower. But without the additional nine columns it would be much more troublesome to get at the equivalent of 5270 kilowatts, the procedure being thus:

5200 kilowatts = 100 × 69.74 H.P. = 6974	h.p.
70 kilowatts =	93.88 h.p.
5270 kilowatts =	7067.88 h.p.

With the additional columns, however, the desired equivalent can be taken directly from the table without any arithmetical work whatever. Thus, 527 kilowatts = 70.68 horsepower; hence, 5270 kilowatts = 7068 horsepower.

Sometimes it will be found more convenient to use one of the tables "backward" than the other one "forward." Thus, if 1215 horsepower is to be converted into kilowatts, the use of the horsepower-watts table would require two conversions and an addition, thus:

1200 horsepower =	894,800 watts
15 horsepower =	11,185 watts
1215 horsepower =	905,965 watts

or 906 kilowatts. By finding 121.5 in the body of the other table, the kilowatt equivalent is read directly. Thus, 121.5 is in line 90, column 0.6; its equivalent, therefore, is 90.6 kilowatts, and, consequently, 1215 horsepower = 906 kilowatts.

The tables are useful also in ascertaining the relation between motor output and intake and that between the output of a generator and the indicated engine horsepower required to drive it. For example, a 15-horsepower motor is of 90 per cent. efficiency; how many watts will it take from the supply circuit? From the horsepower-watts table, 15 horsepower = 11,185 watts, which would be the intake at 100 per cent. efficiency. At 90 per cent. the intake would be

$$11,185 \div 0.9 = 12,427.8$$

watts, or 12.43 kilowatts.

Again a motor delivering 18 brake horsepower takes 15,200 watts from the line; what is its efficiency? Referring to the horsepower-watts table, 18 horsepower = 13,422 watts. The intake being 15,200 watts, the efficiency is

$$\frac{13,422}{15,200} = 0.883,$$

or 88.3 per cent.

A generator is rated at 900 kilowatts and the combined efficiency of the machine and its engine is 84 per cent.; what will be the indicated horsepower at full load?

From the kilowatt-horsepower table, 900 kilowatts = 1207 horsepower, and $1207 \div 0.84 = 1436.9$ indicated horsepower.

Again, a motor delivering 18 brake generator shows 957 indicated horsepower when the generator is delivering 585 kilowatts; what is the combined efficiency of the outfit at that load? From the horsepower-watts table, 957 horsepower = 713,590 watts or 713.59 kilowatts. The efficiency, therefore, is

$$\frac{585}{713.59} = 0.8198,$$

or practically 82 per cent. In such a case, the division would be less tedious if the kilowatts were reduced to horsepower, because the divisor in the efficiency fraction will be 957 instead of 713.59. Thus:

585 kilowatts = 784.6 horsepower,

and

$$\frac{784.6}{957} = 0.8198,$$

or 82 per cent.

A 7-foot flywheel upon a Russell engine went to pieces the other day at the station of the Allegheny Valley Lighting Company, at Creighton, Penn., causing about $2000 worth of property damage, but no personal injuries.

Correction

In the article on "Some Useful Lessons of Limewater," last paragraph of the first column of page 692 of the April 13 number, there was an error. Instead of stating: "If you should carry this experiment of the gas bag farther you could mix one volume of hydrogen with two volumes of oxygen," etc., the volumes should be transposed, making it two of hydrogen and one of oxygen.

Catechism of Electricity

1025. *Is it generally necessary to use starting resistance in starting an induction motor?*

It is necessary with all single-phase motors and with polyphase motors required to start under considerable load. Small polyphase motors and large ones not required to start under load can be started by simply closing the supply-line switch, as in these the simple "squirrel-cage" form of rotor winding is sufficient. In the others it is necessary to modify the "squirrel-cage" type as explained in answer No. 1023 to permit the use of a starting resistance.

1026. *Explain the resemblance between the starting conditions of an induction motor and those of a shunt-wound direct-current motor when starting resistance is used.*

These types of motor behave very much alike. If the field and armature of a shunt-wound motor are both switched on the supply circuit at once, the armature, on account of its comparatively low resistance, takes a relatively large starting current and its magnetic reaction against the field cuts down the starting torque. The large starting current is, of course, lowered and the torque is increased as soon as the armature speeds up; but if, as is customary, a resistance is inserted in the armature circuit at the time of starting, the results are much more satisfactory. So in the case of an induction motor a resistance inserted in the rotor or armature circuit at the beginning enables the motor to receive its magnetizing current and start with a good high torque. As the motor speeds up, the starting resistance in the rotor or armature circuit is cut out, as in the case of a shunt-wound motor.

1027. *How is the alteration of the starting resistance made easy in many modern types of induction motors?*

By having the starting resistance mounted within the rotor. As the rotor speeds up after starting, a sliding collar on the shaft, actuated by means of a hand lever, cuts out the starting resistance and short circuits the rotor circuit.

1028. *What other common forms of starting devices are used?*

In some induction motors the starting resistance is separate from the machine and is introduced in the rotor circuit through "brushes" bearing upon collector rings to which the rotor winding is connected. A small single-pole, double-throw switch is used in this circuit and is closed in one direction to start and then thrown in the opposite direction after the motor has reached its normal speed. This switch is usually marked "Starting" and "Running" to designate the two operating positions. The switch should not be thrown from the "starting" to the "running" position until the armature has reached normal speed.

There is also an "oil-immersed" type of starting device which comprises a hand-

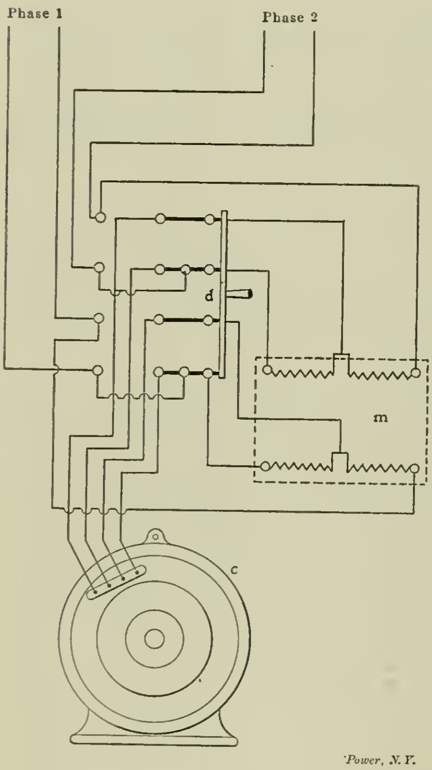


FIG. 287. ARRANGEMENT FOR STARTING A TWO-PHASE INDUCTION MOTOR AT LOW VOLTAGE

wheel or lever controlling a revolving type of switch which makes the required connections in proper sequence. The various positions of the switch are shown by an index plate which indicates the "starting," "running" and "stop" positions. The handwheel or lever of the switch should be moved slowly from the "starting" to the "running" position to allow the armature gradually to reach normal speed without an excessive rush of current through the machine. The switch should always be left either on the "running" or the "stop" position.

1036. *Is any special arrangement necessary for starting an induction motor on a lower voltage than the normal voltage?*

Step-down transformers are used for this purpose. For a two-phase motor they are connected as shown in Fig. 287. In starting, the four-pole switch *d* is closed to the right-hand contacts, which introduces the two step-down transformers at *m* in circuit. When the motor *c* is up to speed, the switch *d* is closed to the left-hand contacts. This cuts out the step-down transformers and applies the line voltage directly to the motor.

1037. *How should the step-down transformers be connected for starting a three-phase motor?*

It is advisable to use three transformers connected in "delta" through a three-pole switch, as represented in Fig. 288. As in the previous case *d* represents the switch, *m* the transformers and *c* the motor. If one transformer breaks down, it may be cut entirely out of circuit and the motor may be operated at a reduced load on the remaining two while the injured one is being repaired. In this case, the voltage of each transformer should be the same as the voltage from wire to wire of the line.

It is possible to install only two transformers to carry the full load of the motor, but in this case the capacity of each transformer must be 173 per cent. of the capacity of each of the three transformers when three are used; hence no great saving, if any, in first cost, and the certainty of a complete shutdown if one transformer breaks down.

1038. *What should be the capacity of the step-down transformers with respect to that of the induction motor?*

The total capacity of the transformers, in kilowatts, should equal the horsepower capacity of the motor.

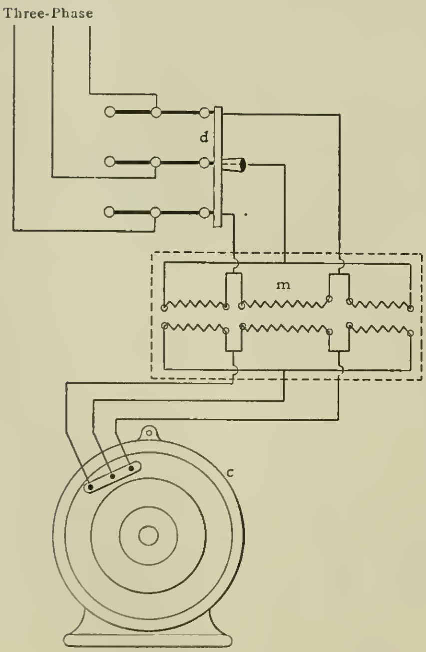


FIG. 288. ARRANGEMENT FOR STARTING A THREE-PHASE INDUCTION MOTOR AT LOW VOLTAGE

1039. *When is the resistance method of starting induction motors preferred to the low-voltage method?*

For work where a very large starting torque is required, as in elevator or hoisting work, the resistance method is always used. In factories where the motor starts only the shafting and the load comes on subsequently, the low-voltage method is satisfactory.

1040. *Is there any other method of starting an induction motor with a good torque?*

Yes, by lowering the frequency of the applied current; because with a reduced frequency there is not as great a slip at low speeds. This method is not as common as the other two because it is not possible to reduce the frequency received from the line. It can be employed, however, when two induction motors are used.

Polytechnic Institute Student Section of the A. S. M. E.

The Polytechnic Institute student section of the American Association of Mechanical Engineers held a regular monthly meeting in the Institute chapel Saturday evening, April 3. After the transaction of regular business, Prof. William D. Ennis, head of the mechanical-engineering department, introduced the speaker of the evening, Harrington Emerson, who talked on "Efficiency." He explained the wage systems in use in different shops and the results obtained. The main thing in an engineer's work, he said, is the ability to size up a new problem and apply old methods to its solution. Then he went on to say that efficiency is a moral, rather than an engineering question; its basis is that of the square deal; unless that principle prevails it is impossible to obtain high efficiency in any direction. Mr. Emerson gave as apropos a quotation from Ruskin: "Every man his chance, every man his certainty; certainty that if he does well he will be honored and advanced, and equal certainty that if he does ill, he will be judged and corrected, for the only thing of consequence is what we do." He ended by illustrating on the blackboard the relations between cost and profit as varied by efficiency.

Mr. Emerson was asked: "What is the practical result, in amount of wages received, of working under the ordinary piece-work system and under the bonus or efficiency system?" He replied that "it is always difficult to turn from piece work to bonus. In one plant I know of they put in the bonus system and paid for a certain piece of work $6. In another plant, using the piece-work system, a man did the same work at a cost of $12 to the company. In the latter shop they found by a time test that the man in question was earning $4.25 per day. They decided to abolish the piece-work system, give him $4.25 per day and a chance to make a bonus. The result was that he made a 20 per cent. bonus and cost his employers less than the $6 man mentioned."

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

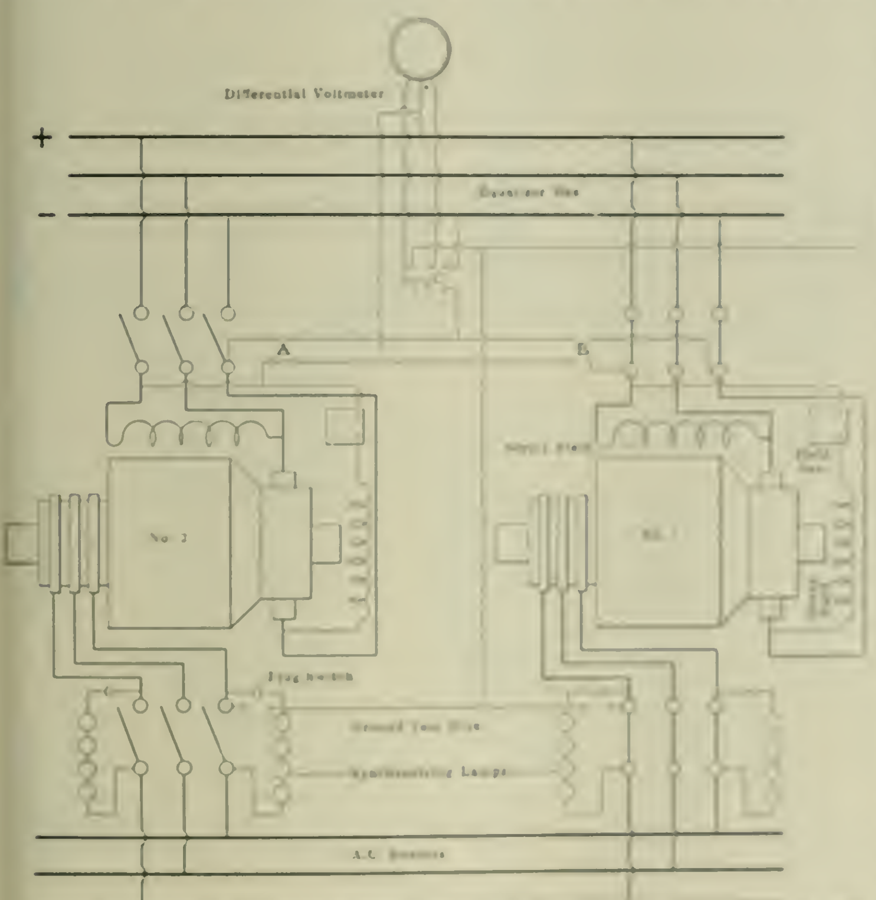
WE PAY FOR USEFUL IDEAS

A Peculiar Synchronizing Trouble

The accompanying sketch shows the connections of a rotary-converter installation which, under certain conditions, develops a peculiar state of affairs. In the actual installation there are three converters, but only two are shown in the sketch. The alternating-current voltage is [illegible] and the reactance coils (not shown) are between the converters and the alternating-current supply circuit.

There are voltmeter receptacles for connecting the differential voltmeter across the direct-current busbars or across the terminals of either machine. This voltmeter has a double scale, with the zero point in the center. If a double-fused plug is inserted at *C* the busbar voltage will be read, the indicator going onto the right-hand scale. If a double-fused plug is inserted at *A*, or *B* and *C* at the same time the voltmeter will register zero, due to the impulses in the two coils of the voltmeter being equal and opposite. It is understood that both machines are in operation when the two plugs are inserted.

If a single fused plug is placed in the proper position at *C*, the busbar voltage will be read. If the plug at *C* is reversed and a plug inserted at *A* or *B* the terminal voltage will be registered on the side opposite to the one which registered the busbar voltage. This last method is the one used, as the voltage of the incoming rotary may be read directly.



CONNECTION OF ROTARY-CONVERTER INSTALLATION

Let us suppose that Nos. 1 and 2 machines (the latter not shown) are operating, and No. 3 is to be brought to synchronism and connected to the alternating-current supply circuit. (The voltmeter plugs are all out.) If but one of the plug switches in the synchronizing lamp circuit is closed, the lamps on one side will blink, burning extremely bright when they come up. If plug *A* is removed there will be no synchronizing circuit until the second plug switch is closed, after which the lamps will behave in the usual manner because they will be operating under normal conditions.

With plug *A* in place and with one or both plug switches closed, the lamps will blink as though indicating synchronism, but will burn with dazzling brilliancy when at their brightest, showing the lamps to be burning above their normal voltage.

In synchronizing it is the practice to remove plug *A* before connecting the machine to the alternating-current circuit, but in one instance plug *C* was removed instead, and when the machine was "thrown in" a display of fireworks resulted, plug *A* being burned up, the switchboard blackened for a space of 18 inches around the receptacle and machines 1 and 2 burned in the connections from the busbars.

Why do the lamps on one side burn with but one synchronizing plug switch closed? Why do they "blink" under this condition, and why did plug *A* burn when the machine was connected to the alternating-current circuit?

C. L. [illegible]

[illegible], Texas.

What Will Happen if the Belt Breaks?

One plant consists of two [illegible]-kilowatt alternating-current and two [illegible]-kilowatt direct-current generators. The alternators are direct-connected to two [illegible] Fleming four-valve engines and are arranged for parallel operation. The exciters are driven by belts from pulleys on the ends of the engine shaft and are not arranged for parallel operation; that is, each alternator drives its own exciter.

Suppose I have the alternating-current machines in parallel, coupled through main switches, and one of the belts were to break or slip off, what effect would it have on the alternating-current generator whose belt was broken while it is still coupled to the other machine through the main generator switch?

H. H. [illegible]

[illegible], Ga.

Blowoff Valves

I have had splendid success with wedge gate valves, as the wedges can be taken out and ground true with a piece of oiled sandpaper placed on a perfectly flat surface.

My rule is to have two valves and always to open the outside valve first and close it last, using the inside valves to cut off the pressure. In this way the outside valve is blown free from scale and can seat firmly.

LEWIS L. SCHEIDERER.

Marysville, O.

Probable Cause of Air Compressor Explosions

I can hardly agree with Frank Richards in his criticism of F. W. Holman's letter on "Probable Cause of Air Compressor Explosions." I think Mr. Holman is nearly right in assigning leaky discharge valves as a possible cause. Everybody knows that when a volume of air is forced through a passage it generates heat, and there is no other place about an air-compressor plant that generates more heat than where the air passes through the discharge valves.

Leaky discharge valves and lack of sufficient radiation will undoubtedly cause the air to reach an abnormally high temperature in a very short time.

I think Mr. Richards is wrong when he says: "This air which has leaked back becomes an inseparable part of the cylinderful, and when the mass is compressed and discharged it is carried along together, and no portion of it can be isolated, and worked back and forth, as assumed, to have its temperature cumulatively augmented."

As Mr. Richards does not state whether the compressor has mechanically driven intake valves, I assume it has not. No air will pass into the cylinder until the pressure has equalized and fallen below atmospheric pressure. If on account of leaky discharge valves the intake, or suction, valve on that end does not lift, is it not an evident fact that as the piston moves back and forth there is a continual displacement, or churning of air going on? One way a leaky discharge valve can be detected is by the abnormally high temperature on the leaky end.

If the compressor has a Corliss, or any kind of driven intake valve, it would be impossible to maintain, or even raise, any pressure in the system, for while the intake valve would be open to receive air, the discharge valve remaining open at the same time, the air would have a free passage to the atmosphere.

Mr. Richards is undoubtedly right in stating that oil will burn bodily in the pipes and system, and that this combustion is frequently going on without our knowledge.

One main fault which should be overcome is the tendency of operators having charge of air compressors to place too much oil in the air cylinder. An air cylinder needs some lubrication, but if only enough oil were admitted properly to lubricate it, I am sure we would never hear of explosions. It is surprising what a small amount of oil is actually required in an air cylinder and what a large amount is frequently used. Oil entering an air cylinder does not become atomized and held in suspension, neither is it washed away by cylinder condensation; but it remains on the cylinder walls until worn away. It acts as a lubricant the same as engine oil on the guides of an engine; but only a good quality of pure mineral oil of a high fire test, say 600 degrees Fahrenheit, should be used. This warning is, of course, needless to nearly everyone who has charge of compressors.

Graphite has of late thoroughly proved itself an ideal lubricant for air cylinders. I gave one of the compressors in the plant I have charge of a thorough test with graphite, using only a very small amount of oil, merely to hold the graphite together until it reached the cylinder. This machine is used to furnish air to lift water out of driven wells, and during a recent dry spell it was run from the middle of April until the first of October, twenty-four hours per day, and was never stopped, except to adjust wearing parts, repack, etc. The cylinder head was taken off several times and its condition noted, and at the end of the season the cylinder walls had attained a deep, black polish, with a coating that absolutely resists any wear. But graphite, as oil, must be used sparingly, and the longer it is used the less must be used, as very little of it passes beyond the cylinder, but remains and forms an almost nonwearing coating.

W. E. TURNER.

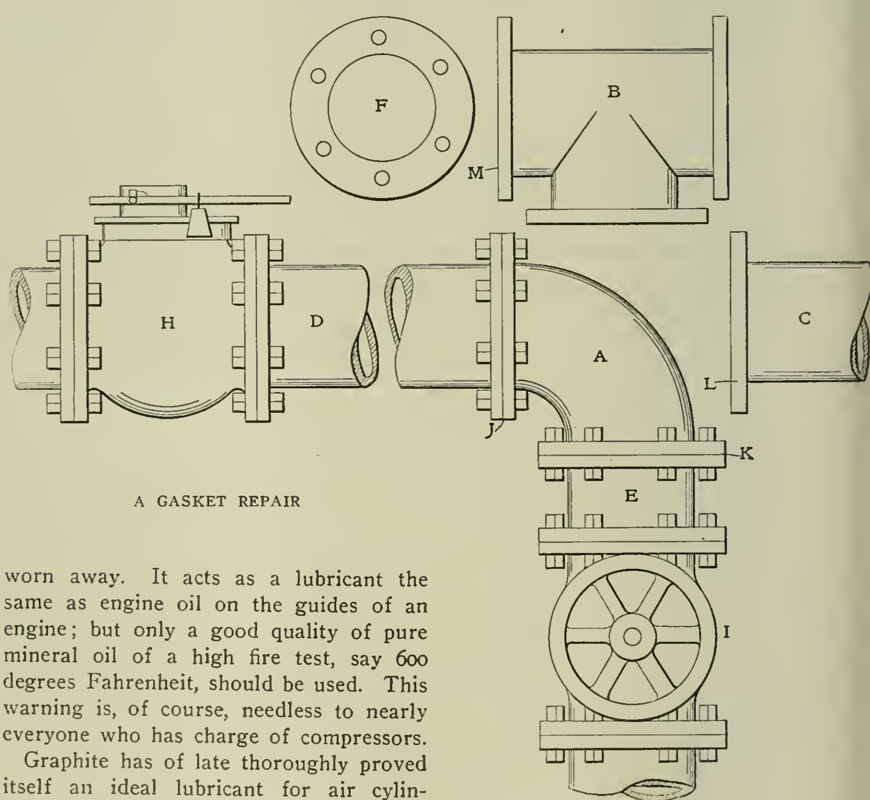
Wilmington, Ohio.

A Gasket Repair Job

I was once employed in a plant where it was necessary to replace the ell at *A* (see illustration) in a 16-inch header, with a tee to receive the exhaust from a new engine. The plant had to run night and day and could not be shut down while we made the change.

The valve *I* leading to the heating system was closed and the exhaust from the engines turned to the atmosphere through the atmospheric valve *H*. We procured a piece of 1/16-inch sheet iron and cut a disk *F* of the same diameter as the flange at the joint *J*.

Holes ¼ inch in diameter were drilled



A GASKET REPAIR

in the disk to coincide with the holes in the flange, and a rubber gasket was glued to one side of it. The other side of the gasket was painted with oil and graphite to keep it from sticking to the flange *J*.

The joint *A* was broken and sprung apart a little. The gasket, being of copper, dropped out and the disk *F* was put in with the gasket next to the flange *J*. The disk was then bolted to the flange with small bolts, the heads of which were small enough to pass through the holes in the flange of the ell *A*, and washers were used under the nuts on the other end. The joint *K* was broken and the ell taken out. The tee *B* was put in place and the joints *K* and *L* made up tight. The small bolts holding the disk were then removed and the disk and gasket pushed out. The tee, having had a gasket glued to its flange *M* was sprung against the flange *J*, the bolts put in and drawn up and the job was complete.

RAY L. RAYBURN.

Decatur, Ill.

Keeping Plant Records

Having noticed, from time to time, the methods used by different engineers in keeping plant records, I submit our system. Hourly readings are taken of the load in amperes and marked in the space for the generator or generators that are running; also, the boiler pressures in the same way, checked up with a recording steam gage. The time of starting and stopping and length of run of each engine are recorded, and the time boilers are cut in or out and the fires are cleaned. The temperature of the feed water before and after passing through the rubbish furnace is also recorded.

This furnace is used for burning waste paper, straw and wood collected during the day. The feed water, as it goes to the boiler, is pumped through two coils, one used as a grate and the other over the fire. By this arrangement the feed water is brought up to 260 degrees or over. Exhaust steam is used on the heating system, and space is provided for recording the back pressure on this system.

We have no way of weighing our coal at present, but coal is measured in a box holding 20 cubic feet. This box has no bottom, is placed on the boiler-room floor and filled even with the top. Then it is lifted, leaving the coal in front of the boiler. The number of boxes used during a run is recorded, also the number used between runs. Coal is weighed once a week in a box holding just 1 cubic foot, to check up the weight of the different lots of coal.

All feed water passes through a meter which is read at the beginning and end of a run. With the meter readings, the temperature of the feed water and the weight of the coal by measure, and the amount of water evaporated per pound of coal can be figured, thus giving an approximate test on the boilers every day.

Another meter is provided for any new water that is used for boiler feed, which in the winter months amounts to very little, as the returns from the heating system are used over. On the opposite side of the card are recorded the cost and output for the day. Wattmeters are read at the end of a run; the cost of supply and labor for the day are kept, and fixed charges, such as depreciation, insurance, rent of space occupied by plant, interest on investment, etc., are added. With the output and cost with and without fixed charges the cost per kilowatt-hour is easily ascertained.

The weather report is posted in the space. This has been found very useful in comparing one month with another, as to cloudiness, which would account for a heavier or lighter load; also, the temperature, which would account for more steam for heating purposes.

Ashes are recorded by the cans, and are removed at a fixed cost per can. At the end of each month a typewritten report is made out as to the amount of coal on hand the first of the month, the amount received, the amount used and the balance.

The amount of water used for the month as per meter for new water, the output for each recording wattmeter, the number of hours each engine has run and the number of hours each boiler was under steam are recorded.

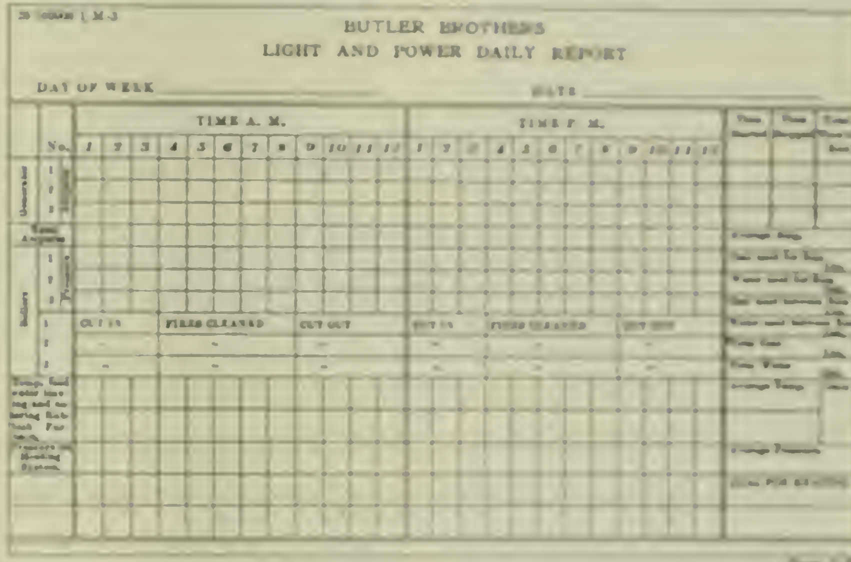
The temperature of the feed water before and after entering the rubbish furnace, showing the gain in degrees and allowing 10 degrees for 1 per cent. saving in coal, and the percentage of coal saved by using rubbish furnace are followed by the cost of coal, water, labor, oil, grease, waste, packing, repairs, etc., to which are added the fixed charges. From this is figured the cost per kilowatt-hour, with and without fixed charges for the month.

During the winter the number of hours the heating system was on and the average pressure are recorded. A monthly report of the weather is attached to the report.

This system has been found very useful in comparing the cost of running the plant from month to month or year to year, and several improvements and changes have been made as the result of these records, which have reduced the cost of operation and cost per kilowatt-hour considerably.

CHARLES W. [illegible]

Jersey City, N. J.



OBVERSE SIDE OF DAILY REPORT

REVERSE SIDE OF DAILY REPORT

The accompanying record is a copy of that of January 1, 1909, and I fill in a blank like this every day. I do not [illegible] it to be as accurate as if I had [illegible] cording instruments, but it is accurate enough for me, and it is very little trouble for one of the men to fill in the reports every hour. Each day I strike an average and put the results in a book, and at the end of the month I do the same again; thus I can look back to any month and know just what was done, and can tell very closely the number of kilowatts generated and the number of hours each machine has run, how much ice it has made, also the supplies used. I weigh all coal as it is brought to the boiler room, and also keep an expense sheet showing the cost and time of purchase of all supplies, and where used.

William A. Hardin.

Atlantic City, N. J.

ROYAL PALACE HOTEL — CHIEF ENGINEER'S REPORT — JANUARY 1, 1909.

	A. M.											
	1	2	3	4	5	6	7	8	9	10	11	12
Steam	85	85	80	85	85	85	80	80	85	85	80	80
Amp.	530	500	300	200	180	200	250	300	200	200	200	175
Volts	110	112	110	112	112	112	110	110	110	110	110	110
No. 1 dynamo												
No. 2 dynamo			off									
Ice machine	on											
R.p.m.	50	50	50	50	50	50	50	50	60	60	60	60
Head pressure	170	170	170	170	150	170	165	175	160	160	155	170
Back pressure	18	18	18	18	16	16	17	15	18	18	18	17
Brine temp.	16	15	14	13	12	11	11	11	8	8	10	10
Salt water temp.	200	200	200	200	200	200	200	200	190	195	200	180
Fresh water temp	210	210	210	208	206	208	200	200	200	210	208	210
Feed water temp.	190	192	194	190	180	186	200	200	200	208	200	200

	P. M.											
	1	2	3	4	5	6	7	8	9	10	11	12
Steam	85	80	75	80	80	85	85	85	80	80	80	85
Amp.	110	110	210	200	475	550	620	560	500	450	450	360
Volts	111	110	110	110	112	112	110	110	110	111	110	110
No. 1 dynamo	off					on						
No. 2 dynamo	on											off
Ice machine						off						on
R.p.m.	60	60	60	60	50	50						60
Head pressure	165	155	160	155	155	145						180
Back pressure	18	17	15	15	15	15						21
Brine temp.	10	10	10	10	10	10	12	15	17	18	19	20
Salt water temp.	200	208	210	208	206	200	200	206	200	200	200	200
Fresh water temp	210	200	200	210	210	210	208	206	206	208	200	200
Feed water temp.	200	196	196	200	190	200	190	196	200	200	190	190

Ice pulled, 30 100-pound cakes.	Engine oil........	Cylinder oil........	Ammonia oil, ½ gallon.

Remarks:

Safety Valves

Regarding the recent discussion of this subject before the American Society of Mechanical Engineers, in my opinion the proposed rule for areas of safety valves should include a term for a fixed lift rather than a variable one, for the reason that with the latter would result a hopeless confusion of safety-valve openings in boilers of the same size. Thus, under Mr. Darling's rule a boiler of a certain size might be provided with a safety-valve connection varying from 2½ to 4 inches in diameter, depending upon the make of valve specified. It would be far more convenient and satisfactory to standardize the safety-valve connections so that any valve, having the capacity required, could be used. To do this it would be necessary that the valves themselves be standardized within certain set limits and this could be done only by a body of disinterested and capable engineers, properly authorized to investigate the subject from a universal standpoint.

What is the proper lift is a more or less debatable question, but it is reasonable to suppose that the average practice of the leading, reliable manufacturers, disregarding the minimum and maximum extremes, is very nearly correct. Considering the elements of design of the various parts, closeness of adjustment, smooth popping and closing action and rate of discharge, a properly constructed valve will work better at a certain lift than at any other. High-lift valves are certainly no improvement nor are they necessary for general purposes. If they were, the standard designs could be very easily altered with but little expense and manufacturers would not be slow in making the necessary changes.

If the lift is too high the seats and spring bearings are subject to a severe pounding action; there is more danger of chattering; close adjustment is not possible; there is danger of lifting of water and the boiler seams are sometimes strained to the opening point.

On the other hand, with a correctly designed valve having a reasonable lift the wearing effects and the dangers are reduced to a minimum; it is capable of very close and accurate adjustment and its action is smooth and reliable.

Having determined what is the proper lift, it becomes a very simple matter to formulate the rule governing safety-valve discharge areas or seat-opening diameters. The only thing remaining would then be to determine what variation there should be in valve sizes to suit various pressures.

Jerome J. Aull.

Cincinnati, O.

In connection with some special work, it was desirable to have reasonably accurate data on the relieving capacities of pop safety valves of various sizes. Kent's "Pocketbook" was naturally turned to, but the 1900 edition had few accurate data. Next, publications emanating from well known insurance companies were examined, and again the data were incomplete. Finally, the rules and regulations of the United States Board of Supervising Inspectors were searched, and as usual nothing was found but generalities and a long list of approved makes of pop safety valve. This was discouraging, as it would naturally be assumed that a safety appliance as extensively used as a pop safety valve would have been most minutely tested by both the United States Government and insurance interests before approving for general use.

As the writer understands it, the primary function of any safety valve is to open at a predetermined pressure and to have a relieving capacity sufficient to handle the maximum amount of steam that the boiler to which it is attached can generate. The promptness with which these functions are performed is a measure of its value as a safety appliance. The durability of the valve in service is a matter of proper mechanical design and the use of the best materials and workmanship.

That the pop safety valve has not long since been thoroughly investigated is surprising, especially when the large amounts of time and money expended in researches having no other possibilities than small gains in operating economy are considered. Economy merits much attention, but should not safety receive equal consideration? Upon what proper data do the United States Board of Supervising Inspectors and the boiler-insurance companies approve of such a long list of pop safety valves? A careful examination of the construction of the various types shows that there must be wide differences in their relieving capacities, size for size, and yet the most diligent search of the United States rules did not show any suggestion that the officially approved valves were widely different in this respect.

In an official publication like the United States rules, the reader naturally assumes that approval, without qualification or specific classification, indicates that the approved fittings are of equal reliability and of substantially similar merit. That such is not the case will be evident to any experienced engineer examining the various constructions.

It would therefore seem that it is incumbent on the Government and the insurance companies (since approval by these authorities is almost mandatory) either to make or to have made by competent engineers complete qualitative and quantitative tests on all approved pop safety valves, and to insist that all new designs shall be similarly tested before approval. Quantitative tests should be made at specified standard pressures to show the relieving capacity in pounds of steam per hour which a particular valve will have at the specified pressures. The tests must be sufficiently comprehensive to determine the relation between the relieving capacity and pressure for each standard size of the approved types, and the experimental results could be set out in empirical formulas applying to each make of valve.

For such formulas the basis is clearly indicated in Kent's "Pocketbook" and involves the circumference of the opening, the form of the discharge passages, reaction, and other constants peculiar to each design. The diagram of relieving capacities at various pressures should consist practically of a series of straight lines having their origin at the zero of absolute pressure. The main experimental work would consist of actual determinations of the relieving capacities at 100, 150 and 200 pounds, and interpolating for intermediate pressures.

In order that the users of pop safety valves, as well as the insurers and inspectors, shall profit by these researches, it could be made obligatory on the part of every manufacturer of pop safety valves permanently to stamp on every valve the relieving capacity at some standard pressure or at the pressure for which it is set. This would place the user in position to specify the relieving capacity at a particular pressure and select his valves on a basis of mechanical design and construction.

At present, it is apparently the practice of boiler manufacturers to make term contracts for safety valves with some manufacturer of approved reputation. With the generality of manufacturers, this means that strictly commercial considerations determine the make of valve to be furnished on the boiler contracts and unless the purchaser very carefully specifies and vigorously insists on the highest quality of valves, an approved valve of inferior grade is supplied.

In view of the commercialism which largely rules, this subject should be taken up and aggressively handled by the great arbiters of safety appliances, namely, the United States Government and the insurance companies.

G. E. Weber

Williamsport, Penn

Knock in an Engine

In reply to J. W. Bryant regarding the knock in his engine, I had the same experience and found that the trouble was in the bull ring, which had about 1-32 inch play. I turned off the follower head to a better fit and the knock was gone.

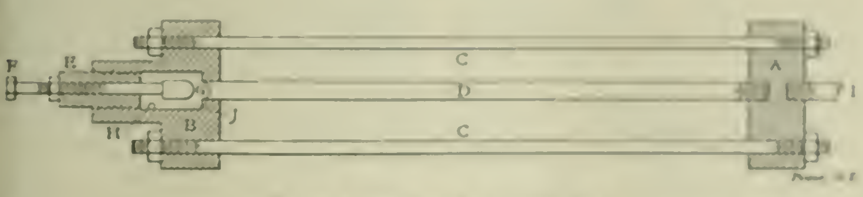
G. W. Gresham

Marietta, Ga.

A Steam Saver

In one of the plants in which I was engineer, several heating coils were connected to the high-pressure steam line and located in such position that it was impossible to connect them to the return line. They were, therefore, allowed to drip outside.

It was decided to make several "steam savers," in the following manner, the expansion and contraction of our iron pipe being the principle involved in the operation:



A "STEAM SAVER" FOR HEATING COILS

The two castings A and B (see sketch) are held at a fixed distance apart by the two 3/4 inch rods C C, which are about 5 feet long and about 8 inches apart. Between these rods is a piece of common iron pipe D, threaded and screwed tight into the casting A. The other end is turned smooth and is a loose fit in the block B, the end being seated at an angle of 45 degrees.

The block B is drilled and threaded to receive the brass plug E, tapped for the valve stem F, which adjusts the valve F to the seat G and is ground to a good fit. A hole at H connecting with the chamber J is threaded for a 1/4 inch pipe to carry away the discharge from the trap. The heater is connected at I and is set with the valve end a little lower than the other end.

To put in operation, screw the valve away from the seat and let steam blow through until the pipe is hot, then set up on the valve until seated, then fasten with the locknut. When the pipe gets full of condensed steam it will contract enough to open the valve and let the water out, but as soon as it begins to warm up it will expand and check the flow.

The valve and seat can be examined without disturbing the adjustment by taking out the plug E, and when once set the valve will not need any attention for a long time.

J. C. Hawkins

Hong, O.

Boiler as a Water Supply Tank

Under the above heading recently, A. J. Dixon describes a water system designed for a hotel plant by an inexperienced technical graduate. That he is inexperienced can easily be seen, and that he is woefully shy on technical knowledge is also manifest.

A much more economical plan would be to place an open tank in the attic, if possible, to be supplied by the house pumps. The water level in the tank could be kept nearly constant by a float operating a current switch at the pump motor. By this plan a much more uniform pressure would be maintained on the house service, and unless the building were a high one the head would be much less than 80 pounds. If the water supply from the pumps were shut off for some time the water in the tank would continue the supply for some time, which could not be done with a pressure tank.

Norman Campbell

Detroit, Mich.

Compound Engines

In a recent contribution C. L. Hansen says I produced indicator diagrams to prove that a compound engine develops twice the horsepower that a simple engine does. I may have a wrong idea of compound engines, but neither Mr. Hansen nor anyone else has proved otherwise.

Mr. Hansen says that the data I furnished only showed that I had the work nearly equally divided between the high- and low-pressure cylinders. That is true, but suppose these diagrams show 100 horsepower in the high-pressure cylinder and 100 horsepower, or nearly so, in the low-pressure cylinder; we have a 200-horsepower engine, do we not? Suppose we remove the low-pressure cylinder, do we still have a 200-horsepower engine?

It is certainly cheaper to build a 200-horsepower simple engine than a 100-horsepower compound, but if a compound can be made to do twice the work of a simple engine is it not more economical than a simple engine whether running condensing or noncondensing?

I have learned that in order to increase the power of an engine one should either raise the boiler pressure, speed the engine up, enlarge the cylinder, or compound by adding a low-pressure cylinder.

G. W. Hanson

Lexington, Neb.

Follower Plate and Bolts Broke

When our 20x36-inch Corliss compound engine was started one morning there was an unusual click in the high-pressure cylinder. We did not shut down, however, but on the morning of the third day the click was more noticeable than ever. About 10 o'clock it knocked so hard that we shut down and taking the cylinder head off, found that the follower bolt had broken off and dropped down into the exhaust-valve port. The valve bracket was broken and the valve stem twisted about half a turn. The bracket was patched and the valve stem turned up and replaced.

The engine ran well for a week, when one day, as the chief was shutting down, another bolt broke. Taking off the cover we found that the follower plate and one bolt were broken, the piston rod bent and the cylinder out of true.

Repairs were made, but we never found out what broke the bolts and follower plate.

F. L. Ferguson.

Adams, Mass.

Puzzling Transformer Action

In reply to E. L. Mason's "Puzzling Transformer Action" in a recent number, I think the iron in the transformer must be working at a low value, and when the switch is in the down or bucking position the transformer works in a reverse condition; that is, the secondary or series winding produces enough flux to induce a higher voltage in the primary winding of transformer *C* than is upon the terminals of the constant-current transformer *A*, thereby raising the line voltage as stated.

By having the primary connected on the load side of the line as shown in the diagram, I should think there was enough phase displacement between primary and secondary to disturb the operating of the line. I advise Mr. Mason to try the primary connected to the power or left-hand side shown in his diagram of connections.

L. Earle Brown.

Ensley, Ala.

I think Mr. Mason has not considered the choking action of the secondary winding of his potential transformer when the switch at *D* is open.

I believe his transformer "bucks" all right, but it "bucks" more when one winding is open. If he provides a switch for cutting out the other winding of the transformer *C* when the switch at *D* is open, he will get the results he is after.

F. W. Cerney.

Mesa, Ariz.

I should say that the only thing wrong with the connection is that the primary of the boosting transformer is connected to the boosted side of the line.

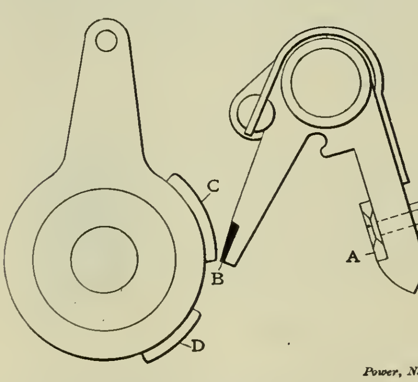
This should not be, as the voltage supplied to the primary has no stability only under certain conditions. I would advise that the primary of the booster transformer be connected to the line between the load transformer and the coil which is in series with the line. Then the voltage supplied to the primary will be practically constant and will not be affected by the lowering or raising of the voltage. Under this condition the results desired can be obtained.

James E. Kilroy.

Lincoln Place, Penn.

Safety Cams

The writer has seen a number of engines on which the steel toe *B* (see sketch) had become worn down as shown. In one instance the engineer shortened the regulator rod to get the desired trip by bringing down the steel *C* nearer to *B*, but throwing the safety trip *D* out of its



ILLUSTRATING SAFETY-CAM WEAR

reach. In case the regulator stop is out and the belt should break under such conditions, away goes the engine at full stroke.

This was once the case in my present plant. To demonstrate the fact, I left the stop out when shutting down one day, with neither steam valve unhooked.

There is also another way of throwing the back trip *D* out of place. In the erecting shop the engine valves are set, and wristplate marked, showing the throw of the eccentric. Then the wristplate is set on its center mark and, according to the diameter of the cylinder, is given the desired lap, which places the eccentric about 135 degrees ahead of the crank when on its dead center. This setting will give a square corner at the closure, and a very late opening for the exhaust.

The engineer will want compression, and the more he rolls the eccentric ahead the more lap he gives the steam valves and the more he throws the safety trip *D* back, making it impossible to unhook should the belt break.

John Tryon.

Lynchburg, Va.

Boiler and Furnace Construction

Those who have made boiler making a separate branch of manufacture have given too much attention to mere relative proportions. One maker places reliance on enlarged grate surface, another on large heating surface, while another demands boiler room enough without, however, explaining what that means.

Among modern treatises on boiler construction this principle of room enough seems to have absorbed all other considerations and the requisites in general terms are summed up as sufficient amount of heating surface, sufficient steam room, sufficient air space between grate bars, sufficient area in tubes and flues and sufficient large grate surface; or, in simple terms, this amounts to saying: "Give sufficient size to all parts and you will not be deficient in any." With reference to the several parts of a furnace, there are two points requiring attention, namely, the superficial area of the grate for retaining the fuel, and the sectional area of the chamber above the fuel for receiving the gaseous portion of the coal.

As to the area of grate bars, seeing that a solid is laid on them requiring no more space than it actually covers at a given depth, it is important that the area be not too large. As to the area of the chamber above the coal, seeing it is occupied by a gaseous body requiring room for its rapidly enlarging volume, it is important that it is not too small.

As to the area of grate bars, seeing grate, this will be easy to adjust, as a little observation will soon enable the engineer to determine the extent to which he may increase or diminish the length or width of the furnace. In this respect the great object consists in confining the length within such limits that at all times it will be uniformly covered. This is the absolute and only way to get economy and efficiency, yet it is the very condition which in practice is most neglected. Indeed, the failure and uncertainty which has attended most anxiously conducted experiments has most frequently arisen from neglect of this one condition. If the grate bars are not properly covered the air will enter in irregular currents through the uncovered parts. Such a state at once bids defiance to all regulation or control.

Now, on the control of the supply of air depends all that human skill can do in effecting perfect combustion and economy, and until the supply of fuel and the quantity on the grates are regulated it will be impossible to control the admission of air. In most boilers the furnace area is invariably made too shallow. The proportions allowed are indeed so limited as to give it rather the character of a large flue or tube, whose only function is to allow the combustible gases to pass through it, rather than that of a chamber in which a series of consecutive chemical processes are to be conducted. Such furnaces, by their diminished areas also have the injurious tendency that they increase the already too great rapidity of the current through them.

Constructing the furnace chamber so shallow and with such small capacity appears to have arisen from the idea that the nearer the body to be heated was brought to the firebed the greater quantity of heat would be imparted. This is, no doubt, true when we present a body to be heated in front of a fire. When, however, the approach of the colder body will have the direct effect of interfering with the process of nature, as in gaseous combustion, absolute contact with flame should be avoided where the object is to obtain all the heat which would be produced by the combustion of the entire constituents of the fuel. So much, however, has the supposed value of the near approach and even impact prevailed that the space behind the bridgewall is frequently made but a few inches deep and called the flame bed. Broader views have shown that it should be made capacious and the impact of the flame avoided. In general, it may be stated that the depth between the top of the grate bars and the shell of the boiler should not be less than 30 inches where the grates are 4 feet long, and increased in the same ratio where the length is greater.

JOHN COOK

Springfield, Ill.

Increase of Salary

As to the engineer being justified in asking for an increase in salary, depends on more than one thing. If his "boss" is the manager or superintendent, and responsible to men higher up, one reason may be that he wants all the credit for the saving due to the paying of a smaller salary, and the saving made by the engineer. In such case the man above the engineer is getting the credit, which will make him that much more solid with his "boss," when it should go to the engineer, who will never get an increase until he asks for it.

Perhaps another reason why he does not get a raise is that the "boss" realizes that he is saving him $30 per week over his former engineer, but in doing so he is letting his plant run down so that when the crash does come the cost of repairs will equal or more than equal that which is being saved at present.

NORMAN S. CAMPBELL.

Detroit, Mich.

If an engineer saves his employer $50 per week and the employer does not offer to raise his salary, it is time they had a heart-to-heart talk about the matter.

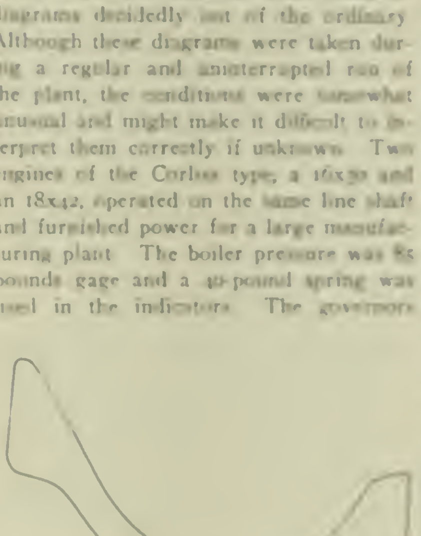
Excessive modesty in this matter of salary is not good for one's purse. It is well, also, to be prepared to tell the "boss" he can get another man for the place if he does not come up with the cash. Have your eye on another job before you bring the matter to a test, however.

F. W. CRAY.

Mesa, Ariz.

Peculiar Indicator Diagrams

The writer was called upon to test a power plant and obtained some indicator diagrams decidedly out of the ordinary. Although these diagrams were taken during a regular and uninterrupted run of the plant, the conditions were somewhat unusual and might make it difficult to interpret them correctly if unknown. Two engines of the Corliss type, a 16x30 and an 18x42, operated on the same line shaft and furnished power for a large manufacturing plant. The boiler pressure was 85 pounds gage and a 40-pound spring was used in the indicators. The governors



EXTRAORDINARY DIAGRAMS

were found to be so adjusted that nearly the whole of the load was carried by the larger engine, which gave fairly good diagrams, cutting off under normal conditions at about 0.4 stroke. The corresponding diagrams from the small engine were similar to and only a trifle smaller than the right-hand or crank-end diagram shown in the illustration. It was only under extremely heavy loads, with the large engines taking steam for practically full stroke, that the small engine began to pick up its load.

A number of diagrams were taken under the normal conditions described and everything was running smoothly when the writer was called away from the engine room. Returning a half hour later he found the small engine giving unmistakable signals of distress. Diagrams were taken with the result shown in the illustration. This led to an investigation of the exhaust valve and it was found that the key had dropped out of the valve stem. After a hurried search the engineer found the key under the cylinder and replaced it with the engine running, to the satisfaction, and all was well, or at least, as well as before.

These diagrams were, of course, only possible on account of the fact that the small engine was driven by the larger during the time of the trouble. It will be noted that the entire area of the head end is negative, representing work done by the piston upon the steam instead of work done by the steam upon the piston, and that this negative area is equal to or slightly greater than the positive area at the crank end. When one notes the pressure in the cylinder during compression it is not surprising that an engine that was generally run down should, to the best of its ability, express its resentment of such treatment.

Perhaps the most peculiar feature of the diagrams is the fact that the compression line is above the admission and expansion lines for the entire length. A very serious amount of leakage by the admission valve seems to be the only way of accounting for this.

H. M. PHILLIPS.

Pittsburg, Penn.

Architects and Heating Systems

While modern practice calls for the mechanical equipment of large office buildings and hotels, especially where independent lighting plants are included, to be designed and supervised by a firm of consulting engineers, or architects having engineers in their employ, many small installations, principally heating systems, are looked after by the architects themselves.

Many architects issue specifications of machinery which has long been standardized, without troubling to ascertain if the particular parts required conform to the manufacturer's standard. For instance, a case which came to the writer's notice a few days ago, and which was primarily responsible for this letter, was that of a firm of architects who were required to provide two boilers for a low-pressure heating system, in which the maximum pressure should never exceed 15 pounds per square inch. The specifications, besides calling for an odd-size boiler, called for a certain thickness of shell plate, which exceeded by 1/8 of an inch the thickness of the shell of a standard power boiler designed with a safety factor of 5 for a working pressure of 100 pounds per square inch.

It is not enough to know theoretically what amount of heating surface or evaporative power a boiler should have, or the amount of water a pump must deliver and the head it must deliver against, and then specify any size to fit the work, whether it be standard or not. Ought not architects who are drawing up specifications for the machinery acquaint themselves with the common standard to which these machines are manufactured, and specify one which would permit of a manufacturer quoting on his standard article, and on which he could be of assistance after quicker delivery and lower price?

Of course there are cases where, owing to conditions beyond the architect's control, a standard pump, boiler or whatever machinery is wanted cannot be installed; but then, and only then, should the architect depart from standard lines and specify special machinery.

N. H. Ballow.

Toronto, Ont.

Burning Slack Coal

The following facts were brought out in recent tests of water-tube boilers with Arkansas slack, which has a calorific value in the neighborhood of 12,000 B.t.u., and for the most part contains no lumps, although occasionally about 5 per cent. of a carload will consist of lumps the size of nut coal.

The grates used in the boilers under test are of the shaking type. The teeth grip the clinkers formed on the bottom of the fire bed, tearing them off piece by piece and working them through the grates. The air space amounts to about 40 per cent., which may seem excessive for slack, yet was not.

Before starting the tests it had been suggested that firing by coking be tried. It was found, however, that the coal would not coke, but would burn into a condition somewhat like a "quick-lunch" Hamburger steak, well done outside but raw in the center.

On the first test the damper was left wide open and a fire from 12 to 14 inches thick was carried. Every 30 minutes the grates were shaken, thus keeping the fire at the same hight without cleaning. The slice bar was used to lift the fire off the grates, being careful not to bar the clinkers up into the live coals. Every 15 minutes the rake was run over the top of the fire to break up the caked coal.

After a twelve-hour run the fire was cleaned and a number of large clinkers were found. They were quite porous, however, and had not cut down the draft to an appreciable extent. The results justify the conclusion that with the same load, 320 horsepower on a rating of 300 horsepower, more frequent shaking, or cleaning every six hours, would prevent the formation of such large clinkers. Another way to prevent large clinkers was tried later and proved even more effective.

A subsequent test on light load, about 170 horsepower, showed that a fire 8 inches thick with the damper half closed would give the best results. It had been the habit of the fireman to leave the damper wide open, carry a heavy fire and regulate the draft with the ashpit doors. This latter practice is all two common, as it is much easier to kick an ashpit door shut than to close the damper. The saving in fuel by operating with a half-closed damper and a lighter fire was shown by the fact that in twenty-four hours from 2½ to 3 tons less coal was burned than with the damper open wide with a heavy fire.

Another point brought out in the tests was the value of a steam jet in preventing the formation of clinker. At one time the clinkers formed in the fire seemed to lack their usual porous quality and the draft dropped. With the introduction of a steam jet through one of the ashpit doors, however, the draft was bettered in a short time, and the test was continued for several hours without cleaning the fire.

In slicing the fire, it had been the practice of the fireman to break up the fire, thus mixing the clinkers with the live coal. Better results were obtained, however, by lifting the slice bar only enough to separate the clinkers from the grate, making a freer path for the air without spoiling the fire.

George W. Martin.

Pine Bluff, Ark.

Reversing Polarity of Machine

I am running a 300-kilowatt direct-current machine in parallel with a 500-kilowatt direct-current machine, both generating current for electric-railway work, at 600 volts. Once in awhile one of the machines reverses.

One man gave as his idea that a heavy load coming on one machine will slow it down and so reduce the voltage below 600.

Does it not pull the other machine down in the same way? If it does not, will someone state why?

B. F. West.

Scammon, Kan.

Central Valve Engines

Mr. Barnett has criticized my letter on "Central Valve Engines." My object in sending that letter was to give a previous correspondent the information which he could not get.

My sketch was intended to show, not so much the correct relative position of the valve to the pistons as the distribution of the steam through the various ports, etc. In trying to show this clearly I committed the mistake as pointed out by Mr. Barnett. With the pistons as shown the valve in these particular engines should have been open to the low-pressure cylinder at the top 3/64 inch, which is the lead for that end, and the bottom high-pressure port should be open 7/32 inch, the lead for that end. The small sketch which I made, to have shown to scale, would have shown the valve practically closed, and it would have been difficult to see how the steam was distributed.

With reference to Mr. Barnett's remark "that I am not conversant with the most elementary principles of valve setting as covering the simplest slide-valve engine," I have up to the present been able to set the valves of not only this particular type of engine, but of various other types, including simple slide-valve, riding-cutoff, Corliss and that interesting central-valve, single-acting engine referred to by Mr. Barnett, having had nearly twenty years' practical experience in running, overhauling and general repair work.

J. J. Stafford.

Birkenhead, England.

Do Crank Pins Wear Flat?

The assertion is often made that the crank pins of steam engines wear flat, but I find that they do not, but they do wear out of center with the bell. Only a few weeks ago, at the plant where I am employed, the shaft and crank of an old 18x36 Corliss engine was replaced by a new one and on calipering the old pin I found it to be badly worn. I was told that the crank had been in use more than sixteen years.

W. H. Stivason.

Wilson, Penn.

A Machine Shop Blunder

A friend who owns and runs a wood-working shop sent for me to come to his place and see if I could find out what was the matter with his 12x16-inch throttling slide-valve engine. He had always had trouble in keeping up steam with a 60-horsepower boiler.

When the throttle was opened and before the engine started, steam could be heard blowing through and it did not seem to make any difference on which stroke we tried it. The valve and piston were removed, but everything seemed all right. While engaged in measuring the lap and the spacing of the ports, I chanced to look above the valve seat and saw a ⅜-inch hole leading from the steam chest to the exhaust port.

In drilling the holes for the cap screws holding the governor to the top of the steam chest, one of the holes came directly over the exhaust port, and the drill had been run through into the port. The valve seat being raised from the cylinder side of the chest, a ⅝-inch drill came through just back of the seat and one side had cut through into the chest about ⅜ inch. A short cap screw had been used which did not reach down far enough to stop the hole.

I took the old cap screw out and after tapping out the hole made a new screw that would reach down into the port, thus stopping this leak.

C. E. Bascom.

Readsboro, Vt.

Some Useful Lessons of Limewater

Interesting Simple Experiments Showing the Relation of Electricity and Chemistry; A Valuable Lesson on the Carbon Compounds

BY CHARLES S. PALMER

There are so many sides to the study of chemistry that it is sometimes difficult to select the best order of attack; but one subject which naturally comes in at this time is the study of the simple primary electric battery. The main points of this primary battery can be easily mastered by anyone, and with the simplest of apparatus. We will first construct the simple battery, and in another lesson we will study some of the most important properties of the electric current, both from the physical and the chemical standpoint. It is true that we do not know much about the nature of the force which is called "chemical affinity;" but, whatever it is, it is certainly very closely connected with electrical action; and you can easily study some of the main points of this marvelous thing, the electric current, both as to the way in which it is started, and also as to what it can do chemically. It is all the easier to do this, now that we have studied the two fundamental elements, oxygen and hydrogen, the typical oxidizer and the typical reducer.

To Construct a Simple Battery

The apparatus which you will need is about as follows: A tumbler of dilute sulphuric acid, a strip of zinc and another of copper, about 1 inch wide and 3 or 4 inches long, and a short piece of common insulated copper wire, say about 1/16 inch in diameter without the insulation, that is, coarse copper wire. The reason for using coarse rather than fine wire is that the laws regulating the flow of electricity through wires are something like the laws of the pressure and the flowing of liquids through tubes; and just as a large tube will carry more liquid, so a coarse wire will carry more electricity. You want to clean and scrape the insulated wire for an inch or two at each end so as to free the wire from all fabric, tar, rubber, wax, or whatever material is used for a cover. If you have worked any with electricity these directions will seem gratuitous and unnecessary, but in any event you must remember that good results can always be obtained, but only at a little expense of careful attention in having the connections clean so that the metallic surfaces will come directly together without having any dirt, grease or foreign substance in between. You will connect one end of the well-cleaned copper wire to the zinc strip, by boring a hole through the zinc, hooking the wire through, and pressing or hammering it flat so that the hooked wire will touch both surfaces of the zinc, as shown in Fig. 1. The other end of the wire is attached exactly the same way to the copper strip, and the connecting wire is twisted into a loose coil or spring which can be easily adjusted to the distance of the two strips apart as they are placed in the tumbler. It may also be convenient to have a bit of some non-conducting substance, like a short piece of rubber, resting in the bottom of the tumbler to keep the two metal strips apart. The arrangement of the two strips of copper and zinc with the short coil of connecting wire is shown in Fig. 2. Now fill the tumbler about three-quarters full of dilute sulphuric acid, say about one part of acid to six or seven parts of water.

The first thing to do is to dip the zinc strip alone in one side of the tumbler of dilute acid, and you will note a rapid effervescence of bubbles, which, of course, you know to be hydrogen, from your experience of the last two lessons in making hydrogen by the action of dilute sulphuric acid upon zinc; or, to put it another way, by the action of zinc upon dilute sulphuric acid. Now there is nothing very remarkable in this, but it is the preparatory step to the next experiment which completes the making of your simple electric battery. As long as the zinc alone is in the dilute sulphuric acid, bubbles of hydrogen come off from the surface of the zinc, Fig. 3, but keeping the zinc in the tumbler and dipping the copper into the other side (the ends of the copper and zinc plates being connected by the insulated wire), you will note that the hydrogen ceases to come off from the zinc plate, and comes off from the copper plate, Fig. 4. There may be slight effervescence from the zinc plate, when both the zinc and copper are dipped in the dilute acid, but this gas from the zinc plate also is mainly oxygen, something which we will try to prove later on. The point that you want to notice is that if you dip the zinc plate alone into the dilute sulphuric acid, you get a brisk evolution of hydrogen gas from the zinc plate; but if you dip both the zinc and the copper plates (connected by the insulated wire) into the dilute sulphuric acid, the principal evolution of hydrogen gas is from the copper plate. We will neglect for a moment the slight evolution of oxygen gas from the zinc plate, when both the plates are

FIG. 1

FIG. 2

FIG. 3

dipped into dilute acid, to study the main evolution of hydrogen gas which comes off of the copper plate.

"Action at a Distance"

Evidently something very remarkable is happening here because, as shown in Figs. 3 and 4, the hydrogen, which would come off from the zinc alone, seems to be thrown off at the copper plate. This is not the same hydrogen as that which would come off at the zinc plate alone, but it is the same kind of hydrogen in quality and quantity; and its appearance on the copper plate an inch or two away from the zinc plate in the tumbler is what is called "action at a distance," and this action at a distance is characteristic of the electric battery. This action of copper in throwing off hydrogen, when the zinc-copper couple are connected by a wire and dipped into dilute acid, this action of the giving off of hydrogen from the copper plate, is all the more remarkable because *copper alone does not* give off hydrogen in such quantity and with such readiness in dilute sulphuric acid. You want to prove this point, namely, the action of dilute sulphuric acid and copper on each other alone, because it is the whole point of experiment. Indeed if you stop here and take both the zinc and copper out of the dilute acid and then dip the copper only into the acid you will note almost no action, because dilute sulphuric acid has hardly any effect on copper, at least for a few moments. The following points, then, you have established:

First, that the zinc alone in the dilute sulphuric acid gives off a rapid bubbling of hydrogen.

Second, that the copper plate alone when dipped into dilute sulphuric acid does not give off any hydrogen to speak of.

Third, that when the zinc and copper (connected by the insulated wire) are both dipped into the dilute sulphuric acid at the same time there is a rapid evolution of hydrogen gas, but from the copper plate.

As stated, something remarkable is happening here, and you can see that it is the action of the so-called electric current between the metals, through the dilute acid and through the conducting wire, which seems to transfer the evolution of the hydrogen from the zinc plate to the copper plate. It is just this action of the electric current which you want to note. There are a great many sides to this experiment, some of which we can take up now, and some of which will come up from time to time later on. This zinc-copper couple in dilute sulphuric acid, the zinc and copper being connected by the insulated wire, forms the typical simple galvanic or voltaic electric cell. There is an electric current flowing around, from metal to metal, through the liquid and through the connecting wire; indeed, there are probably two currents flowing around, one the so-called positive current, flowing in the liquid from the zinc to the copper and carrying hydrogen from the zinc to the copper in the tumbler (and then going on around through the wire back through the zinc again), and the so-called negative current, which carries oxygen from the copper to the zinc in the tumbler, and which goes on around the wire back to the copper. These two currents, the positive flowing in one direction carrying hydrogen and the negative current flowing in the opposite direction and carrying oxygen, are always equal in quantity and in intensity, and exactly balance each other. Indeed, we cannot have a positive current without having exactly the same amount of the opposite kind, namely, the negative; and, similarly, we cannot have the negative current without having exactly the same amount of the positive current.

While we cannot go very far into the explanation of this at present, yet it should be said here that we probably have and use what are essentially the same thing as these positive and negative currents in every chemical action; but they are so mixed up with each other and they balance each other so evenly and quickly that one does not realize this until he separates them very much in the same way that you are doing in your simple primary battery made of the zinc-copper couple. Indeed, this simple primary battery is nothing more than a simple but elegant and marvelously ingenious scheme for separating the results of the two currents so that one can take them apart, as it were, and study each one separately.

Defects in the Zinc-Copper Battery

There are several defects in this simple zinc-copper battery, which you will note if you let it work for a few moments. One of these defects is that the hydrogen bubbles will soon begin to stick to the copper plate, and your battery will soon become tired and "polarized," as the expression is; therefore, later on you will try to get some way to overcome this difficulty of the accumulation of the hydrogen at the copper plate. This is done by surrounding the copper plate (or what may take the place of the copper plate) by some "de-polarizing" or oxidizing substance. Another defect of this battery is that the zinc is altogether too active in the dilute sulphuric acid and is quickly corroded and eaten up; whereas it may be preserved against needless waste by rubbing the zinc plates with a few drops of metallic mercury carefully applied with an old rag. This amalgamating of zinc plates in primary batteries used to be a very important point in the old days before the modern power generator or dynamo was used to develop electricity, and when they had to depend on such primary batteries as a source of electricity.

There is another side of this, also, which we may study right here. While there are always both the positive, the hydrogen-carrying or the metal-carrying, current and the negative, or the oxygen-carrying, current in every battery, yet for convenience and simplicity we purposely neglect the negative current and speak in terms of the positive current, as though

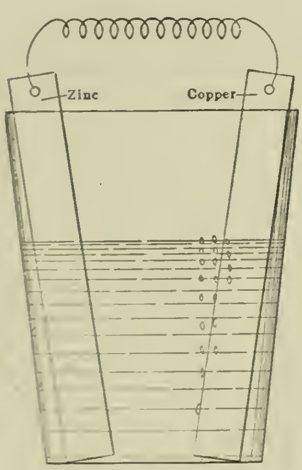


FIG. 4

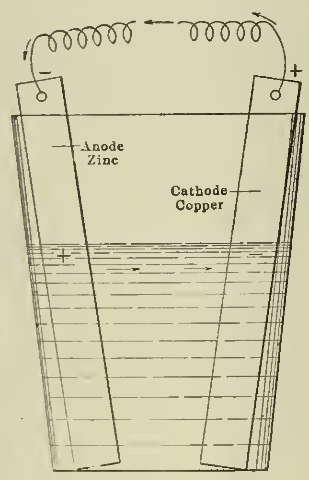


FIG. 5

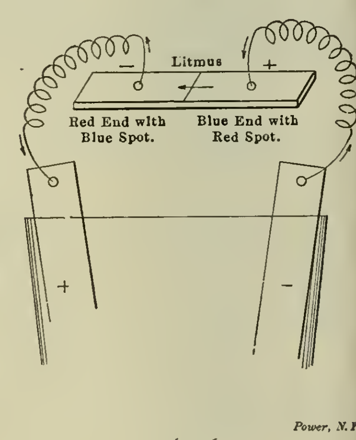


FIG. 6

that were the only kind of current. One reason for this is that the carrying of the metals, as hydrogen, is usually more easily noted and measured than the carrying of the nonmetals, as oxygen, by the electric current. Another reason is that when the double electric current gives off hydrogen at one plate or "pole" and oxygen at the other plate or "pole," there are two volumes of hydrogen to one of oxygen, these being the proportions in which oxygen and hydrogen unite to form water (H_2O).

The "Anode" and the "Cathode"

In studying this positive electric current in this simple primary battery it is plain that the action *seems* to start at the surface of the zinc plate in the dilute acid. We will therefore think and speak of this zinc plate as being the starting point for the positive electric current. We will also call the zinc plate or "pole" the "anode" (the "road up" or the "up road"); and we will call the copper plate in the battery the "cathode" (that is, the "down road" or the "road down"). Thus, we will speak of the zinc plate or the metal-exciting plate *in* the battery as the anode, and the copper plate or the metal-receiving plate or "pole" *in* the battery, as the cathode. That is, *in* the battery the current goes "up" into and through the zinc plate, across through the dilute acid, "down and out" through the cathode or copper plate, and so on through the insulated conducting wire to the zinc plate again. We have taken the greatest liberties with both fact and language in talking about this electric current in its passage through the anode and cathode; but on the whole perhaps it is justifiable, if you remember that we are still in the infancy of our ignorance regarding the nature of chemical affinity and the electric current.

It will do you no harm to think about this positive electric current as though it were an invisible current of fluid force or energy; but we must always be careful to name the facts in the right order and contrast. This is the more necessary because if we cut the connecting wire in the middle, as we are going to do in a moment, the end of the wire leading from the cathode will itself become an anode or "road up," and the other cut end of the wire, leading up to the zinc anode of the battery, will itself become a cathode or "road down or out," considering only the cut ends of the wire.

There is also another way of looking at this flow of the positive current in the circuit, from anode to cathode in the battery and from anode to cathode at the cut ends of the conducting wire *outside* the battery, and that is by the use of the signs + (plus) and − (minus). Just as we think of the temperature as falling from plus (+) above zero, on the thermometer, to minus (−) below zero (say from 10 degrees above zero to 10 degrees below zero), so we can think of the electric current, that is, the positive electric current, as always going in the direction in which it falls from plus (+) to minus (−). You will notice that we have indicated these signs carefully and exactly in Fig. 5 and you will want to study this figure and memorize the relative positions of these signs; for they stand for the governing direction of the flow of the positive electric current.

Now, to show you that we are talking about real chemistry and not about a mere dream, take the two ends of the cut wire as shown in Fig. 5 and put one on the upper and the other on the under side of your tongue, when you can easily *taste* the electric current. Indeed, if you take a strip of plain clean zinc about 1 inch square and lay it on the under side of your moist tongue, and then place a clean copper cent on the upper side of your tongue and let the projecting ends of the zinc and copper touch each other, you will have a little electric battery and you can taste the electric current every time that you make the zinc touch the copper cent. Of course, in this simple battery in the mouth, the saliva represents the dilute acid, and what you are tasting is a strange mixture of the reducing effect of the positive or metallic current and the negative or nonmetallic current; and you cannot fail to note the strong metallic taste of this simple tongue battery.

To find out just what it is that you are tasting in the tongue battery, and just what it is that you have produced in the zinc-copper couple in the tumbler battery, try the experiment indicated in Fig. 6. Take a piece of common litmus paper and dip it into a little dilute soda or acid so that one-half will be colored blue and the other half red. The strip of litmus paper should be about ½ inch wide and 2 inches long. Then neutralize a little sulphuric acid, say a teaspoonful of dilute acid, with a few drops of caustic soda, until it is exactly neutral, so that it will leave red litmus paper red and blue litmus paper blue. You can get this point of exact neutrality by a little fussing and by adding a drop of dilute acid from one tumbler and a drop of dilute caustic soda from another tumbler until the sodium sulphate produced is exactly neutral.

Then dip the strip of litmus paper into this neutralized solution of sodium sulphate. Lay the red and blue litmus paper, which is saturated with the sodium sulphate, on a clean glass or saucer and put the end of the cut conducting wire from the copper pole on the blue end and the end of the conducting wire from the zinc pole of the tumbler on the red end of the litmus paper, having both the zinc and the copper plates immersed in the tumbler battery. At once you will notice that where the wires touch the sensitive strip of litmus paper, on the blue end around the wire from the copper pole will come a fine red spot, and on the red end of the litmus paper around the end of the wire from the zinc pole will come a blue spot.

This experiment will teach you everything that you need to know about the fundamentals of the chemical action of the electric current. You will see that the current is flowing, that is, the positive current, in the direction of the step arrows, as marked in Fig. 6; you will note, also, that where the current from the battery goes into the litmus paper, the end of the wire from the copper being an anode shows the oxidizing or acid action of the negative current and turns the blue litmus red, while the end of the wire leading to the zinc, on the litmus paper, shows the metallic or basic action and turns the litmus paper blue. The actual reactions which are happening (in the sodium-sulphate solution in the litmus paper) are quite complicated, and we will not stop to analyze them completely at this time; but you can see that the electric current can be broken up anywhere in the circuit into its two parts, the one part at the pole where the current goes in always showing an oxidizing or acid effect, and the other part where the current goes out always showing a basic or reducing effect. You will have to be patient with yourself, and you will have to read and re-read this chapter several times; but you can easily memorize the main points in one very simple and easy way—by doing the experiments. Indeed one hour of experiment is worth many hours of reading and study. One wants to read and study just enough to see how to perform the experiment; then the experiment itself becomes the teacher, takes charge of all of us as students and teaches us how to see and how to remember.

Two Main Points to be Noted

There are many other and many applications to this fundamental experiment of the simple primary electric battery; but there are two main points for each of us to note at this time: one is the way in which the hydrogen is driven off from the copper rather than the zinc pole in the tumbler battery, and the other is the way in which the cut ends of the conducting wire, carrying the electric current, show very clearly the opposite chemical action of oxidation or acids at one pole and bases or reduction at the other. If we will stop here and let our imaginations work a little, we can easily see something of the almost unlimited possibilities of the chemical action of the electric current.

In this experiment we have produced a very feeble electric current from a primary battery; but the chemical effects of the electric current are the same whether the electric current is produced by a primary chemical battery, or by a mechanical generator or dynamo, provided the current is what is called a "direct current." The chemistry of the alternating current is a different matter and cannot be considered here; but the action of enormously powerful direct currents, such as those produced at Niagara falls and used in the manufacture of aluminum, the clay metal, and many other equally interesting substances, all this shows a little of just what you have begun to block out in this lesson.

There is another word of explanation which should be offered here. I refer to the difference between the so-called "primary" and "secondary" batteries. There is really very little difference in theory between the primary and secondary battery; both have their anodes and cathodes, and in both the positive current flows in the way indicated in noting the course of the current in our simple tumbler battery. But, *practically*, there is a great difference between the primary and secondary battery; for the electric current represents a form of power or energy, and the electric current can be produced either by the mechanical dynamo or generator, or by the primary battery (though at present the primary battery is not used as an economical source of large currents). Now in the saving up or storing of the energy of electric currents use is made of the secondary battery, which is frequently made of two lead plates (one in the form of metallic lead, the other in the form of the brown oxide of lead, PbO_2); these "secondary" or "storage" batteries make a large subject, and they represent a problem which is only half worked out at present. This word of explanation is simply given to show the meaning of the word primary as we have used it for our tumbler battery in a simple form for originating an electric current.

In the next lesson we will consider some of the other chemical and physical aspects of the electric current; and incidentally it will be a good thing for you to get another piece of insulated copper wire, 4 or 5 feet long, and also a small pocket compass, even one as small as the common watch-charm compass; for anything of this sort will come in very handy. You will also want to get a short piece of good steel, 4 or 5 inches long, and magnetize it by holding it close to a certain part of any direct-current generator; any friendly operator will help you to magnetize it. But do not forget to go over and over the material presented in this lesson, and to clinch it by experiment, so that you will learn it as though you were going to remember it forever; it is worth knowing.

The principal producing countries of lignite are Germany, Austria and Hungary, which in 1906 produced 55,513,000 tons, 23,779,000 tons and 6,263,000 tons, respectively, while the provisional figures available for Germany in 1907 show a production of 61,542,000 tons, and in Austria 25,840,000 tons. In the United Kingdom the production has for some years been *nil*.

The Inception of the "Van Stone" Joint

In a group at the Engineers' Club the other evening, the conversation turned upon loose-flange joints, suggested by W. F. Fischer's article upon the subject which had just appeared in POWER, and George I. Rockwood, who was of the number, related the story of the inception of this type of joint by himself, as follows:

"In 1903 I had occasion to put some 8-inch high-pressure steam pipes into the

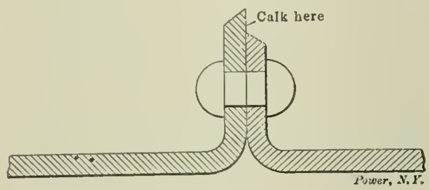


FIG. 1

plant of the Samuel Winslow Skate Manufacturing Company, Worcester. Casting about for the best form of pipe joint, I investigated the work which had been put up in Providence, about that time, in the Narragansett Electric Light Company's station, where the ends of the pipe were flared out and riveted directly together in much the same way that the flanges on the ends of the abutting sections of Lancashire-boiler furnaces are riveted together (Fig. 1).

"I was informed that considerable trouble had been experienced with this form of joint and that most of the piping had to be replaced after a short time, owing to the impossibility of contending successfully with the strains produced by the expansion and contraction of the line. It then occurred to me to make use of the heavy cast-iron flange (Fig. 2). The flange was bored a rather close fit to the pipe, its face was turned to the section shown, and the flange was then slipped over the pipe and temporarily left some distance on it from the end. The blacksmith then heated and flanged over the end of the pipe, after which he moved the cast flange up to the heated end, secured it there and molded the two flanges together.

"The fundamental object I had in view was to secure together the abutting flanged ends of two pieces of pipe in such manner that the expansion strains of the line could not affect the relative positions of the contacting faces. By making the flanges with deep skirts and by flaring the outer faces of the flanges to admit a calking tool, I was able to correct any tendency of the pipe to leak when first put up, by simply calking the steel up against the heavy anvil-like faces of the flanges.

"A year or two later, after I had watched the behavior of the pipe joints in this factory, I contracted with the Walworth Manufacturing Company, in Boston, for a long line of pipe varying from 16 to 6 inches in diameter, and provided with this same style of pipe joint. Before letting the contract to the Walworth Manufacturing Company, I attempted to get figures from several other pipe contractors, but entirely without success, as no one else wished to attempt the flanging-over process for fear of lack of success due to splitting of the ends of the pipe when subjected to such a treatment. The Walworth Manufacturing Company evidently did not realize the difficulty of the job, for after it had had the contract for some days, its salesman called at my office and asked to be allowed to provide screwed flanges, as they found it almost impossible to prevent the splitting of the pipe when they attempted to flange it. However, after some persuasion and further experimenting on the part of their superintendent, Mr. Van Stone, with an oil furnace, and after some practice on the part of their men in hammering over the edge of the heated pipe with long-handled wooden mallets, they were able to finish the job and erect it in position.

"It was an entire success, and during the following summer, after a long absence from home, I called at the office of

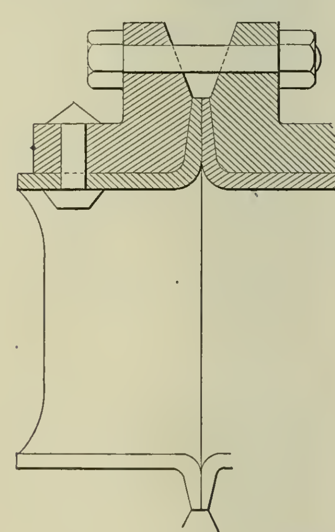


FIG. 2

the Walworth Manufacturing Company and asked them what they thought of the joint. Their answer was that they thought it an excellent joint in principle, but too expensive to build for the market. I, however, had my suspicions aroused and went over to see what they were doing with it in their factory, where I found their shop literally full of orders for piping with this style of pipe joint. I also found they were advertising it as the 'Van Stone Pipe Joint'. Meantime, I had had a patent issued to me—No. 580,058, April 6, 1897. This patent was for a pipe joint (Fig. 3) in which the flanges have divergent opposite sides to admit a calking tool. The Walworth Manufacturing

Company has continued to make its so-called 'Walmanco' pipe joint (the name which they switched over to after Mr. Van Stone left their employ and formed the company of Lumsden & Van Stone, Boston), which is practically a Chinese copy of my patent.

"I talked with the Walworth Manufacturing Company for a good while about their buying this patent; but, owing to a defect in the way the claim had been drawn, I found it was necessary to secure evidence that pipe joints which had been erected and subjected to steam pressure and had leaked, owing to defective workmanship, had actually been tightened by the use of a calking tool introduced between the divergent opposing sides of the flanges. Owing to the difficulty of securing this testimony, and to a certain reluctance to engage in a legal struggle with the Walworth Manufacturing Company, I never did anything further to enforce my rights.

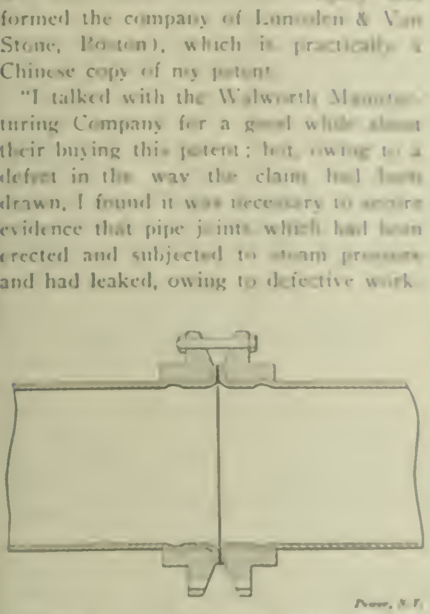


FIG. 3. ROCKWOOD PIPE COUPLING

"In the original pipe joints made by me, I thought it safe, after discussing the matter with my friend, Capt. Charles H. Manning, and in view also of an experience with a pipe line of somewhat similar construction in Natick, R. I., where an engineer was killed while calking a line, due to the pulling of the pipe out of the flange, to introduce a few rivets into the skirt of the flange to take the strains off of the corner where the pipe is bent over. The rivets had the additional advantage of holding the flange in position while the blacksmith flanged the end of the pipe over against it. But, whether the rivets were provided or not was immaterial to the main fundamental advantages of this type of flange.

"I have had it alleged to me that I got the idea of making this type of joint from previous practice in coppersmith's work, where the slatting ends of copper tubes are spun over and are pinched between two light flanges. No one who had ever seen the drawing of such a flange would be likely to have made a steel pipe joint in the way shown in my patent. No suggestion of the advantages of such flanges as anvils against which to calk the joint tight is suggested by their shape. Furthermore, the fact that the flange was original with me is shown by the further fact that it was not until after I had made and used this so-called 'Van Stone' joint that modern practice shifted quickly over to it, practically to the abandonment of all other kinds of joint for use in high-pressure pipe lines."

License Law for Colorado

A bill has been introduced into the legislature of Colorado providing for the examination and license of persons operating steam engines, boilers, etc. Two persons who have had not less than ten years' practical experience each in the care and management of steam boilers and steam engines are appointed by the governor for a term of two years, and these, together with the State inspector of steam boilers, constitute a board of examining engineers.

"It shall be the duty of the board of examining engineers to meet from time to time and at least as often as once in four weeks in the city of Denver, or elsewhere in the State of Colorado, for the purpose of examining the qualifications of applicants for license to operate steam power."

The fee for upon application is $5. If one fails and tries again, the fee is $2.50, and the license must be renewed yearly, the fee for which is $2. The examiners may accept licenses granted by other lawfully constituted bodies in lieu of an examination. Any rejected applicant may apply for a re-examination by an engineer of his own choosing, who shall act in conjunction with a member of the board and a third engineer to be satisfactory to both. Each member of the board shall be paid $5 for each day's actual service and seven cents per mile for each mile actually traveled in the performance of his duties. Railroad locomotives and steam fire engines owned by an incorporated town or city are exempt.

There are also bills before the legislatures of the States of Oregon and New Hampshire providing for the establishment of an inspector of steam boilers but not for the examination and license of stationary engineers. That in New Hampshire has been reported unfavorably by the committee to which it was referred.

License Act for California

There is a bill before the legislature of California to regulate the operation and supervision of stationary steam machinery, which prohibits the employment of any person to operate, supervise or control any stationary engine, steam boiler or other stationary apparatus for generating steam, except persons licensed in accordance with this act. It exempts only apparatus in connection with private dwellings.

The law is to be administered by a board appointed by the governor and consisting of three members, one of whom shall have been employed as a stationary engineer for five years before the ten years preceding his appointment, one shall have had the active management for a like period of some factory or workshop in which steam-generating apparatus is used, and one shall be a graduate of some reputable college of engineering. They are expected to serve without compensation but are to receive their actual and necessary traveling expenses while engaged in the business of their office.

The board appoints an examiner and makes rules and regulations for the conduct of examinations, for which and for the granting of licenses a reasonable fee may be exacted. The examiner is to travel about the State and is allowed a salary and his actual traveling expenses, but no provision is made for deputy examiners.

A New N. A. S. E. Association

On Wednesday evening, March 31, a new branch of the National Association of Stationary Engineers was formed at Fort Smith, Ark. The new association is known as "Border City No. 5" and was instituted with twenty-four members. Although the inclemency of the weather kept many from attending, a most enjoyable night was spent. The following officers were elected: A. T. Hubbard, president; Frank Harris, vice-president; S. B. Robertson, secretary; B. C. Culpepper, corresponding secretary; S. T. Rowe, conductor.

The Largest Steam Turbine in Sweden

The De Laval Steam Turbine Company, in Stockholm, has recently supplied the largest steam turbine to be installed in Sweden to the [illegible] Power Company's electrical central station at [illegible]. It is of the De Laval multiple type, has a capacity of [illegible] horsepower and is direct-connected to a three-phase alternating-current [illegible] generator. The turbine company has supplied the whole of the plant, including two boilers, etc.

The "Laurentic" of the White Star line, will come under her own steam to the Montreal-Liverpool service. She has a tonnage of [illegible] and is fitted with reciprocating engines working in conjunction with steam turbines. Her sister ship, the "Megantic," has the reciprocating engines only.

In the test of a plant by the [illegible] Society for the Suppression of Smoke the thermal efficiency with the [illegible] was [illegible] per cent, and with [illegible] per cent.

POWER AND THE ENGINEER

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April 13	37,000
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Producer Gas Power in Small Units

When one stops to think of the possibilities of small gas producers and engines, it seems strange that the use of that class of apparatus is not vastly more widespread than it is. A suction anthracite producer of any size up to 25 horsepower is no larger and no more troublesome to operate than the hard-coal stove commonly found in country stores, and not nearly as intractable as the average kitchen range. We are vigorously opposed to underestimating the degree of care required by machinery of any kind, and we do not ignore the fact that a small producer and engine plant do require intelligent attention; nevertheless, it is undeniably true that the *amount* of such attention needed by the type of plant under consideration is astonishingly small.

There is an enormous field for such small plants throughout the country, and the builder who has the foresight to develop it and get in first ought to reap a prodigal harvest. A good deal of missionary work along Missourian lines will be necessary, however, in order to convince the prospective customer that the monstrosities which were sent out by some builders in previous years have had their day and that "real" producer-gas engines and anthracite producers are as easily obtained now as abortions were five years ago.

The Presentation of Engineering Papers

Most engineers enjoy a good lecture, or a paper on some uptodate subject. That is one reason why engineering societies have adopted the practice of having papers presented by men of distinction in their lines. If the members who attend organizations did not feel an interest in such matters they would not be there. Without attendance, an engineering society must fail; therefore, it devolves upon any such body so to conduct its meetings that they will attract, not repel. Getting men into a lecture room and boring them to death is not conducive to success.

Most engineering societies publish in advance the papers that are to be read at any particular meeting, in order that the members may have an opportunity of discussing them intelligently at the meeting. This is a good idea, but what is the use of wasting the time of several hundred men by forcing or allowing the author to read in full a paper which every interested member has previously read for himself? If an author is thoroughly conversant with his subject (and he is foolish to attempt a paper if he is not), he should find no trouble in giving concise expression of the ideas presented in his paper without reading it, or even lengthy parts of it, and the audience would undoubtedly find more interest in listening to the speaker than to the reader.

The time usually taken up in reading papers which have been previously distributed in printed form could much more profitably be spent in discussion, and if the members once understand that papers will not be read in full, they will form the habit of reading them carefully beforehand and, consequently, be much better prepared for discussion at the meeting.

The Three Phase Circuit

The three-phase alternating-current circuit is still a good deal of a puzzle to the operating engineer whose early training was obtained in connection with the simple two-wire direct-current circuit. The attempt at simplification by advising that one wire be considered as a common return for the other two does not usually help matters and vector diagrams merely emphasize the confusion. The easiest way for beginners to approach the subject is to consider the three-phase circuit as a consolidation of three simple two-wire circuits, as outlined in a recent article* on the subject. On this basis each wire of the three-phase circuit is the combination of two wires of two of the imaginary two-wire circuits, one wire of each circuit being combined with one wire of one other circuit to form the single resultant wire of the three-phase circuit. Each wire of the three two-wire circuits must be assumed to have a cross-sectionel area equal to 0.577 of the cross section of each wire in the actual three-phase circuit, if the questions of "drop" and energy loss are to be considered.

When one is concerned only with the loss in the line, however, the simplest method is to assume that the requisite power is to be transmitted by a four-wire two-phase circuit. The size of wire required to transmit a given power at a given loss is exactly the same in a three-phase circuit as in a four-wire two-phase circuit, and by working (on paper) with two phases instead of three, all of the confusion as to interlinking of phases is avoided. For example, if a twenty-horsepower three-phase motor is to be connected up for two per cent. loss in the line at full load, assume that it is a two-phase motor of the same horsepower, efficiency and power factor, and figure the line as a two-phase line; then throw out one wire of the four and the remaining three will be correct for the three-phase motor actually to be installed.

It must be remembered, however, in checking the size of wire by the insurance requirements, that the current per wire

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is greater for a three-phase than for a two-phase motor of the same size and characteristics; what has been said above refers only to voltage drop and energy loss in the line. For example, if the twenty-horsepower motor be of ninety per cent. efficiency and eighty-eight per cent. power factor, and the circuit voltage be 220, the current per wire would be fifty amperes for the three-phase motor and forty-three for an equivalent two-phase machine. The drop and energy loss in the circuit would be the same for both kinds, with a given size of wire, but the underwriters would not allow smaller than No. 4 rubber-covered wire for the three-phase circuit, while No. 5 would be permitted for the other.

To Improve the Load Conditions of a Power Station

When the load on an electric-power station is such that another generating unit must be put in parallel with those already running, it is common practice to readjust the division of load amongst the machines so that the one just "cut in" will take its share. There is no alternative to this practice where direct-current generators are operated, but if the machines are alternators and the load is inductive, it will frequently be found preferable to operate the incoming machine as a synchronous motor in order to improve the power factor of the system and enable the other generators to load their prime movers fully. The condition under which this method is advantageous is the combination of a low power factor and either equality of capacity between each generator and its prime mover or a preponderance in favor of the prime mover.

For example, suppose that each prime mover is just able, at maximum economy, to drive its generator at full rated load when the power factor is ninety per cent. If the power factor should happen to be seventy-two per cent. the normal heating limit of the generators would be reached when the prime movers were doing only eighty per cent. of their maximum-economy output. Under these conditions cutting in another alternator and dividing up the load between all of them would not only reduce the load on each prime mover still farther below the economical point but would farther impair the power factor of the system. On the contrary, if the additional alternator were synchronized, cut in and then allowed to run as a synchronous motor, driving its prime mover idle (with steam cut off), its field excitation could be increased so as to improve the power factor and enable the other prime movers to carry full load without overheating their generators.

This raises an interesting question: For power stations carrying highly inductive loads would it not be worth while to equip one or more of the alternators with a simple dental clutch by means of which its prime mover could be disconnected from it when the machine was needed as a synchronous motor for raising the power factor?

Another "Smoke Consumer" Has Made Its Appearance

In the Dayton (Ohio) *Daily News* of March 22 there appears a reading notice heralding the discovery of a compound which, mixed with coal to the extent of twenty cents' worth of compound per ton of coal, will eliminate all of the gases which cause soot and smoke, and in addition will clean the flues of the boiler, the inside of the chimney, or stack, and add "forty per cent. energy to the coal."

It is said that a satisfactory demonstration was made in the presence of the smoke inspector, who remarked: "These men have the goods."

It has long been known that with a properly designed furnace, operated by intelligent attendants, smokeless combustion of the most smoky grades of bituminous coal can be accomplished, and it has still longer been suspected that human brains had more influence in producing smokeless fires under boilers than mixtures of salt, lime, calcium carbide, oxalic acid, water, etc.

A manufacturing chemist who was burning with his coal a lot of damaged salt said: "There is nothing in salt, oxalic acid or water that can add anything to the heat value of the coal in the furnace, but we use lots of these things. Do you see this ring? There is and can be no connection between this ring and rheumatism, but if you have rheumatism put on this ring and you forget all about rheumatism."

It may be the same with the users of the new smoke-destroying compound. It has no relation in any way to combustion, it may even be detrimental, but put it on the coal and straightway everybody concerned forgets all about smoke. There is nothing known to the industrial chemist "twenty cents'" worth of which mixed with a ton of coal will add to its fuel value in proportion to its cost and at the same time produce smokeless combustion. [illegible] has repeatedly warned its readers against the use of these compounds, and it is thought in some quarters that the United States postal authorities have been negligent in allowing the mails to be prostituted in the carrying of fraudulent solicitations of worthless nostrums.

The John Fritz Medal Presentation

The steam engineer, whether he follows that vocation professionally or in an operative capacity, will find a fund of inspiration and interest in the addresses which accompanied the presentation of the John Fritz Medal to Charles Talbot Porter on Tuesday evening of last week, at the Engineering Societies building in New York. The steam engine has had a greater part in making possible the highly developed civilization in which we live than any one other factor, and so accustomed have we become to its benefits and advantages that the fact that its application to industry and transportation upon any considerable scale covers hardly a century, comes almost as a revelation when it is recalled. The statement of Professor Goss of the conditions existing at the time of Watt and during the early development of the factory engine, the steamboat and the locomotive, and by Professor Hutton of the influence of Mr. Porter's work upon the engine as he found it at the middle of the last century, will throw a new light upon the relations of steam engineering to the world for the layman and quicken the interest of the engineer in his life's work.

The previous awards of the medal have been made informally. The institution of the simple but impressive ceremonial, so much in keeping with the character of the man whose imprint the medal bears, is to be commended and it is hoped that the annual presentation of this medal will become one of the notable functions in American engineering society.

We congratulate Mr. Charles Talbot Porter upon this recognition of his work, conferred in the eighty-third year of his life, and bearing, as he said in brief and dignified acceptance, the expressed approval of time.

Obituary

John McKay, chief engineer and superintendent of the City Investing building, New York City, died Saturday, April 10.

Producer gas, as the term is commonly applied, is intermediate between air gas and water gas. Air gas is made by passing air alone through a bed of incandescent carbon and water gas by passing steam alone through such a bed. Producer gas is made by passing air and steam together through the bed of incandescent fuel. Air gas is almost entirely carbon monoxide; water gas is largely carbon monoxide but carries also hydrogen obtained by the decomposition of the steam. Producer gas is chiefly carbon monoxide with 10 to 20 per cent. of hydrogen.

Charles T. Porter Awarded Fritz Medal

Mr. Porter's Pioneer Work on the High Speed Steam Engine Fittingly Recognized. The Benefits to Modern Industries Pointed Out

With simple but impressive ceremonies the John Fritz medal was awarded, on Tuesday evening, April 13, to Charles Talbot Porter, the father of the high-speed engine. The audience arose as Mr. Porter was escorted to the front of the stage by Jesse M. Smith, president of the American Society of Mechanical Engineers, who addressed the chairman, Henry R. Towne:

President Smith's Introduction

The John Fritz medal was established in 1902 by the profession of engineering as a meed of recognition for notable scientific or industrial achievement. By direction of the Board of Award I present to you and to this company the chosen recipient of the medal for 1908-1909, to whom

it has been awarded for his work in advancing the knowledge of steam engineering and in improvements in engine construction. We thus honor him because he was the first to see the possibilities of the high-speed steam engine; for his mechanical genius in the design of parts and details to embody these principles, and for his insight in recognizing the necessity of the very best mechanical construction in realizing these ideals. He introduced into the development of the power plant an idea and an influence which was so revolutionary as to mark an epoch in the history of the art of engine building, and which has been as world-wide in its effects as has been the use of the reciprocating steam engine as a prime mover. Many of the present generation have inherited without effort the knowledge which it cost Mr. Porter many years of painstaking study and experiment to establish; many, perhaps, use this heritage without a thought of or recognition to the pioneer who won it for them.

That he may now receive the John Fritz medal, I have the honor to present Charles Talbot Porter.

Presentation and Acceptance

E. Gybbon Spilsbury, chairman of the Board of Award, in presenting the medal, said:

Charles Talbot Porter, veteran engineer, assiduous student of science and of the mechanical arts of construction, skilled expert in design of engine details and the application of physical laws to the solution of problems in the field of prime movers which you made peculiarly your own, in the name of the profession of engineering, and on behalf of the John Fritz Medal Board, I do now present you this medal, together with an engraved certificate of the award, in the presence of this distinguished company, and confer upon you all the rights, honors and distinctions which attach to this emblem. May you live long and happily to enjoy the appreciation which is your due at the hands of those whom you have so benefited by your work.

Mr. Porter, in accepting the medal, said:

Mr. Chairman and Gentlemen of the Board of Award of the John Fritz Medal: I thank you most sincerely for this token of appreciation of my work, which is all the more grateful to me that it expresses the approval of time.

"The Debt of Modern Civilization to the Steam Engine"

was the title of Prof. W. F. M. Goss' address, which was as follows:

The progress of the human race has been marked by the implements it has employed. The creation of each new utensil, tool or machine has given mankind greater freedom of choice, and has augmented his power. With the employment of mechanical means for driving machinery came great influence in manufactured products; when better means of communication followed, the range of man's activities was extended, and when labor-saving processes were introduced they brought opportunities for intellectual exercise and development. Thus from the beginning, invention and the development of the useful arts have given new life to the activities of man, have created new procedures, have led to the establishment of new standards of living, have stimulated speculation and have even directed the tendencies of thought.

Among the factors which have played their part in these civilizing processes none is more important than steam, a statement which becomes the more significant when we reflect that at the time its use as a source of power began, the world was already old and very many potent forces were having their effect upon society. The mass of the great common people were making themselves felt and heard. They were reading books and were showing an interest in science, and they were not afraid to undertake new enterprises. Dreams of the possibilities of steam belong to the day of Addison, Steel, Swift and De Foe, when the public was instructed and amused by the "Spectator," the "de Coverley Papers" and the stories of those famous adventurers, Gulliver and Robinson Crusoe. The day of triumphs in English architecture had reached its meridian, for Sir Christopher Wren had already directed the rebuilding of London after its great fire, and was finishing its masterpiece by the completion of St. Paul's cathedral. It was a day when the American colonies, occupying a fringe of territory along the Atlantic seaboard, were exercising themselves as became a stirring people in a new land, fighting their wars and gathering their strength for a greater war which was to come.

Such a period was worthy to usher in the era of steam, was in fact waiting for it, for though it boasted of brilliant men of letters and of great statesmen, there was work waiting which it had no means of doing. There were no large factories in England, because there was no way by which their machinery could be driven. Many English mines had been abandoned because they were flooded with water which could not be removed. For lack of cheaper and more effective means, women and girls were employed in many coal mines to convey coal to the surface. Where galleries resulted from the working of thin veins and head room was lacking, women nearly naked crawled on their hands and feet and pulled loads of coal in cars behind them. Again, at the shafts, women and girls, early misshaped by the severity and monotony of their task, toiled up inclines or climbed a succession of ladders, each carrying to the surface a burden of a hundred pounds or more of coal. Suffering and degradation was the common lot of the women in the mines, and fatalities through accidents were frequent. The traveler desiring to journey from Edinburgh to London was obliged to intrust his trunk to the skipper of some sailing vessel and himself to proceed on foot or horse, usually in company with other travelers as protection against outlaws.

In America, many years after the period of which I now speak, even within the memory of some who live today, the pioneer settler, finding it necessary to pay a bill or collect an amount in Philadelphia or Baltimore, not infrequently journeyed thither on foot from his home in Indiana or Illinois, preferring walking to riding because he could make more rapid progress. The movement of merchandise by land was equally laborious, and as a result there could be little interchange of trade between the people of different communities. Men restricted their requirements to those things which they could themselves produce, and in every country at least, the primitive life, while not devoid of dignity and pleasure, offered many hardships and even [illegible]. Travel by sea was even more hazardous than by land and was attended by far greater misery. A traveler from England to America in 17[illegible] has recorded the following incidents of his trip:

On January 1, the vessel drifted down the Thames. On the third she was aground, and after some damage had been done she was floated again. On the fourth anchor was cast off Deal, where the pilot was given up. Starting again on the [illegible], the vessel soon encountered a storm lasting for several days, was driven off its course, and finally was allowed to drift about until a [illegible] pilot had given the captain his course for Portsmouth harbor, where anchor was cast, the passenger feeling, as he said, "like one risen from the dead." The passengers [illegible] their spirits by visiting the English [illegible] whence they had started, and on the twenty-ninth, practically a month after leaving London, they again set sail. Soon they encountered a period of light winds and calms followed by gales so heavy that they were obliged to lie four days in a trough. Then head winds blew, and supplies ran so low that they were all put on short rations, until 99 days from London, when they had reached the vicinity of the Azores, they fell in with an East Indiaman, four years out, homeward bound to Boston. The larger ship was well manned, well equipped and well provisioned, and the [illegible] had the good fortune to get [illegible] [illegible]

Charles Talbot Porter

taken by one which was known to be very slow. By way of experiment, the captain collected his passengers and crew at the stern, with the result that the speed at once quickened. A subsequent change in the location of a few water casks served permanently to make the vessel the fastest of the fleet.

Into the midst of such conditions came the steam engine. It first freed the mines of England from water, thus reviving industries long dormant, giving employment to the idle, and increasing the fuel resources of a nation. It soon began to hoist the output of mines, to the relief of thousands of toiling women who had suffered without redress for generations. It turned the wheels of factories with a power unprecedented, making possible the introduction of new systems in manufacture by which raw materials might be converted into products serviceable to mankind, and by so doing became the foundation upon which has been reared the industrial prosperity of nations. It supplied pure water and effective means of sanitation to cities, and, supplemented by electric transmission, it furnished light, power and heat to offices and homes.

The steam engine is no longer merely a center of motion for factories, but is a necessary adjunct to the modern home. It usurped the place of the wind in the propulsion of ships, and they now proceed steadily through any sea. Steam also serves in the orderly administration of ships, in hoisting and handling the cargo, working capstans, weighing anchors, supplying water for sanitation and for fire protection, generating electricity for light, and transforming the slightest movement of the quartermaster's hand into the strong, steadily applied force needed to work the helm; it has, in fact, by the performance of numerous functions transformed a slow, uncertain and most uncomfortable process of navigation into one of the speediest, most certain and most delightful means of travel. It has supplied means for the safe and speedy transportation of people and merchandise by land, correlating the activities of cities and uniting different communities into a single people.

Steam, through the agency of the locomotive, has carried order and civilization into Africa, and has made possible the execution of great schemes for internal improvement on that continent; it has carried bread to the hungry in India, and has served in our country almost as a creature of fancy in pointing out to multitudes of settlers the way to new lands and new homes. It has given shape to the frontier, it has carried forward the settlers, and it has made it possible gradually to convert unsettled territory into populous country and untilled lands into productive gardens and farms of a continent' breadth.

All these achievements wrought through the agency of steam are direct contributions to the upbuilding of our modern civilization, the keynote of which is service. The service of the steam engine has not only enlarged the resources of all countries and increased the power of man, but by creating facility in communication is a tremendous force in modifying social life. The ease of present-day travel is a characteristic of our modern civilization. People of all nations may freely intermingle. Through opportunities thus afforded State lines are of less significance, and the prejudices and limitations of communities are lost and forgotten. Business and social interests which are made possible between nations are weaving a bond of common friendship which is world-wide in extent, and which grows stronger with every passing year. The power of navies and artillery, which has so long served to emphasize boundaries and separate nations, is gradually being supplanted by the power of the steam engine which promotes communication, makes possible introductions, and stimulates acquaintanceships, the effect of which is to draw people together and to encourage them in an acknowledgment of their mutual dependence. Through intercommunication the dwellers on the earth are beginning to see that if one nation suffers severely all nations are likely to suffer in some degree, and they are learning respect and sympathy for their fellow-men, and this is a long step toward world-wide international peace.

"The Debt of the Modern Steam Engine to Charles T. Porter"

was the title of Prof. F. R. Hutton's address, which was as follows:

We have just heard that the John Fritz Medal for the current year has been awarded to Charles T. Porter for scientific or industrial achievement under the terms of the deed of gift, and that his achievement has been to advance the knowledge of steam engineering and effect improvements in engine construction.

I am to speak in detail of the character of these achievements and improvements; and of the debt that the reciprocating type of steam engine at the beginning of the twentieth century owes to the pioneer work of Mr. Porter in the latter middle of the nineteenth.

This debt may be grouped under four heads:

First, we owe to him the first vision of the advantages to spring from the plan of making the crank shaft of a steam engine turn at a high number of revolutions; or to have the piston make a large number of traverses per minute in the bore of the cylinder.

It must be remembered that in 1860, when this inspiration came to Mr. Porter, the United States was scarcely as yet an industrial community in the sense in which it became one after the Civil War, and after the engineering schools began their service following the Morrill Land Grant Act of 1862. Great personalities had arisen, such as Haswell and Copeland, Horatio Allen and Ericsson, Stevens and Latrobe, Baldwin and Winans; and their successes were in evidence. But the great mills of New England were run by water power, as was the armory at Springfield; the great producing plants, which grew up subsequent to the war of '61-'65 were unthought of. The boy in kilts, who like myself had a hankering to see the railway locomotive, was escorted by a patient maid to the extreme limit of the city among the market gardens and ruralities of the northern end of the Fourth avenue tunnel at Forty-second street, and a successful blast furnace was in full operation at One hundred and Thirtieth street and the Hudson river, where the Edgewater ferry houses now stand. Sickels, Worthington and Corliss were in the first or second decades of their productive activity, but had made little widespread impress on the manufacturing centers. The locomotive and the marine type of engine had felt the influence of master creative minds, but the stationary power plant of small size was still under the headway of Watt and the standards received from England. English practice grew from the early requirement of the pumping engine for its mines and water works, and the slow rotation favorable to pumping, to paddle propulsion and to the beam type of transmission was the heritage of all designers.

The electrical age had not yet been born, for the Faraday discovery of the mechanical generation of electric current was still only embodied in a piece of laboratory apparatus exhibited with respectful awe to students of the natural sciences, because as yet there was no commercial solution to the problem of the electric arc and lamp, no filament for the incandescent globe and no practicable motor for the reconversion of electric into mechanical energy. No engine designer of stationary engines for mill or factory work cared to speed up the line shafting, for the millwright of the day was perforce using partly balanced pulleys and cast gears with hand-profiled teeth. The factory power unit was comparatively small because the mill was, also. The piston speed was standardized between 200 to 300 feet per minute, or an engine with 2-foot stroke turned from 50 to 75 revolutions per minute.

It should not be necessary in this presence to do more than to refer to the conditions in the reciprocating-piston pressure motor that the work per minute is the pressure P in pounds per square inch over an area A in square inches as the force; and that this force moves over a space in feet which is the length L of the piston traverse in one stroke multiplied by the number N of such traverses. Nor to the fact that the factors which give weight and bulk to the motor are the length L and the area A. To increase N adds little to the weight and inappreciably to the bulk; and to increase *P* necessitates increased strength of parts, but adds nothing to cylinder diameter or length, but may enable both to be reduced. By his recognition and advocacy of the sectional boiler with tubes inclined from the vertical as made by his associate, John F. Allen, Mr. Porter helped to raise initial steam pressures; by increasing the rotative speed from 50 or 75 turns per minute to 150 per minute, he initiated the era of the high-speed steam engine.

From this seed thought of reducing the weight of the motor per horsepower have grown many stately plants of modern day, in the sight of whose blossoms we sometimes forget the hidden roots. Or, to change the figure, there are many structures which rest upon this idea as their foundation, whose appeal to our instant recognitions makes us forget that they are upheld by this early vision of our honored guest. The direct-connected dynamo to be later referred to; the high-speed steam launch, the motor vehicle, the aëroplane, all rest upon the concept of diminished weight per horsepower capacity. Someone may say that this is so obvious that engineers could not help seeing the principle. Granted. But it was given to Mr. Porter to see it *first* as far back as 1860, and to make the hard fight necessary to secure its recognition. All honor to the man who sees a truth for the first time, and before it has been revealed to all!

The second debt we owe Charles Talbot Porter is for recognition of the truth that the problem of mass-accelerations for the reciprocating parts was a vital one, and success was bound up in solving it aright. When the pumping-engine piston or that of the paddle-wheel boat making 30 revolutions a minute, with 8-foot stroke, starts from rest, the moving masses have the time of one-half stroke to reach the velocity of the uniformly revolving crank. This is approximately one-half second. The force necessary to impart this stored energy is the product of the mass accelerated into the half square of the velocity per second. When the time of one revolution is changed from the speed of 30 per minute to 150 per minute, the time for acceleration becomes one-fifth of what it was before, or it must be effected in one-tenth second; and the force to store this greater energy increases as the squares of the velocities if the masses are the same. Hence the fact first observed and worked out by Mr. Porter, that the push of the steam in the cylinder only reaches the crank pin after the work of acceleration has been completed. This also has become a commonplace of the textbooks, and a platitude of the computing designer. Mr. Porter's graphical method of solution by superposing the steam effort *P A* upon the acceleration resistance diagram is everywhere now in use. But he used it first, and we owe him this debt.

The third debt which we owe to Mr. Porter is his recognition of the fact that the high rotative speed and the problem of mass acceleration compelled a standard of mechanical construction for the steam engine which was far ahead of the standards and practice of his time. This is perhaps the greatest unshared obligation of all. It would not do for the crank pin to be oval, or with axis inclined to the plane of connecting-rod effort. It would not do for the shaft to bear only upon a group of segregated points in the bearing. The crank pin must not fit or bring pressure upon an area much less than that computed as necessary for effective lubrication and consistent with long life and cool running. The crosshead must not bump along in contact only with high places upon the guides; the latter must not be warped surfaces, flexing and twisting the connecting rod in its work. Valve-rod pins must bear over their whole length and projected areas; joints in the governor must be drilled in parallel planes so that the pins shall not twist and bind and retard the governor action. Platitudes and commonplaces of engine construction, do I hear anyone say? Indeed, yes, for the twentieth century, but they are so because Mr. Porter first made them obvious. These were not recognized in 1860; that they are now is because of painful uphill effort against shop inertia and the conceit of the craftsman of that date. All honor to Mr. Porter for making these visible to us for the first time.

In this same class are his recognition of the advantages of the double crank unused before for stationary practice, and now so usual in the high-speed center-crank engine; his initiative in the matter of automatic lubrication of bearings both stationary and moving; the utilization of centrifugal force to compel oil to go where desired and needed and to prevent its creeping where it was not wanted. These are universal now; their design was a creation by Mr. Porter in 1860. The design of bed plate with a sweeping curve from the plane of the guides forward to the plane of the path of the crank pin, [illegible] as the "Tangye" bed by British writers, is Mr. Porter's idea, and the overhanging cylinder attached to the bed at its crank end and free to expand toward the head end without deformation is a Porter form as is the collarless crank pin with a [illegible] held in place by a [illegible] bolt. It is given to few to have their creations so completely [illegible] for the first time.

Our fourth obligation to Mr. Porter is for his creation of a form of steam-engine condenser with an air pump capable of being directly driven at high speed of piston traverse from the piston rod of a high rotative-speed engine. This design eliminated the [illegible] plunger moving in and out of a mass of water within the chamber [illegible] the upper portion of the [illegible] and [illegible], acting as a water piston to create and maintain a vacuum above it, without dependence on piston packing. The jet condenser was above the plunger, and the hot-well was beside the injection chamber. The bottom of the latter, or of the condenser proper, had an inclined bottom, so that the water would be drawn out first through the foot valve, and the air following it later in the stroke. The water passing with that of the water piston in the lower part of the pump chamber would pass out into the hotwell through the discharge valve last, the air going first from the upper part of the chamber, so that the tendency for the water to [illegible] was greatly lessened. Mr. Porter considers this pump one of his most notable triumphs of that day; and it is a commonplace of the pumping practice of today.

And, finally, we owe to Mr. Porter the origination of the earliest form of loaded-weight governor. Historically, this was one of his earliest ideas. It was to modify the conical pendulum as applied to regulate an engine, so that the force [illegible] bringing down the balls of the revolving pendulum should be greater than that due to gravity upon the mass of the balls themselves, and to eliminate the friction which had been caused in the joints of a governor by the inertia of the mass required to give necessary power, when such mass was placed in the revolving balls. This change in governor design made it possible to speed up the spindle and revolving balls, and both speed and diminished friction added enormously to the sensitiveness of the spindle type. But not alone do we owe to Mr. Porter the central-weight design; we owe to him further the idea of using a spring having an initial tension to force the revolving balls inward against the tendency they manifest to follow the tangent and fly outward. While first designed for a marine engine governor, to be independent of position of the spindle, it is the basic idea used later by [illegible], by [illegible], and all designers of shaft governors as their underlying scientific principle, with the loading [illegible] appearing in the designs of [illegible] & [illegible] and others. It underlies also the [illegible] spring designs of [illegible] and Pickering.

What, therefore, are we tonight and here doing [illegible] to [illegible] the debt of our age to Mr. Porter:

(1) For his vision of the high-speed steam engine.

(2) For his grasp of the principles of mechanics which [illegible]

(3) For his setting a standard of mechanical work and construction [illegible]

(4) For his creation of two types of mechanism in [illegible] engine [illegible] with [illegible]

I [illegible] debt [illegible] Charles T. Porter [illegible] ingenious mechanic, skilled designer and originator of the Richards form of the steam-engine indicator, present with us tonight as an honored guest. He created this at the urgence of Mr. Porter, to meet the demand for a steam-engine indicator capable of giving a reliable record of pressures in the cylinder of a high-speed steam engine. His concept of a multiplying parallel motion whereby a stiff spring and small piston motion with light masses should be used has underlain the derivatives which have replaced his early design. I am reminded by Mr. Porter that Mr. Richards also designed the first Allen engine bed, and the engines of the Colt armory, now running after more than 40 years, a most bold and successful achievement. May he live long to enjoy the esteem of his associates and fellow workers.

The other reference is to John F. Allen, who has gone to his reward, so that the tribute of this gathering must be only as a wreath upon his tomb. I do this the more gladly since it has been requested of me by Mr. Porter himself.

To Mr. Allen we owe the elegant invention of the single-eccentric link and four-opening valve, with pressure plates, to secure elimination of friction pressure. He gave to the slotted eccentric strap an adjustment which equalized the pressure diagrams taken from the opposite ends of the cylinder, at every point of cutoff, and retained, with a simpler and positive mechanism the features of constant release and compression with variable point of cutoff, which up to then were the exclusive prerogatives of the liberating system. These are today features of every high-speed engine gear. He gave to the locomotive the double-port opening property by the use of the hollow channel over the back of the shell; he designed a sectional water-tube boiler, in which how tumultuous soever might be the circulation of water and steam gas, the tube could never go empty. He invented a riveting machine using either pressure or percussion to upset the metal, and a high-speed air compressor to be its adjunct. I am glad to connect up to Mr. Allen these factors of his ability, which meant so much when the engine of the seventies and eighties became known as the Porter-Allen engine.

"The Debt of the Era of Steel to the High-speed Steam Engine"

was the title of Robert W. Hunt's address:

Naturally, I feel honored by having this opportunity to represent the American Society of Civil Engineers and the American Institute of Mining Engineers, in this first ceremonial presentation of the John Fritz medal. Aside from any personal equation, I am glad that such a manner for the bestowal of the medal has been inaugurated, and I sincerely hope the custom will be maintained for all future presentations. I regard the receipt of that medal as one of the highest honors which can be paid an engineer, and it is fitting that its presentation should be attended with an impressive but simple dignity, typical of the men in whose honor the medal was established. As you will recall, this was done, and the necessary fund secured, as one of the surprises given Mr. Fritz by his uncountable friends upon the celebration of his eightieth birthday. All who know him appreciate that his modesty would have prevented his having taken such action of his own volition. That he may live to participate in the bestowal of the medal for many years to come, is our earnest prayer.

I suppose if a man will only live long enough, his life will certainly cover some more or less eventful periods. It seems to me that my life must have been a very long one, or else the world has been more than busy during its continuance. It has been my fate to have been in touch with the happening of a lot of things, and some of them have been connected with the solutions of iron and steel problems. I have witnessed the development of bessemer steel from its struggling birth through its tremendous, almost unbelievable, growth up to its now suggested decadence. Practically all of those accomplishments were made possible by a more rapid application of power.

Perhaps because the smelting of iron and its subsequent manipulations were titanic in character, and because man was habituated to slow movements, it was imperative that the early processes should have been deliberate; at all events, the original ones were so. The first power applied in the industry beyond that of man, came from the slow-turning water wheel; later, from the slow-speed steam engine. As developments required faster movements, it was obtained through accelerating gears and belts.

Among the first, if not the first, engineers to make direct attachment of a rolling-mill engine to its train of rolls, were John and George Fritz. They thus avoided the expensive and frequently breaking intermediate gears; but the practical speed of their comparatively short-stroke engines was limited, and, so far as I know, Charles Talbot Porter was the first one to give the rolling-mill engineer a controllable, direct-connected, economical high-speed engine.

In 1876, I was general superintendent of the Albany & Rensselaer Iron and Steel Company, of Troy, N. Y., to which organization Alexander L. Holley was consulting engineer. One of the company's buildings had been used as a puddle and top-and-bottom mill, with its necessary puddle and heating furnaces, rolls, etc. The substitution of the manufacture of steel in place of iron rails threw this plan out of commission, and it was determined to convert it into a bessemer merchant-steel mill. The puddle and top-and-bottom mill had been driven by a walking-beam low-pressure engine which had been removed years before from the steamboat "Swallow," following its historic wreck on the Hudson river. The engine stood between the two trains and ran at from 35 to 40 revolutions per minute, the speed of the rolls being increased through heavy gears.

The possibilities of the adaptability of bessemer steel for uses other than rails had been so fully demonstrated by the European exhibits, notably those from Sweden, at the Philadelphia Centennial exposition, that our company decided, as has been stated, to take up its manufacture, and, acting under Mr. Holley's advice, put in two three-high mills, driven by Porter-Allen engines; a 22x36-inch one for the 16-inch train, and an 18x30-inch one for the 9-inch train of rolls. I believe those were the first of Mr. Porter's engines applied to the driving of iron or steel rolling-mill rolls. These new mills were located in the south end of the old puddle-mill building; the old "Swallow" engine and trains were in its north end, and we subsequently remodeled the trains and used them for rolling steel. To see the "Swallow" engine performing its duties with so great seeming deliberation at one end of the building, while in the other end Mr. Porter's two little engines were humming away and accomplishing much greater results, was an educational sight.

We frequently rolled light-section steel rails on the 16-inch train, and were so doing when Mr. Porter made us the visit mentioned in his "Engineering Reminiscences." He relates that our president, Erastus Corning, while standing with him watching the operation, asked a boy, probably a "water boy," "why they were not feeding the billets to the rolls faster." The boy replied: "Because the gentlemen at the hooks could not catch them, sir." The fact that the "gentlemen" of not only that mill, but also at our regular steel-rail mill rolls, could not work faster led me to put in the power-driven tables, which have since in their development done so much to make possible the tremendous output of American rail mills.

This first use of Porter-Allen engines was followed rapidly by other parties, until direct-acting high-speed engines became the typical American rolling-mill type, and I take this occasion to put on record the great debt which iron and steel engineering owes to Charles T. Porter. It has been my good fortune to claim him as a friend for many years, and from the first I have known him and esteemed him as I do now, as a high- and simple-minded, clean-living man, and a profound student. The heavy hand of time has perhaps taken from him a former additional appellation, which was truly his, that of a hard worker, but if ever a man earned the right to rest, it is he!

"THE DEBT OF THE ERA OF ELECTRICITY TO THE HIGH-SPEED STEAM ENGINE"

was the title of Frank J. Sprague's address:

Mr. Chairman, guests of the evening, ladies and gentlemen. It is a trite saying, but often true, that expectation is better than realization, and hence due consideration for the comfort and pleasure of an audience sometimes, and in this instance surely, warrants a late speaker in first acknowledging the truth of the obligation declared in the subject set for his remarks, and then as promptly as permissible dismissing consideration of it. This is a liberty accorded at a time of general rejoicing, when pessimism may be thrown to the winds, and dry statistics consigned to temporary oblivion.

It has been said that every stable government should have, and is benefited by a sizable national debt; and with that happy disregard of the fact that like business fundamentals should govern private and public business, our political sponsors, representatives and executors cheerfully pile obligation on obligation for the stability and happiness of posterity.

So tonight, in interested humility, we have listened to many tales of the debts of our industrial development to the high speed engine, until they have piled up so high as to awaken the envy of a national treasurer complacently facing a $100,000,000 deficit. I am sure that our esteemed confrere, the honored guest of the evening, must at times have felt as did our patron Crœsus when he first securely established his prior lien on a great industry, and perhaps, in an ecstatic impulse of generosity he would be inclined, if only these debts could be cashed in, to establish a Porter Foundation for the Benefit of Indigent and Superannuated Engineers.

The connection of Charles Talbot Porter, individual, with the electrical industry, has not been directly a wide one. It is nearly fifty years since he, an American engineer, sought for his hunting ground, not Mombasa, or the country of the blue Nile, but the home of Watt, in the very fastnesses of insular prejudice and complacent engineering authority. His experience in combating for six years certain preconceived notions and practices has already been most eloquently told, but I may recall the fact that in 1867, at the French exhibition, he installed with British and two Porter-Allen engines, the only high-speed machines, I believe, there exhibited, to drive generators for supplying current for lighthouse apparatus. While these engines were not directly coupled, it is a curious fact that the piston speeds and revolutions were what is common today in isolated direct-coupled plants. At that same exhibition a 300-revolution engine was also installed, and this was sometimes operated without load at over three times this speed. In the dozen years succeeding his return to the United States, Mr. Porter built many engines for various purposes, most of them having certain common characteristics, high piston speed and revolutions, solid engine bed, overhung cylinder and babbitted bearings, but in all this time there was no electric driving until a contract was made for engines for this purpose in Philadelphia.

About this time appeared a "wizard." It was once said that engineers constituted "the best educated set of damn fools in the world," and I suppose among us we must include that class known specifically as inventors. Now there is a very narrow margin between the wizard and failure, on one hand, and eminent success on the other. Happily, in this case the middleman was Thomas A. Edison, for whom, about 1880, Mr. Porter installed a high-speed engine in the laboratory at Menlo park. Shortly after, when planning the installation of the Edison station, first district, at Pearl street, New York, Mr. Edison decided upon an equipment of so-called steam dynamos, later familiarly known as "jumbos," each to be independently driven by a direct-coupled engine. As a consequence, Mr. Porter was invited to construct the first of these engines, and it is a curious commentary that in this particular combination he, in a general way, reversed the ratio of weights for engines and dynamos, the proportion being about 7 to 1 in favor of the engines. It is needless to dwell upon the vicissitudes of that first installation, or the changes which were necessary; both apparatus and plant have passed into history. But I may remark in passing that high engine revolutions is simply a function of high piston speed and length of cylinder, and that in some of our greatest installations, that of the Fifty-ninth street Interborough station, which marks the acme of this type of installation, high piston speed has been accomplished by a comparatively low speed of revolution, but with direct-coupling because of the great size of the electric generators. For this class of service the reciprocating engine is now on a fast descending scale of use for all new work, and the more modern turbine, the outcome of the work of Parsons, Curtis and others, will reign supreme.

Debt there has been, and a large one, of electric development to the high-speed engine, but I am sure that our friend will agree with me that all sound bookkeeping must show a credit entry for every debit one, and in that generosity of heart characteristic of all engineers imbued with catholicity of spirit he will admit that whatever that debt, it is being repaid in royal fashion. Let us think, then, not of debtor and creditor, but of a most interesting fact, an industrial marriage, one of the most important in the engineering world, that of the prime mover and the electric generator.

The world traveler, sailing into the harbor of Kobe, on the southern coast of Japan, and forgetting for a moment the spectre of war so [illegible] improvable and [illegible] will, if favored by happy circumstances, find himself in the presence of an impressive sight, for there, as it were [illegible] apparently floating on a bed of fleecy clouds, he will see the truncated summit of a great volcano, once a terror but now extinct, Fujiyama, the sacred mountain of Japan, famous alike in history and in art.

It is many years since, on a summer's day, while I lay exhausted half way up its rugged slopes, I saw far below me a man and woman, attended by native guides, laboriously working their way over the sand and scoria which deeply covered the mountain sides. Curiosity as well as fatigue impelled me to await the coming of, naturally, two Americans, a professor at the Imperial College at Tokio and his wife, the first white woman, I believe, who made the difficult ascent. This chance meeting ripened soon into a friendship which afforded me an early opportunity to learn of a graceful, courteous characteristic of the inner life of a remarkable people, for shortly after, on the occasion of a marriage anniversary of my friends there was presented to them by a Japanese servant a beautiful picture of the great volcano, and a poem congratulatory of their married state. This likened the man to the majestic mountain in all its dominant strength and overpowering grandeur, and the wife to the beautiful Lake Biwa, resting in happy security beneath the protecting shadow of her consort, fed from his melting snows, and mirroring and reflecting from her pure and placid bosom with unchanged truth, [illegible] the changing moods of her mate, each a complement of the other, both necessary for a harmonious unity.

It is a far cry from the sacred [illegible] the Atlantic coast, from a [illegible] home in the Hermit Kingdom to the [illegible] meeting place of the engineers in Manhattan, but [illegible] heart a [illegible] tion, and the thought of perfect union and [illegible] Japanese [illegible] with us, and [illegible] tion of the elements of every great engineering work.

Our engineering fraternity is a "[illegible] [illegible] there shall be no complaining? And in all our clientele is there any more perfect example of an industrial marriage than the modern high-speed direct-connected electric generator, any more beautiful, enduring and graceful monument of engineering skill?

Let the busy cynic come away from bank and mart, from press and ticker, from club and sport; and woman, too, from household cares and the social whirl, from matinee and bridge, from astrology and the suffragette; and learn a lesson from our humble friends in a great central station, at the starting of their career in housekeeping. The courtship has been a long one, and the marriage ceremony perhaps a little tedious. The groom, forsaking the early tenets of his slow-moving ancestors, and impelled by an innate consciousness of virility vital to meet his coming burdens, has awakened to the necessity of a quickened life, while the bride, in early life a little flighty and nervous, has sobered down to a realizing sense of her new responsibilities. Like the ostriches, they are mated for life; there may be grief and disaster, but there will be no divorce.

How is it these two machines have come together, economizing space, increasing economy, augmenting capacity, reducing investment and increasing dividends? Is this final result the work of any one man? Would the electric art have stood still were there no high-speed engines? To both questions we must answer, No. The truth is that here were two machines destined to be joined in some fashion. One was, in its early development, when used for stationary purposes, normally a slow-speed machine, the other a high-speed one; and so constructed that the only connection was through countershafts, gearing and belts. Every practical consideration, especially when considering central-station operation, pointed to the necessity of eliminating all extraneous devices between the two, and hence augmenting the speed of one and reducing the speed of the other until they could be physically united. And in this development every advantage had to be taken of the possibilities of each, and likewise due heed paid to their individual limitations. Primarily and largely due to Porter, the high-speed possibilities of the former were commercially demonstrated before the necessity arose for reducing dynamo speeds to coincide with engine requirements, although in the great commercial and mechanical development each machine has been indebted to the other, but all honor must be paid and credit given to the men who first blazed the way for the present possibilities.

In every industrial development there appears at some time an engineer with imagination, courage and foresight, who defies chance, courts failure, and embraces opportunity. He may not clearly see the goal to which he is aiming, he may be unconscious of the full measure of the influence of his work, but somehow he is impelled by certain primal convictions which in the face of every discouragement lead him onward. It is to the man and the men, then, not to the machine, that the modern industrial development is indebted. It may be true in this case that the machines which bore the brunt of early development, and the men who staked their all upon it, may have disappeared as practical factors in the present status of the art. Newer makes of machines, improved and widely different governing apparatus, entire abolition of the reciprocating engine for great central-station units, may be the verdict of history. The spirit, however, which blazed the way never dies, and the names of Porter and Allen, Armington and Sims, Sweet, and a host of others, will be linked in industrial history with those of Parsons and Curtis. .

It is precisely such occasions as this, and such honorary tribute as mark tonight's gathering, which happily commemorate the early sacrifices and influence of the pioneer. And so on behalf of the electrical profession, I extend hearty congratulation to Charles Talbot Porter for the honor which has, by the verdict of his brother engineers, so deservedly come to him.

Distinguished Guests Present

Seated upon the platform were Henry R. Towne, who presided; E. Gybbon Spilsbury, chairman of the Board of Award; Prof. Charles B. Richards, who was associated with Mr. Porter in his earlier work, and who invented the Richards indicator to make it possible to indicate his high-speed engine; Jesse M. Smith, president of the American Society of Mechanical Engineers; Sir Charles Algernon Parsons, inventor of the steam turbine; John E. Sweet, Rear Admiral George W. Melville, James C. Brooks, president of the Southwark Foundry and Machine Company, present builder of the Porter-Allen engine; Rear Admiral George W. Noble, Former Chief Engineer Wallace, of the Panama canal; James Douglass, past president of the Mining Engineers; George G. Ward, representing the Institution of Electrical Engineers of Great Britain; Charles L. Clarke, of the Mining Institute; George H. Pegram, of the Interborough, who installed the first dynamos in this country having connected engines; M. Pickler, a Hungarian engineer and old friend of Mr. Porter; Charles Warren Hunt, secretary of the American Society of Civil Engineers; Schuyler Skaats Wheeler, ex-president of the American Institute of Electrical Engineers; and Prof. F. R. Hutton, Prof. W. F. M. Goss, Robert W. Hunt and F. J. Sprague, the orators of the evening.

Telegrams from John Fritz and E. D. Leavitt, letters from William H. Maw, editor of *Engineering*, from "All Hoyle," and a former apprentice at the Southwark Foundry and Machine Works during Mr. Porter's time, together with cablegrams from the Iron and Steel Institute, Institute of Mechanical Engineers, and the Institute of Civil Engineers were read.

Power Plant of West Point Military Academy

A Gilt-edge Lighting and Heating Plant. Test Record Shows Remarkable Thermal Efficiencies for Noncondensing Engines

Since March, 1802, West Point has been the seat of the U. S. Military Academy, which is located on the west bank of the Hudson river about 50 miles above New York. The reservation extends for about three miles in a north and south direction with the principal buildings located in the immediate vicinity of the parade ground, which is located upon a broad plateau about 150 feet above the river level. During the past few years Congress has appropriated a total of 7½ millions of dollars for the enlargement and improvement of the academy, this being made necessary by an increase in the corps of cadets from which most of the commissioned officers for the army are appointed. With this large appropriation it was proposed to build a new cadet headquarters, cadet barracks, hotel, academic building, administration building, chapel, bachelor officers' quarters, cavalry and artillery stables and barracks, quartermaster's storehouse, riding hall, power house and other buildings of less importance.

Extending to the north and south from the parade ground the main roads afford means of reaching the officers' quarters, while at the extreme south end of the post are grouped the stables and barracks for cavalry and artillery companies stationed at West Point. At the extreme north end of the post is the hospital and site of the proposed [illegible]. North of the parade and alongside of the river is a flat low-lying plain level with the railroad tracks and on the gradual slope from the parade above to the plain are located the quartermaster's buildings, shops and barracks for some service detachment and barracks for the band.

As first proposed the power plant was to supply steam as well as electricity to all of the buildings, but as the buildings at the extreme north and south ends of the post were separated by a distance of over two miles, steam distribution through tunnels was out of the question, so that it was decided to restrict the distribution of steam to the buildings bordering upon the parade, the only large buildings not reached being the cavalry and artillery stables and barracks at the south part of the post, and the quartermaster's stores and other similar buildings at the north. These are to be taken care of by separate plants, either by hot water or by steam arranged on a gravity system. Consequently, the proposition was to design a plant sufficient to supply steam and [illegible] the large buildings of the central group then proposed and to be

FIG. 1. THE WEST POINT POWER HOUSE, [illegible]

nish electricity for lighting and for power purposes for the entire post, the plant to be of sufficient size to permit of future installations should the corps of cadets increase to 1200. Provision must also be made for the storage of 4500 tons of anthracite coal in the plant.

A study of the plans for the various buildings seemed to indicate that about 3000 horsepower would be required for warming and ventilating the buildings and supplying hot water for bathing purposes, with a possible increase of 600 horsepower required by the increase in the corps mentioned. The estimated electrical load appeared to be about 1200 kilowatts for the buildings immediately contemplated, and about 200 kilowatts additional for the increase.

Several locations for the power plant were considered, but the logical site from an engineering standpoint seemed to be on the low-lying land between the railroad and the river. Here the underlying rock sloped off so quickly that proper foundations could not be secured, but it was finally decided to blast out a pocket in the rock over the southern entrance to the railroad tunnel and there locate the power house. Under the circumstances, this was undoubtedly the best thing to do, although it must be admitted that the cost of such construction would undoubtedly be prohibitive for an ordinary power plant. The unusual arrangement of the building will be noted in Figs. 1, 2 and 3. It will be seen in Fig. 4 that the chimney is to be concealed in the tower of the riding hall which is soon to be built, and in Fig. 2 that a tunnel has been provided for the mechanical handling of coal either from rail or water delivery, and for the disposal of ashes in the tower noted at the entrance. The elevation of the railway track at this point is about + 10 and that of the road leading from the railway depot up to the parade ground about + 95 opposite the plant.

The boiler house extends north and south and contains a boiler room on the main floor with a basement extending under the front of the boiler room only. The coal bunker above is a large flat-bottomed structure 148 feet long, 57 feet wide between column centers and about 21 feet 6 inches deep on the clear. A tower at one corner of the boiler room contains the elevator for raising coal, and this tower is connected to the ash tower by the tunnel previously referred to; the tunnel incloses the belt conveying the coal from the cars up a steep incline to the base of the elevator. Beneath the engine room is also a basement, and a tower at the corner of the room provides the principal means of access between the engine and boiler rooms, also space for the chief engineer's office and toilet, and lockers and bathrooms for the operating force.

FIG. 2. VIEW OF POWER PLANT FROM THE ROAD

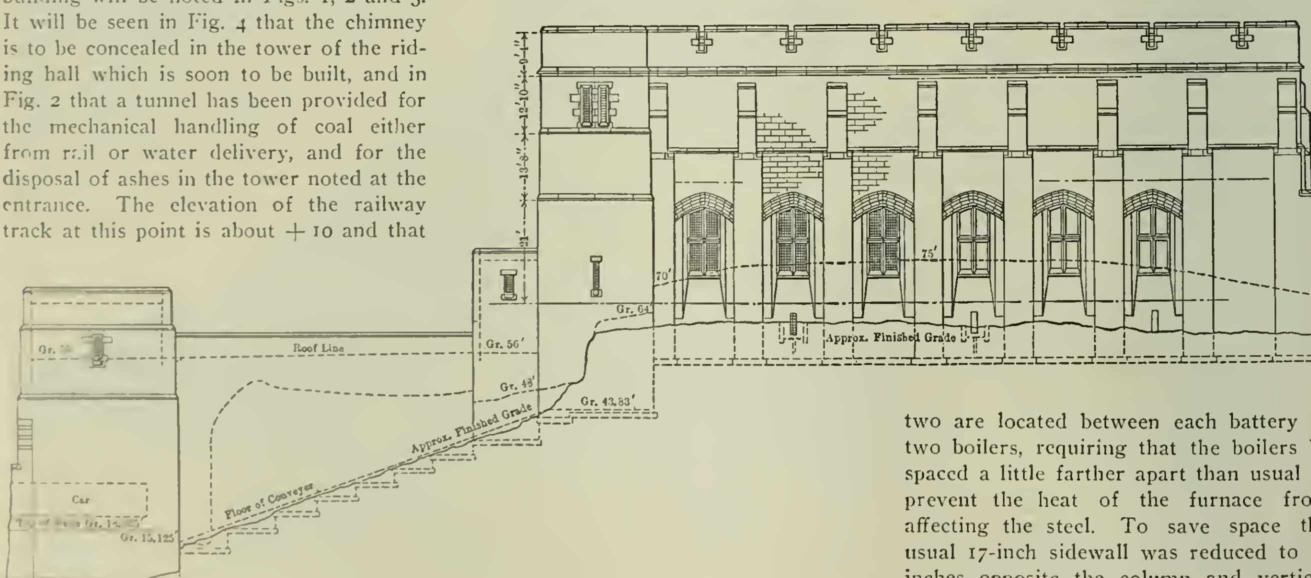


FIG. 3. POWER PLANT ON RIVER SIDE, SHOWING ELEVATIONS OF COAL TUNNEL AND BUILDING

Boiler Installation

At the present writing four Babcock & Wilcox boilers are installed in the plant, each containing about 4400 feet of heating surface and 210 tubes arranged 21 wide and 10 high. The boilers are equipped with Treadkill grates which are proportioned to give 87 square feet of surface under each boiler and a ratio of heating to grate surface of 50 to 1—an unusual ratio for small-size anthracite coal, but permissible in this case as mechanical draft is available when needed.

The boilers are suspended by straps around the drum from horizontal channels carried by the building columns, and the spacing of the columns is such that two are located between each battery of two boilers, requiring that the boilers be spaced a little farther apart than usual to prevent the heat of the furnace from affecting the steel. To save space the usual 17-inch sidewall was reduced to 13 inches opposite the column and vertical cast-iron channels were bolted to the walls to secure an air space. In front of the columns the spaces between the settings were closed by iron plates secured to the flanges of the channel, and bull-nosed brick were laid to finish against the plate.

A Custodis radial-brick chimney has been erected, and this, as previously mentioned, is to be later inclosed by the tower of the riding hall. The inner core of the chimney has an inside diameter at the top of 10 feet, and the stack rises 145 feet above the grate. A ladder on the interior has been provided and also lightning rods

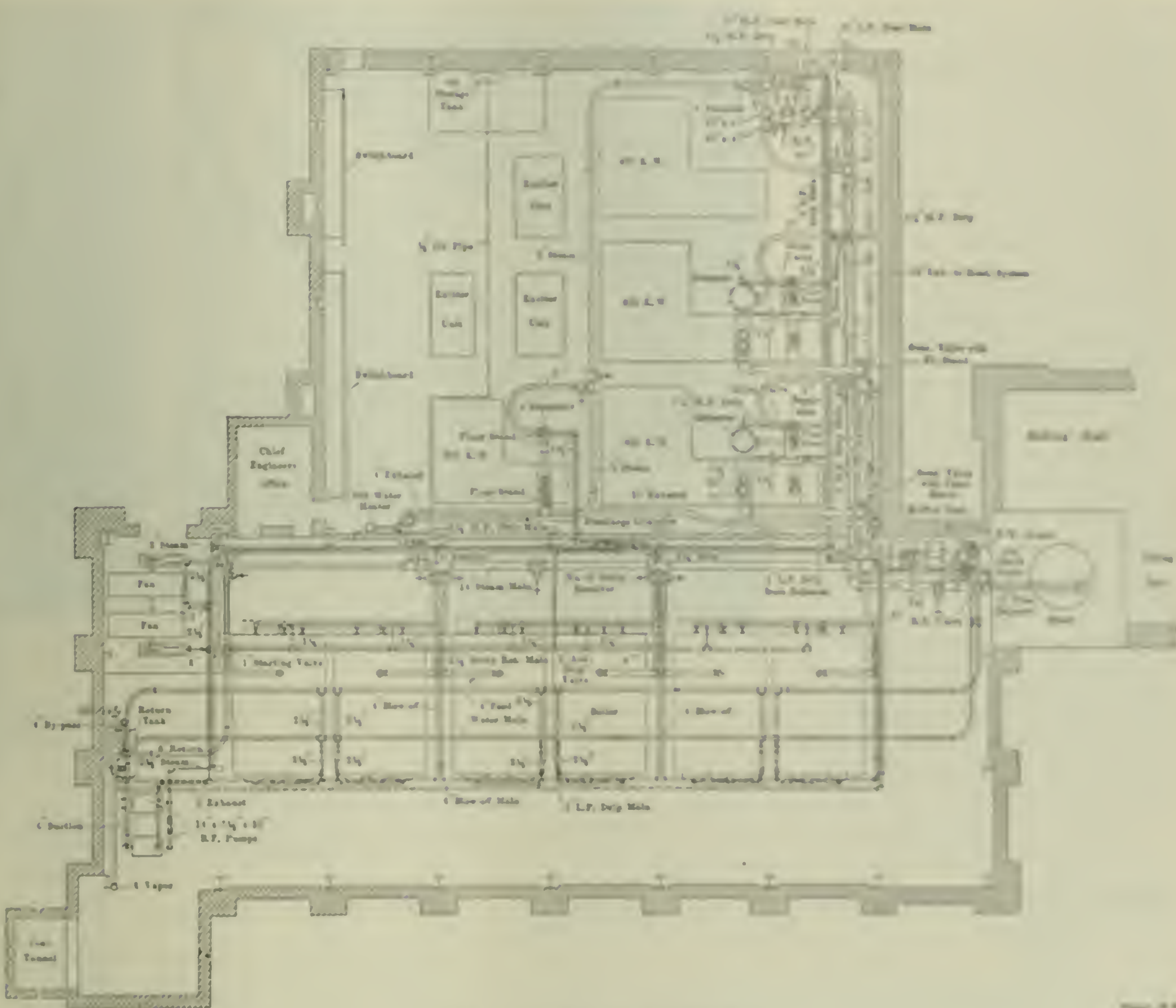


FIG. 4. PIPING PLAN OF STATION

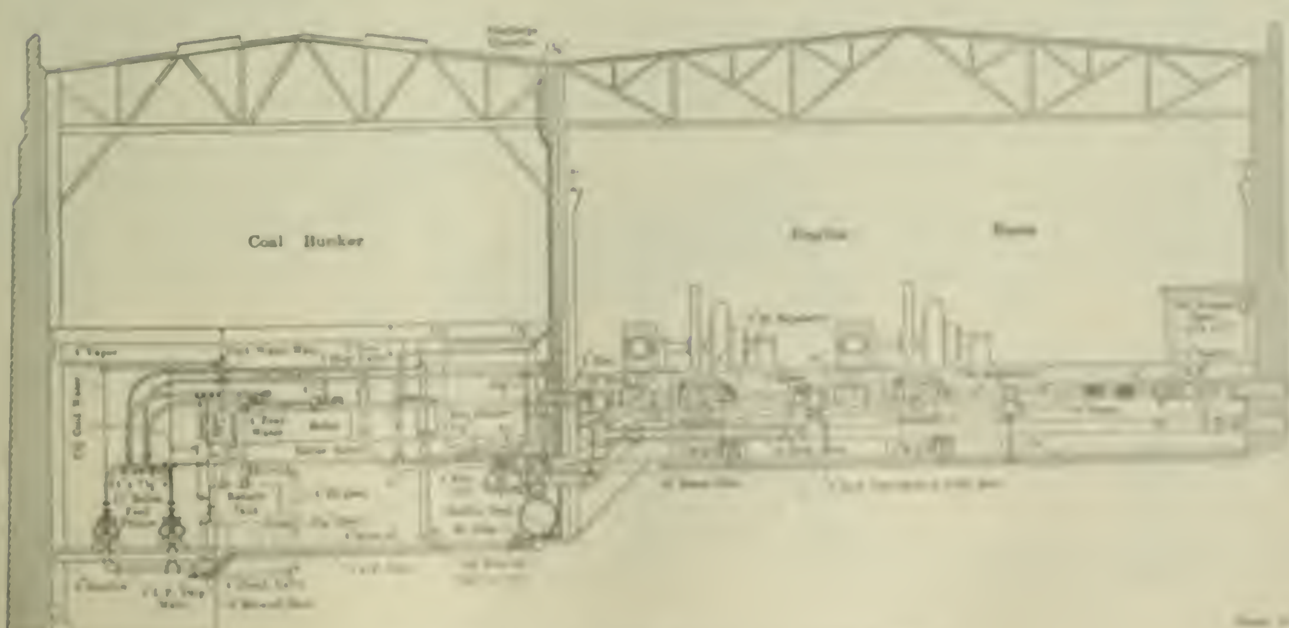


FIG. 5. ELEVATION THROUGH ENGINE AND BOILER ROOMS

connected by a copper cable with an extension run down to the river and there soldered to a submerged copper plate. Within its internal area the chimney also contains a 16-inch cast-iron flanged pipe which was provided to discharge the free exhaust from the engines at the top of the stack, as the escape of this exhaust above the engine-room roof would be objectionable. For architectural considerations the chimney was limited in hight, so that in order to obtain sufficient draft to burn the low-grade coal and run the boilers at their rating, a mechanical-draft plant was installed to help out the chimney in emergency. This plant consists of two Sturtevant fans 8 feet in diameter and 4 feet wide, with engines of sufficient size to drive the fans at 250 revolutions a minute, at which speed each fan is supposed to furnish 55,000 cubic feet of air per minute at a pressure of 2½ inches of water. The installation is located on a mezzanine floor, and each blower discharges downward through an iron duct into a masonry duct running below the boiler-room floor level and extending across the boilers at the rear of the bridgewall, as shown in Fig. 7. Entrance to the ashpit is made through a cast-iron blast box and is controlled by the usual dampers operated by levers extending through the fronts of the boilers. The fans are controlled by a Foster regulator actuated by the boiler pressure.

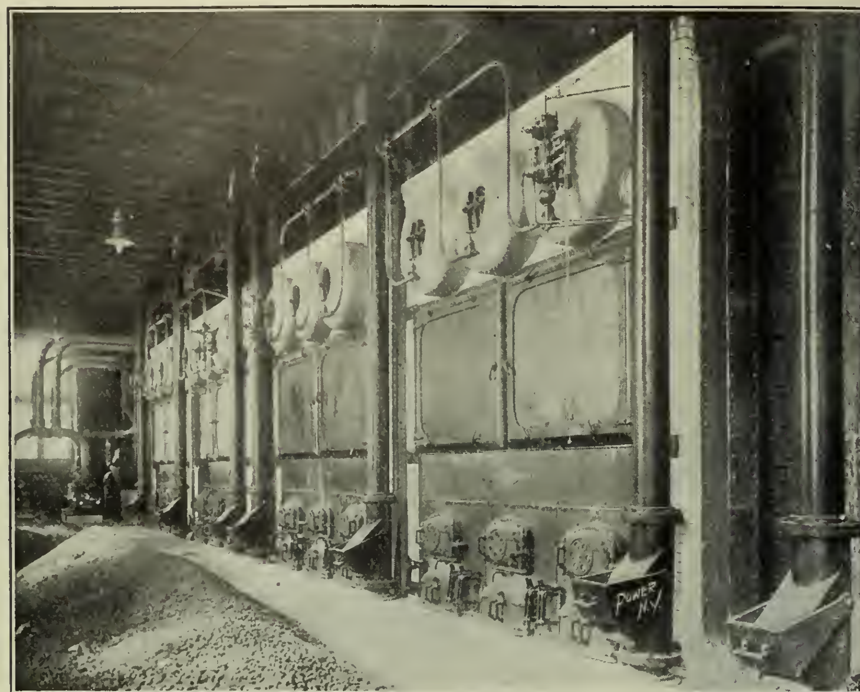


FIG. 6. THE BOILERS AND COAL CHUTES FROM THE BUNKER

From each boiler the smoke connection to the flue is also shown in Fig. 7. The flue has a concrete floor, brick sidewalls and double rowlock brick arches sprung between transverse I-beams for a top. The flue is provided with a pair of dampers close to the chimney. These dampers are illustrated in Fig. 8 and are made of cast iron, heavily ribbed and suspended from the steel floor beams of the coal bunker by a chain of several links with a turnbuckle for vertical adjustment. A Locke damper regulator controls the posi-

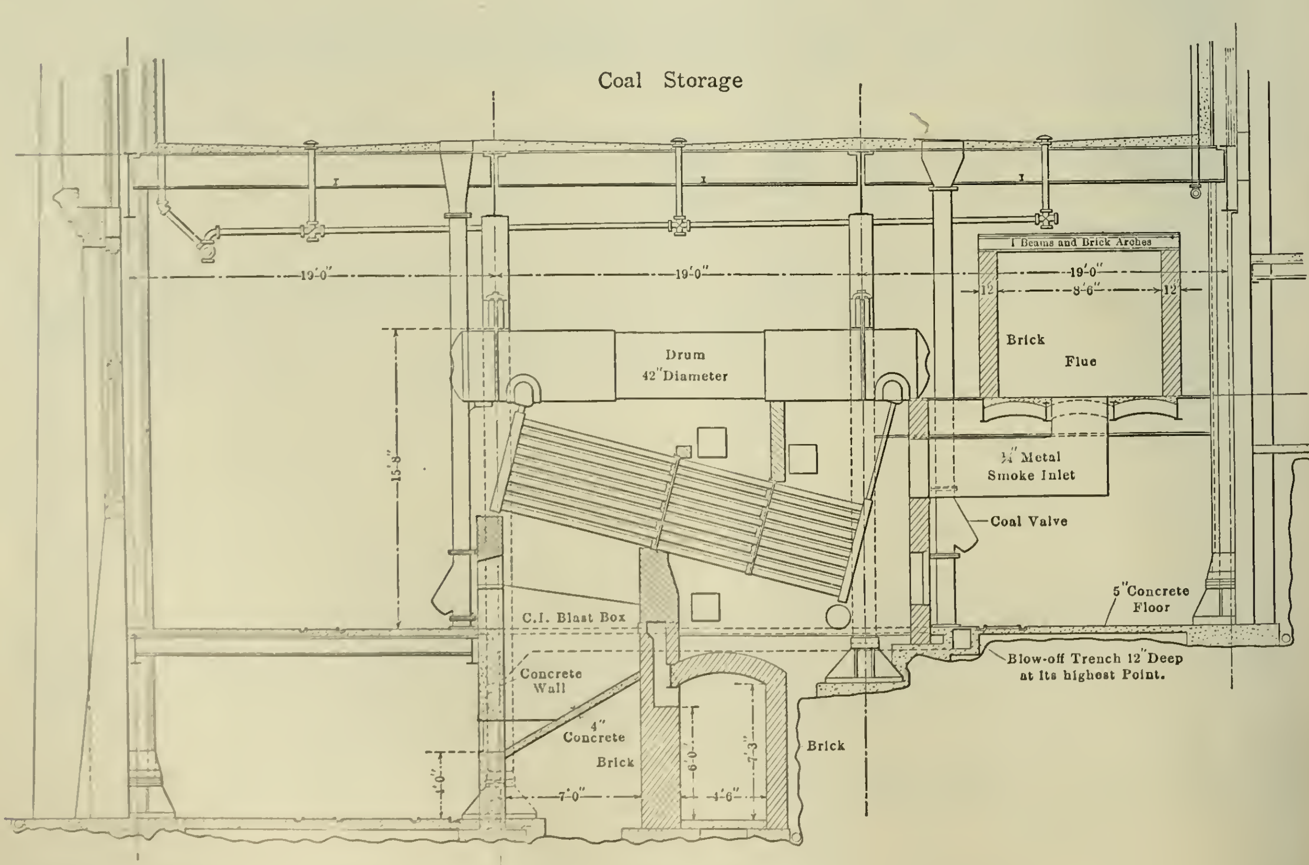


FIG. 7. SECTION THROUGH BOILER ROOM

tion of the damper, but this is not used when the fans are in operation.

Coal and Ash Handling

Figs. 9 to 12 give a fair idea of the coal- and ash-handling equipment. At the present, means are provided only for the mechanical handling of coal delivered by rail, but the system is designed with the idea of taking care of coal by water at any time that it might be desired to so receive it. As the facilities for switching cars at West Point were somewhat limited, it was decided to arrange for the unloading of four 50-ton hopper-bottom cars without shifting. To meet these requirements two tracks were arranged so that two cars could be run in on each side of a belt conveyer and slightly above it, so that a gravity discharge could be obtained through chutes onto the belt.

From beneath the unloading platform the belt runs upward at an angle of about 23 degrees to the base of the boiler-room tower and there discharges into the boot of an elevator which raises the coal to a point above the top of the bunker. From here the coal is spouted onto a transverse belt conveyer extending across the south end of the boiler house, and this discharges into the bunker or onto either one of two longitudinal belts which deliver through automatic trippers to any part of the bunker (except those. In Fig. 9 the conveyer A and the transverse conveyer B are equipped with belts each 18 inches in width, and the longitudinal conveyers C and D are 16 inches wide. The elevator E has buckets 24 inches long, 16 inches wide and 8 inches deep made of No. 12 steel. The system was designed to handle 60 tons of 2240 pounds per hour, but upon test it has considerably exceeded this requirement.

Three Westinghouse motors operate the system, one driving the lower conveyer A, one driving the elevator E and the transverse conveyer B, and one driving the two longitudinal conveyers C and D. The motors are of the inclosed type, and the starting boxes are inclosed in dust-proof iron boxes. An electrical connection is run from each starting box inside of the switch to a pilot lamp on a board in the boiler room. This board also contains an automatic circuit breaker in the main lead supplying all of the motors. The solenoid of the breaker is connected by wires to push buttons at various parts of the conveying system, so that an attendant can by pushing a button stop the operation of the entire plant when necessary. Swinging chutes are provided to deliver the coal from each car to the lower belt, and the

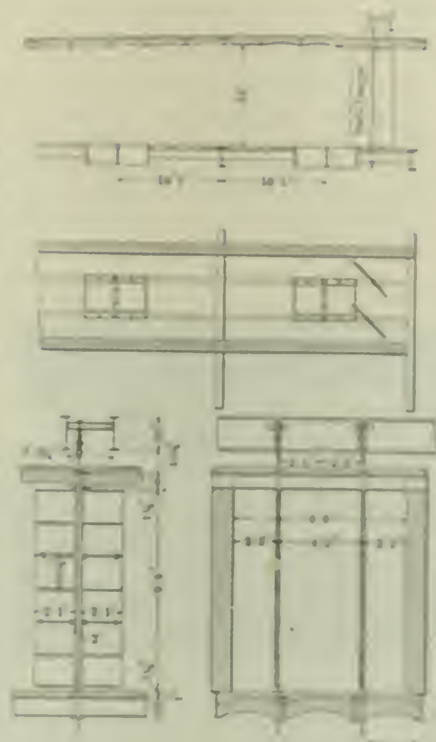


FIG. 8. FLUE DAMPER NEAR STACK

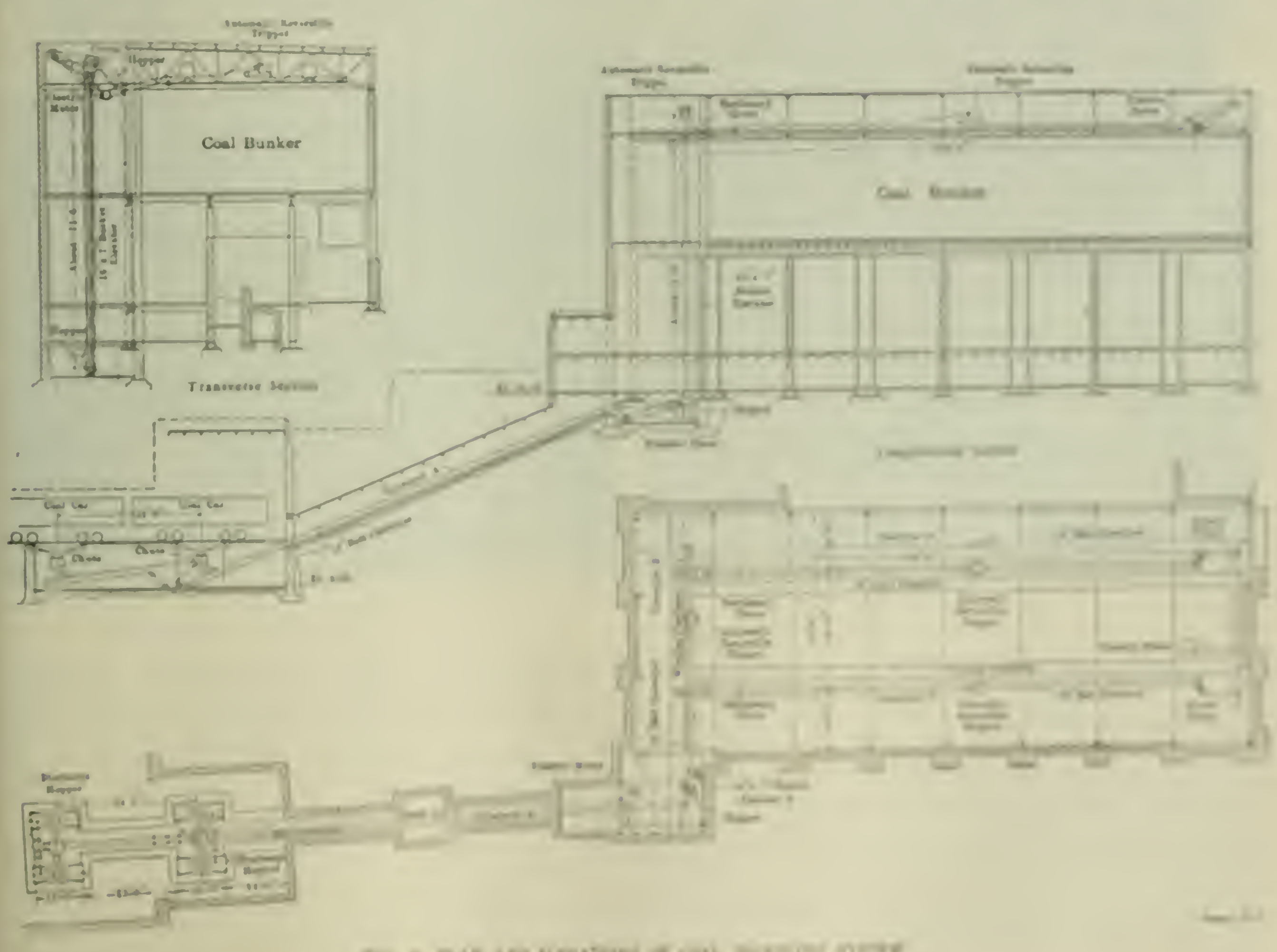


FIG. 9. PLAN AND ELEVATIONS OF COAL HANDLING SYSTEM

motion of this chute is controlled by a wheel on a shaft extending up through the platform on which the cars are located. The Robins Conveying Belt Company supplied the entire conveying system.

From the bunker coal is discharged to the boiler-room floor through a number of chutes located at the corners of the settings, as indicated in Fig. 6. As the bottom of the bunker is flat, similar chutes are provided at the rear of the boilers and are arranged to dump into

FIG. 10. COAL-CONVEYING SYSTEM ABOVE BUNKER

Hunt standard charging cars, so that the coal may be carried on tracks to the front of the boilers. The valves at the bottom of each chute will be noted, and just below the bunker-floor level there is also provided a sliding gate.

Ashes drop from the grate into a deep

FIG. 11. PROVISION FOR REMOVAL OF ASH

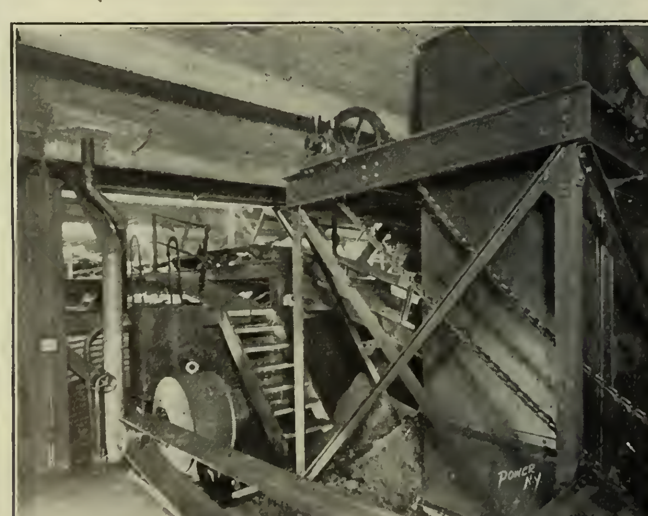


FIG. 12. FROM ELEVATOR TO BELT CONVEYER

hopper provided with the chutes shown in Fig. 11, from which the ashes may be drawn out into industrial cars and run through the boiler-room basement and onto the roof of the conveyer incline to an ash hopper which will be constructed in the near future in the upper part of the tower. From this location the ashes may be discharged into railroad cars for removal, but at present they are used for filling in and are being discharged through a temporary opening through the side wall of the power house by means of wheelbarrows.

Engines

In this department it was decided to install two 400-kilowatt and one 200-kilowatt direct-current generators, each of the larger machines being driven by a tandem-compound Corliss engine and the latter by a simple Corliss engine. These machines, Fig. 13, develop direct current at 240 volts for both light and power, and motor generators are used to obtain alternating current at 2200 volts for the extreme north and south ends of the post. Due to the large amount of steam required for heating during the winter months, and also to the fact that the river was 60 feet below the engine-room level, it was decided to run the engines noncondensing.

A careful selection of the bids of various builders resulted in the selection of Rice & Sargent engines made by the Providence Engineering Works. These units were to operate on a normal working pressure of 130 pounds at the throttle, which might be increased to 150 pounds when considerable back pressure was placed upon the engines during the heating season. The speed was limited to 100 revolutions per minute and the engines were to be capable of running at 50 per cent. overload for short intervals. The tandem compounds were 24x36x36 inches, and the simple Corliss had a cylinder 22x30 inches. Each compound engine was provided with a large reheating receiver containing 0.6 square foot of reheating surface in brass pipes per rated horsepower of the engine. The simple engine has a cylinder steam jacketed in both heads only, and the compound engines have both cylinders jacketed in a similar manner. As apparent in Fig. 13, the engine piping is below the engine-room floor and the main throttle valves and the valves in the exhaust pipes are operated by floor stands.

Trial Tests of Engines

When the time for the trial tests of the engines arrived George H. Barrus was retained to conduct the tests. The guarantees were expressed in the following terms:

"The steam consumption of each compound engine will not exceed 19 pounds of steam per indicated horsepower with a steam pressure of not less than 130 pounds at the throttle and one pound back pressure in the exhaust pipe.

"The friction load of each compound engine will not exceed 4½ per cent. of the rated load which is to be taken at 600 horsepower.

"The steam consumption of the simple engines will not exceed 23 pounds per indicated horsepower per hour when the engine is developing from 275 to 325 horsepower with a steam pressure not less than 130 pounds at the throttle valve and one pound back pressure at the exhaust valve.

"The friction load of the simple engine will not exceed 4½ per cent. of the rated load which shall be taken at 300 horsepower.

"The friction load is to be obtained by

running the engine at its rated speed with a steam pressure of not less than 150 pounds, with the brushes of the generators not in contact with the commutator and the field unexcited.

"A separator will be placed in the steam pipe to each engine and unless there is evidence to the contrary the steam will be assumed to be dry."

The simple engine was designated as engine No. 1 and the two tandem compounds as engines Nos. 2 and 3. It was decided that a test of one of the compound engines would suffice and No. 2 was selected. This engine had been in operation under a load less than three days when the tests were made, and the simple engine had been running under varying loads every night for about twelve weeks. The main steam line, both in the boiler room and in the engine room basement is so arranged with valves and connections to the boilers that No. 1 engine could be run independently from No. 1 boiler, while the other engines and the auxiliary apparatus and other work of the plant are supplied from the remaining boilers. Likewise Nos. 2 and 3 engines can be run independently from Nos. 2, 3 and 4 boilers, while No. 1 boiler is used for supplying the simple engine and all the remaining work of the plant.

Drainage of the steam lines is effected by separators, one for each engine, and by drips located at various low points on the line, all of which discharge into the Holly system installed in the plant. The drainage from the two reheaters of the compound engines, each having 300 square feet of surface, and that from the jackets of the various engines also discharged into the Holly system. Two feed pumps are provided, each discharging into two independent feed lines, either of which can be used for the supply of any boiler. The water is ordinarily drawn from a feed tank in the boiler room, which collects the hot-water returns from the various buildings. The simple engine, which is 22x36 inches, has a piston rod 3.75 inches in diameter and a clearance of 6.1 per cent. The compound engine, 14x26x36 inches, has the following dimensions: Diameter of high-pressure piston rod, 4 inches; diameter of low-pressure piston rod, head end, 4 inches; crank end, 4½ inches; clearance of high-pressure cylinder, 5.1 per cent.; clearance of low-pressure cylinder, 7 per cent.

In conducting the test the method followed was in substantial accord with that recommended by the engine-test committee of the American Society of Mechanical Engineers. For the purpose of securing constant-load conditions an artificial resistance was provided consisting of a water rheostat having about 1000 feet of iron wire, No. 12 Birmingham gage, placed in a tank of running water and divided into five equal sections, each section being controlled by a switch.

Steam consumption was determined by feed-water measurement, corrected for leakage and condensation in engines and mains. No. 1 boiler supplied the steam on the test of the simple engine and Nos. 2 and 3 boilers on that of the compound engines. The same feed pump was used on both tests, and the water was drawn from a temporary weighing apparatus erected for the purpose. The drainage from the separator and drip pockets in the steam main connected with the engine under test was cut off from the Holly system and carried through a temporary pipe to the feed reservoir mentioned. Each of these drips was provided with a water column and gage glass with a regulating valve beneath to keep the pipe clear without loss of steam. The reheater and jacket drips were also disconnected from the Holly system and drained through water columns. The drainage from these points was discharged separately on the boiler-room floor and thrown away. The leakage of the boilers and mains was determined as soon as possible after the conclusion of the principal run of each engine by the water-glass test, the consumption being based on the rise and fall of the level. During the progress of the main tests a set of indicator diagrams, one from each end of each cylinder was taken every twenty minutes, together with the usual observations of

FIG. 13. THE ENGINE ROOM

gages and revolutions per minute. Every half hour records were made of the hight of water in the gage glasses of the boilers and the quantity of water fed from the weighing apparatus. At equal intervals put of the generator were observed. The the instruments showing the electrical out-accuracy of the indicator springs, gages, weighing scales and electrical meters were all verified.

Immediately after the economy runs the friction tests were made. the engines being first shut down in order to raise the brushes from the commutator. In the simple-engine test the pressure in the steam pipe was 97 pounds and in the compound-engine test, 76 pounds. these being the highest pressures which could be carried without undue slamming of the valves, and without introducing conditions unduly affecting the reliability of the indicator diagrams. For these reasons the guarantee requirement of 130 pounds steam pressure for friction tests was waived. The data and results of the economy tests are given in Table 1 and those of the friction tests in Table 2.

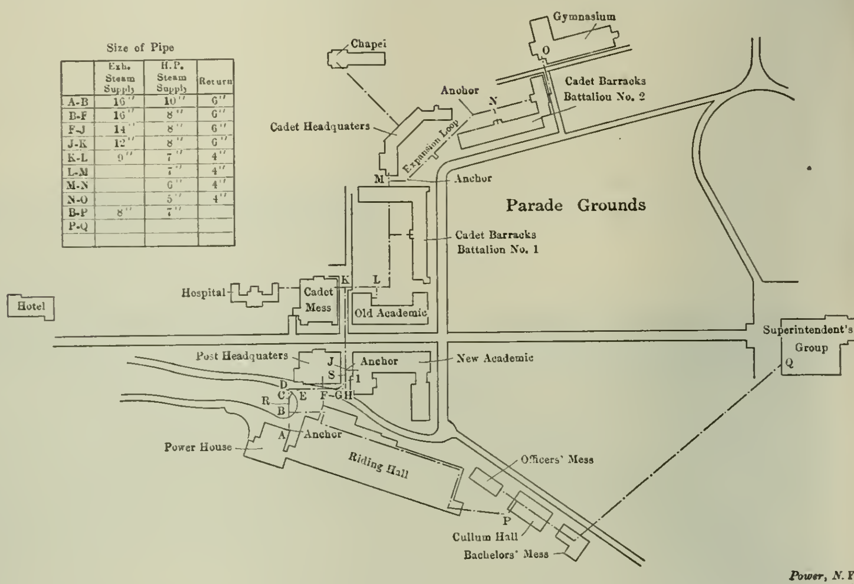
In conclusion, Mr. Barrus states that the steam consumption of the compound engines was 18.33 pounds per indicated horsepower per hour, which is 3.5 per cent. better than the guaranteed performance of 19 pounds. The simple engine consumed 20.98 pounds of steam per indicated horsepower per hour, which is 8.8 per cent. better than the guaranteed performance of 23 pounds. The percentage of friction of the compound engine was 3.8 per cent. and that of the simple engines 3.6 per cent., both of which are within the 4½ per cent. guarantee.

Computing the efficiency ratios from the above data gives some remarkable results —an efficiency of 69.6 for the simple engine and 79.2 for the compound engines. These efficiencies are much better than what is usually obtained in engines of this character, even of much larger capacities, and exceed considerably the efficiency ratios of steam turbines. It will be of interest to note how near these efficiencies will be maintained in everyday operation.

Tunnel System and Piping

In the larger buildings near the power house pipes are distributed through a system of underground tunnels shown in outline in Fig. 14. The gymnasium is the most distant building supplied with steam and this is at a distance of 2160 feet from the power house. The work on the tunnels has not yet been completed, as some of the buildings have not been built. To the gymnasium the main tunnel varies in size, depending upon the number of pipes that it contains. It is of rectangular cross-section and from the power house to the point *K* is 7 feet high and 6 feet wide, the side walls being 12 inches and the roof 10 inches thick. From points *K* to *M* the tunnel is 6 feet 6 inches high. 5 feet wide, with side walls and roof 10 inches thick. From point *M* on the tunnel is 6 feet 3 inches high and 4 feet wide, with walls and roof 10 inches thick. The floor is 8 inches thick throughout. The roof, floor and walls of the tunnel are of concrete construction except at curves, where rubble walls were used to save the cost of forms for concrete. A considerable portion of the excavation was through rock, and in the construction special provision was made to keep water from entering the tunnel.

Fig. 4 shows the general arrangement of the steam and exhaust piping in the engine and boiler rooms. As will be noted, the boilers are connected to a 14-inch main steam header with two valves in each boiler connection, that at the boiler being a Foster automatic stop valve. An 8-inch ring main supplies the engines, and this is fed from either end of the 14-inch header in the boiler room. A valve in this header subdivides it into sections, so that either side may be used as desired. Connections from the ring



Size of Pipe

	Exh. Steam Supply	H.P. Steam Supply	Return
A-B	16"	10"	6"
B-F	16"	8"	6"
F-J	14"	8"	6"
J-K	12"	8"	6"
K-L	9"	7"	4"
L-M		7"	4"
M-N		6"	4"
N-O		5"	4"
B-P	8"	7"	
P-Q			

FIG. 14. STEAM-DISTRIBUTING SYSTEM

TABLE 1. DATA AND RESULTS OF ECONOMY TESTS.

	Compound Engine No. 2.		Simple Engine No. 1.
Total quantities:			
Duration, hr	5.0		5.0
Water fed to boilers, lb	57,073.0		32,126.0
Hourly quantities:			
Water fed to boilers, lb	11,415.0		6,425.0
Loss of steam and water per hour due to leakage of boilers, mains, etc., lb	264.0		0.0
Net steam consumed per hour by engines, lb	11,151.0		6,425.0
Pressures (corrected):			
Steam pipe pressure near throttle, lb	150.4		148.5
Receiver pressure, lb	21.0		
Indicator diagrams:	H.P. Cyl.	L.P. Cyl.	
Mean effective pressure, lb	47.79	12.36	54.72
Sample diagrams:			
Initial pressure above atmosphere, lb	140.7	20.4	141.9
Corresponding steam pipe pressure, lb	149.0	21.0	148.0
Back pressure at mid stroke, lb	21.8	1.1	0.7
Pressures above zero at selected point near			
(a) Cutoff, lb	134.5	28.8	133.8
(b) Release, lb	38.5	17.8	38.0
(c) Beginning of compression, lb	43.5	17.4	16.9
Percentage of stroke at selected point near			
(a) Cutoff, per cent	24.7	60.5	20.1
(b) Release, per cent	93.9	94.3	83.7
(c) Beginning of compression, per cent	7.2	5.2	29.5
Aggregate m.e.p. referred to each cylinder, lb	75.7	33.6	54.6
Steam accounted for in lb. per I.H.P. per hour, near			
(a) Cutoff, lb	14.13	17.36	16.04
(b) Release, lb	14.46	16.59	17.07
Speed:			
Revolutions per minute	99.2		98.5
Power:			
H.P. developed by H.P. cylinder	384.5		
I.H.P. developed by L.P. cylinder	223.8		
I.H.P. developed by whole end	608.3		306.2
Results:			
Steam consumed per I.H.P.-hr., lb	18.33		20.98
Percentage accounted for by indicator diagrams, near			
(a) Cutoff, per cent	77.1	94.7	76.5
(b) Release, per cent	78.9	91.1	81.4

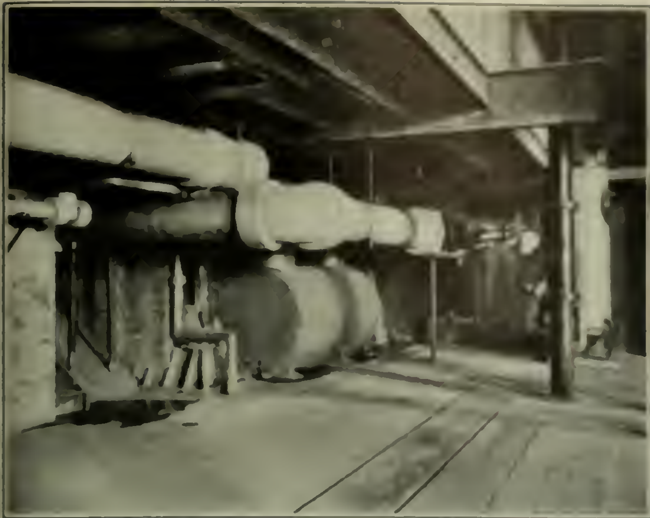


FIG. 15. MUFFLER TANK AND FEED-WATER HEATER

FIG. 16. LIVE- AND EXHAUST-STEAM CONNECTIONS AT ENTRANCE TO TUNNEL

main to the engines consist of long radius bends which enter Stratton separators of the receiver type, these being supplied to insure dry steam and also to provide a receiver of moderate steam volume close to the engine throttle. A 3-inch connection from the end of the boiler-room header supplies the boiler-feed pumps and fan engine, and in addition there is a separate 2½-inch line run from the end of the Holly main which may be used to operate the feed pumps.

Exhaust-steam pipes from the engines are connected into a 16-inch exhaust line which discharges into a Utility combined muffler tank and grease separator provided with the usual bypass, and from here the exhaust escapes to the atmosphere through a free-exhaust pipe of the same diameter running upward through the interior of the stack. During the heating season the exhaust steam passes through a 16-inch line to the tunnels, and as it rises from the basement of the engine room to the entrance of the tunnel, connection is made with the high-pressure line which supplies steam direct from the boilers through a Foster reducing valve when the exhaust is insufficient to heat the buildings. In the tunnels the exhaust steam is carried as far as the academy building. On the direct lines from the boilers to the buildings there is also provision to reduce the initial pressure of 125 pounds to from five to two pounds for the tunnel system.

TABLE 2. DATA AND RESULTS OF FRICTION TESTS

	Compound Engine No. 2	Simple Engine No. 1
I.H.P. developed by H.P. cylinder	101.2	
I.H.P. developed by L.P. cylinder	78.6	
I.H.P. developed by whole engine (negative)	23.1	10.[illegible]
Rated H.P. of engine	600.0	400.[illegible]
Percentage of friction H.P. to rated H.P.	3.8	2.[illegible]

All drip points on high-pressure lines are connected to the Holly system, and the condensation in the various buildings connected to the central plant is returned to the power house by Bundy pumping traps through a line that gradually increases in size up to 6 inches as it enters the power house. In the boiler room this return line connects to the top of a return tank which is provided with a vapor line to the atmosphere, so that it is practically an open tank. Ordinarily the boiler-feed pumps draw their supply from this return tank, but also have connection to the cold-water supply. To provide make-up water three ball cocks are placed inside of the tank, each with a valve connection, so that at least one of the valves will always be in working order. A perforated partition divides the tank, so that any discharge of water into the tank from the return lines will not affect the ball cocks.

Two 12x7½x10-inch Worthington piston pumps feed the boilers, and the dis-

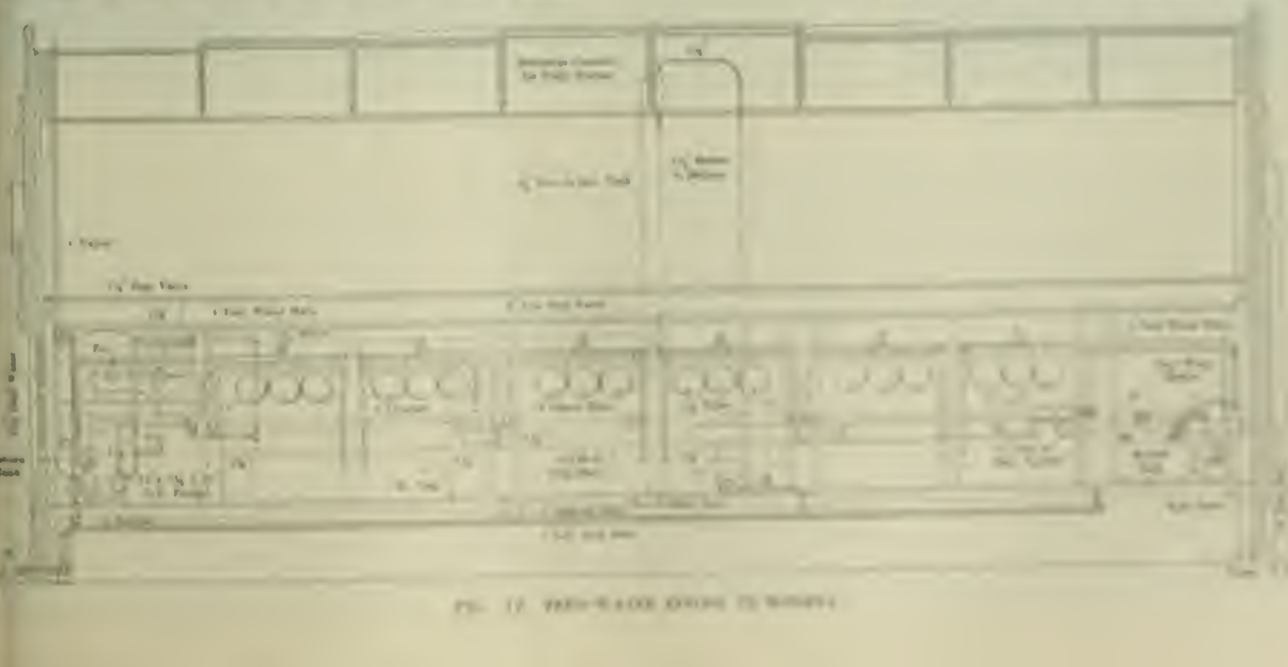


FIG. 17. FEED-WATER PIPING TO BOILERS

charge is so arranged that the pumps may feed into either end of the ring main which passes through the feed-water heater. From the main there is a double connection to the individual feed lines of each boiler and each of these connections is provided with a stop and check valve having an extension stem within easy reach of the boiler-room floor. The heater is of the Wainwright even-flow type and has a rated capacity of 1500 horsepower, which was considered large enough as the plant is run only to its full capacity during the heating season, when a large part of the water will consist of the hot returns from the buildings.

All greasy drips from engine and pump cylinders, grease separator and various points of the exhaust line are trapped into a low-pressure drip line connecting with the boiler blowoff main, to which are also attached the three blowoff connections on each boiler. Each blowoff pipe is provided with a straight-way valve fitted to a Homestead blowoff cock. Boiler pressure, the reduced pressure to buildings and the pressure in the exhaust system are all indicated on three special gages located on a marble board placed upon the side wall of the engine room.

In the entire piping system all high-pressure steam pipes 2 inches in diameter and over are provided with extra-heavy flanged fittings and with extra-heavy flanges for connecting the piping. In all piping 5 inches in diameter and over the Van Stone type of joint with rolled-steel flanges is used. All of this work and the pipe bends were manufactured by the M. W. Kellogg Company for the Thompson-Starrett Company, which firm had the contract for all piping in the plant and tunnels.

All low-pressure piping in the power house, excepting the blowoff piping, is provided with standard-weight fittings and flanges except in certain locations in the exhaust lines where it was thought necessary to install extra-heavy fittings on account of the expansion and contraction that might readily occur. In the tunnel the construction was such that it was possible to take care of the expansion by means of numerous right-angle bends in the line, and at curves the pipe was furnished with hangers which would permit lateral as well as longitudinal expansion to occur. The high-pressure and the return mains in the tunnel were suspended from the roof beams, but the exhaust main was supported by brick piers with a bluestone cap on which a roller resting in a chair was placed, the piers being constructed in every case so that the upper surface of the bluestone cap would be parallel with the axis of the pipe, even on a steep incline.

FIG. 18. PIPING TUNNEL

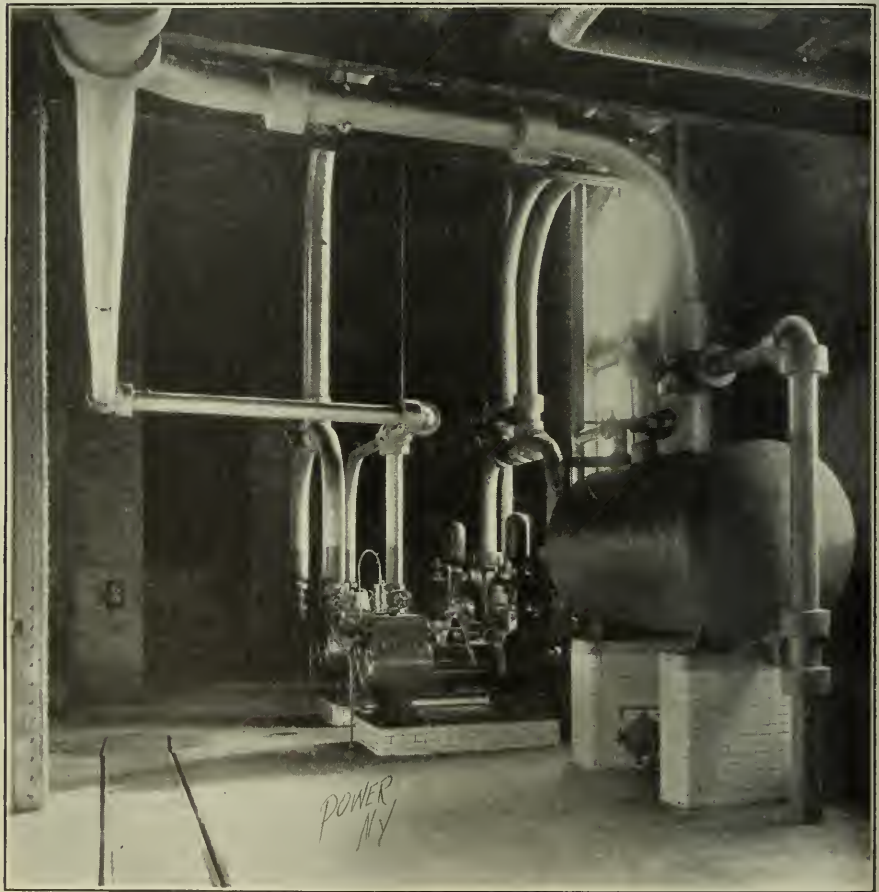


FIG. 19. RETURN TANK AND BOILER FEED PUMPS

Electrical Equipment

While the greater portion of the load consists of lamps, a number of elevators are to be used in the central group of buildings, and also a considerable number of small motors for various purposes. For instance, the cadet mess hall, containing one of the most elaborately equipped kitchens and bake shops anywhere in the world, uses a number of motors for dishwashing, breadmaking, food preparing and other purposes. The buildings requiring most of the power, however, are within 2700 feet of the power house. The buildings at the south end of the grounds, about 8000 feet distant from the power house and consisting of the cavalry and artillery barracks, had an estimated wired load of 75 kilowatts in incandescent lamps, and the soldiers' hospital and a number of other buildings located at the extreme north end of the reservation require current for lights only.

The desire to use direct current as far as it could be used economically led to the adoption of a 250-volt two-wire system for light and power, and it was found that this system could supply about 75 per cent. of the total load without great expense. The remainder of the load and the street lighting required alternating current, and it was decided to use motor generators delivering 60-cycle single-phase current at 2200 volts, the current being supplied to the street-lighting system through tub transformers. On the direct-current system, the maximum lighting load for the buildings amounted to 925 kilowatts and an additional 100 kilowatts for power. The maximum alternating-current lighting load approximated 250 kilowatts and the street lighting about 90 kilowatts.

To handle this load, two 400 kilowatt and one 200 kilowatt generators were installed. The normal full-load voltage of all the generators is 250, but means are provided for varying the shunt fields so that the voltage may be adjusted within reasonable limits. To compensate for the drop in the feeder system, each generator was designed to overcompound 10 volts from no load to full load, but this overcompounding may be reduced to various lesser amounts by means of a special series-field shunt.

To furnish alternating current three motor-generator sets have been installed, the generators having capacity to carry a normal load of 125 kilowatts when supplying single-phase current at 2400 volts and running at a speed of 600 revolutions per minute. The three sets are arranged to operate in parallel. All electrical apparatus in the power house was supplied by the General Electric Company.

Distribution of the current is effected entirely in an underground subway system consisting mainly of about 85,000 feet of single clay ducts and 83 manholes, with branches from the manholes to the buildings and from the manholes to the street-lamp posts when the latter are near enough to make this method advisable. Where the lamp posts are remote from the subway system, one duct in the upper layer of ducts opens into a pull box and a branch connection of fiber is run to the base of the lamp post. A total of 142 pull boxes have been installed. The clay ducts are of the 3 inch standard type laid in cement mortar with a concrete envelop on the top, bottom and sides, the top being not less than 2 feet 6 inches below the surface. The fiber ducts for the street lighting are 2½-inch American conduit laid on a bed of concrete and afterward inclosed on the top and sides with a concrete envelop not less than 2 inches thick.

Direct-current distribution consists of an extensive system of feeders in which the outer terminals of the feeders are looped together by mains. From the junction point pressure wires are run back to the power house and a sliding voltmeter switch is provided on the station desk for reading the voltage at these points. There is a double set of positive direct-current busses and one negative bus. The positive leg of each feeder circuit is connected to the middle point of a single-pole double-throw switch, so that the circuit may be thrown on either positive bus as required. With this arrangement and double-throw generator main switches, the generators may be run at slightly different voltages. For instance, one generator may be connected to the high bus and the other to the low bus, and each feeder may be thrown on the high or low bus as desired, in order to maintain equality of voltage at the mains and to compensate for unequal drops in different feeders. The switchboard is of blue Vermont marble and consists of 21 panels, having a total length of about 67 feet. The panels are fully equipped with the usual quota of direct- and alternating-current instruments, circuit-breakers, etc.

In the underground system, all cables are rubber-insulated and lead-covered. The direct-current cables are single-conductor lead-covered, and all alternating-current cables except transformer leads are of the duplex type in a single lead sheath. At the present time, 11 direct-current feeders have been installed, and each leg terminates in a watertight junction box in a manhole, where connection is made to the corresponding leg of the main and to such buildings as may be served from the manhole. The positive and negative sides are separate throughout, there being separate positive and negative junction boxes.

For house lighting the alternating-current system consists of 2200-volt duplex conductors connecting through single-pole cutouts to transformers located in a few instances in manholes and in most cases in vaults forming a part of the building supplied. The greater portion of the secondary alternating current is distributed on the 120-240-volt three-wire system. In the case of the officers' quarters, which are small residences, one transformer serves a number of buildings. A three-wire service is brought into each building to a three-pole cutout, and the two-wire distribution in the different quarters is connected alternately to the different sides of the three-wire circuit so as to obtain a proper balance.

In wiring the buildings supplied with direct current arrangements were made for changing over to the 120-240-volt three-wire system. Three-pole service cutouts were installed, and if the change is ever made, a neutral main may be pulled into the conduit system, to which neutral leads from the various buildings may be connected. This arrangement was made so that Tungsten lamps might be installed at a later date if desired.

Cram, Goodhue & Ferguson, of Boston, were selected as architects for the entire work, with Olmsted Brothers, of Brookline, Mass., associated with them in the landscape work. During the administration of Brigadier-General Albert L. Mills, superintendent of the Military Academy, until 1906, the general plans of the work were completed and many of the contracts awarded. Since the above date Colonel Hugh L. Scott has directed the preparation and approval of plans and carried on the work. Major J. M. Carson, Jr., constructor in charge of construction, has been the superintendent's representative in the matter of approval of plans and specifications and in carrying on the construction since the inception of the work, and Henry C. Meyer, Jr., of New York City, was retained as consulting engineer for the power plant, the street lighting and the distribution of steam and electricity to the walls of the various buildings.

"Notice to Visitors"

A correspondent sends us the following "Notice to Visitors (by an Old Engineer)," culled from the columns of a Tennessee daily:

1. When you enter the engine room spit on the floor. We have water, lye, soap, mops and brushes, and we will clean up as soon as you leave.

2. Rub your hand on all polished work. It will give someone work and use the surplus polish.

3. Put your hands on the engineer's bright work. You will then know if it is smooth, hot or cold. Tell others to do the same.

4. Stay in the engine room as long as you please. The engineer has nothing to do but entertain visitors.

5. Be sure to tell the engineer if his engine is pounding or running right, as he will not know it unless you do. He will stop and make repairs while you wait.

6. Don't tell the engineer who you are. He is a mind reader and always knows you. Go anywhere in the engine room and you will please him.

7. Advise him what to do, as you know best. The engineer is only there every day, and does not have a chance to see as much as you will in an hour.

8. If the engineer is busy making repairs, tell him a good story you heard the other day and, if possible, get in his way.

9. Be sure and tell all you know. "It won't take long."

10. Call again and repeat as above.

The newly established department of mining engineering at the University of Wisconsin has just published a bulletin announcing different special courses in mining engineering for undergraduates leading to the degree of bachelor of science in the mining-engineering course, and an advanced course is being arranged for next year for which the professional degree of engineer of mines will be conferred. As the courses of the mining engineer are diverse and comprehensive, the four-year undergraduate course is designed to give the student fundamental training in chemical, mechanical and electrical engineering, chemistry and metallurgy, and special work in geology and the application of these subjects to mining and dressing with metallurgy.

The Coming Hudson-Fulton Celebration

Description of the "Half Moon" and "Clermont," Replicas of Which Are Now Being Built to Participate in the Great Naval Parade

BY WARREN O. ROGERS

The celebration which will take place September 25 to October 9, inclusive, under the management of the Hudson-Fulton Celebration Commission, will commemorate the three-hundredth anniversary of the discovery of the Hudson river by Henry Hudson and the one-hundredth anniversary of the first successful steam navigation of that river by Robert Fulton. These men occupy prominent niches in the world's history. One brought to

FIG. 1. HENRY HUDSON (Ideal Photograph)

knowledge the Hudson river; the other gave to the navigable waters of the earth an inestimable commercial value.

Henry Hudson

On April 4, 1609, Henry Hudson (see Fig. 1) set sail from Amsterdam, with a crew of 18 Dutch and English sailors, to find a northern passage to China, but after rounding the North cape he was driven back by contrary winds, whereupon his crew mutinied and refused to continue the voyage. Hudson then proposed that a search be made to find a northwest passage. The crew agreed to this proposition and they set sail. The ship reached the American coast on July 12, and on September 2 arrived off what is now known as the Navesink Highlands on the south side of New York bay, and this date is recognized as that of Hudson's first view of the great river. The next day the "Half Moon" moved up the bay and anchored on the inside of what is now known as Sandy Hook, where several days were spent in exploring the nearby waters, and on September 12 the "Half Moon" passed in through the "Narrows" and entered the mouth of the river.

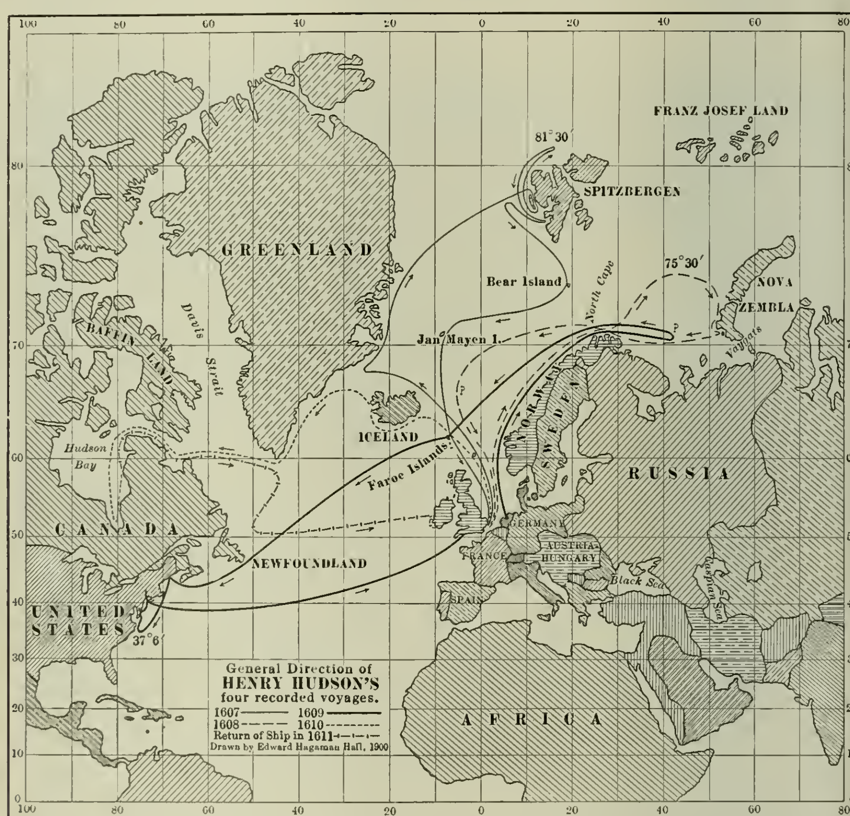


FIG. 2. SHOWING GENERAL DIRECTION OF HUDSON'S FOUR RECORDED VOYAGES

The voyage up the Hudson was made during the daylight hours, as wind and tide served, the ship being brought to anchor as soon as darkness set in. In this manner, the site of the city of Albany was reached on September 19, the farthest point north to which the "Half Moon" was sailed, though small boats were sent out to investigate the upper river in hopes that deep water would be found. When Hudson was convinced that this was not the passage to the Pacific, he weighed anchor on September 23 and returned to the harbor, passing out to sea October 4. The discovery of the Hudson river was on the third voyage of the four made by Hudson, the routes of which are shown in Fig. 2.

Hudson's fourth voyage proved to be his last in making the attempt to discover a northwest passage. This voyage took him through what is named Hud-

FIG. 3. LAST DAYS OF HENRY HUDSON

son's strait into the bay also bearing his name. The voyage was disastrous, as the crew, in mutiny, put Hudson, his son and seven companions into a shallop and set them adrift in a sea of ice and snow. No tidings of Hudson nor his companions were ever received, and Hudson's bay, without doubt, became his grave. Fig. 3 is a reproduction of a painting which represents Hudson and his companions abandoned

FIG. 4. REPLICA OF THE "HALF MOON"

FIG. 6. ROBERT FULTON

FIG. 5. COMPARISON OF THE "HALF MOON" AND OCEAN LINER "[illegible]"

on June 22, 1611. Strangely enough nothing is known of this determined explorer's life prior to April 19, 1607. Then in four short years, this man accomplished that for which thousands will do him honor during the forthcoming celebration.

The "Half Moon"

One of the most interesting and notable features of the celebration will be the presence of a replica of Hudson's ship, the "Half Moon." Patriotic citizens of Holland are now building it, and it will be delivered to the commission in ample time to participate in the various events. As there are no known drawings or paintings of the original "Half Moon," paintings and plans of similar ships were used in preparing the specifications, so that the 1909 "Half Moon" will appear as nearly like the "Half Moon" of 1609 as possible. The new "Half Moon" is shown in Fig. 4.

The dimensions of the replica will be as follows: Length over all, 74.44 feet; length between perpendiculars, 48.70 feet; breadth of beam, [illegible] feet; depth, 10.08 feet; draft, 7.05 feet.

The new "Half Moon" will make her first official appearance Monday, September 27, when she will be received by the officials of the commission and take her place in the line of international war vessels and merchant ships, where she will undoubtedly be given a greeting such as to few vessels, great or small, is accorded.

A wonderful opportunity for comparison will be afforded when the "Half Moon" reaches New York harbor and modern steamships pass her on their inward or outward bound voyages. Fig. 5 illustrates in a striking manner the gigantic strides that have been made in marine architecture since the Hudson river was first navigated.

Robert Fulton

In taking up events pertaining to the life of Robert Fulton, too much cannot be said as to the great benefits they conferred upon the civilized world. While it is true that other men had constructed boats propelled by steam power, their boats were not commercial successes. It is also true that if Robert Fulton had not constructed a steamboat that was enabled to steam the 150 miles between New York and Albany, someone else would have done so; but nobody else did, so the name and invention of Robert

Fulton will be honored in a fitting manner during the days of the celebration. A reproduction of a portrait of Robert Fulton is shown in Fig. 6.

The "Clermont"

A replica of the "Clermont" will also play a prominent part in the celebration. It will be an exact duplicate of the boat in which Fulton made his famous run to

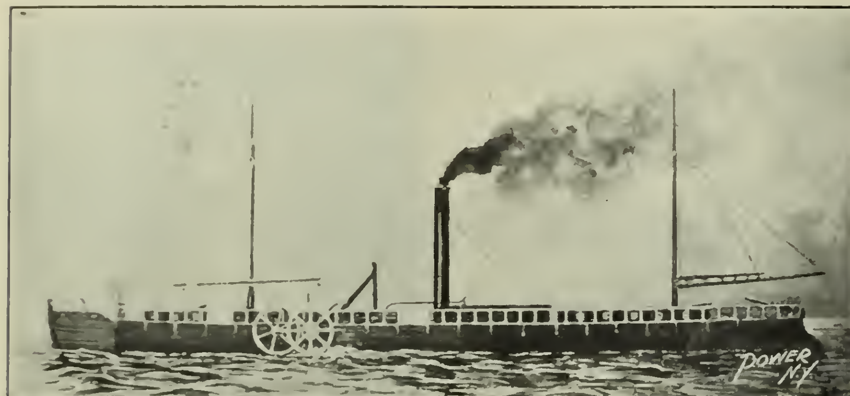


FIG. 7. THE ORIGINAL "CLERMONT"

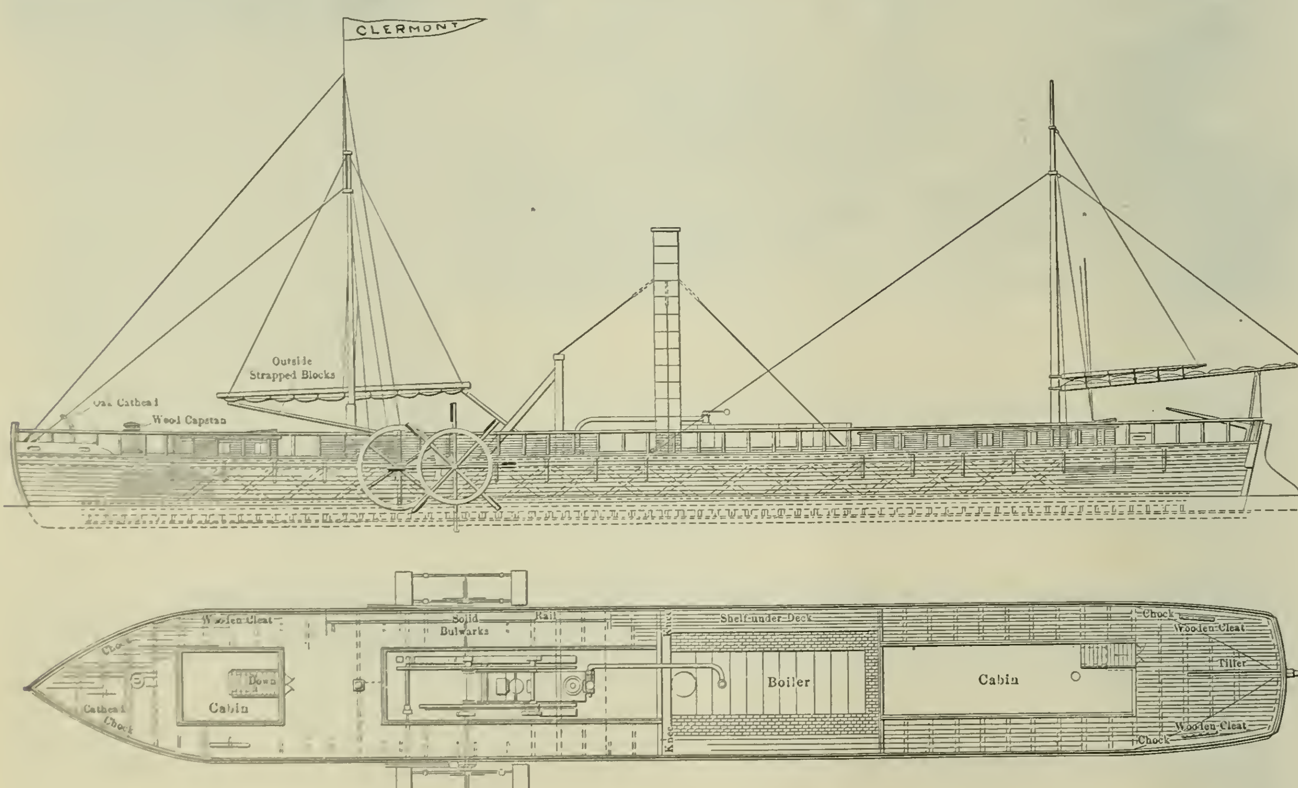


FIG. 8. PLAN VIEW AND SIDE ELEVATION OF THE "CLERMONT"

Albany and return, with the exceptions that the boiler will be equipped with a safety valve and life preservers will be placed on board, to comply with the United States marine laws.

The original "Clermont" is illustrated in Fig. 7. She was 150 feet long and 13 feet wide, had a depth of hold of 7 feet and drew 2 feet of water. The hull below the deck had a wedge-shaped bow and stern, cut sharp to an angle of 60 degrees. The sides were almost parallel, being a trifle wider on deck than on the bottom, which was flat and without a keel.

Referring to Fig. 8, it will be seen that the "Clermont" had two masts, one stack and two cabins, one fore and the other aft. The engine, which was made in England by Watt & Bolton, was placed just aft of the foremast. The engine was without housing and the boiler was constructed of copper. The paddlewheels were 15 feet in diameter and were originally uncovered, although later they were incased in wooden guards. The flywheels of the engine were placed outside of the hull forward of the paddlewheels. Fig. 9 shows a comparison of the "Lusitania" and the "Clermont."

Up the Hudson

The life of Fulton is so well known that it is not necessary to go into it here. While some of the incidents of the voyage from New York to Albany, 200 years after Hudson sailed up the river, were humorous, it can well be assumed that to the inventor the run was one of great anxiety. Several days before the beginning of this great run to Albany, the "Clermont" was taken around from the East river to the North river and anchored off what is now known as West Tenth street, or opposite the Delaware, Lackawanna & Western ferry slip, on the New York side of the river. It is conceivable, however, that the river did not appear then as now. The changes that have been made in the map of New York City are clearly illustrated in Fig. 10, the area outside of the heavy black line showing the made ground since Fulton's time. There were no great steamship docks on the river front such as are seen today, and the spectators had no difficulty in finding locations on the river bank from which they could hurl taunts and jeers toward the confident, expectant inventor. With the newspapers skeptical, it is no wonder that the public pinned little faith on the success of Fulton's steamboat.

The start was made at 1 o'clock and, with the throttle wide open and the paddlewheels slowly revolving, the "Clermont" began the momentous voyage, while the spectators looked on with astonishment. The run from New York to Albany was accomplished at practically an average hourly speed of five miles, the return trip being made at the rate of just five miles per hour.

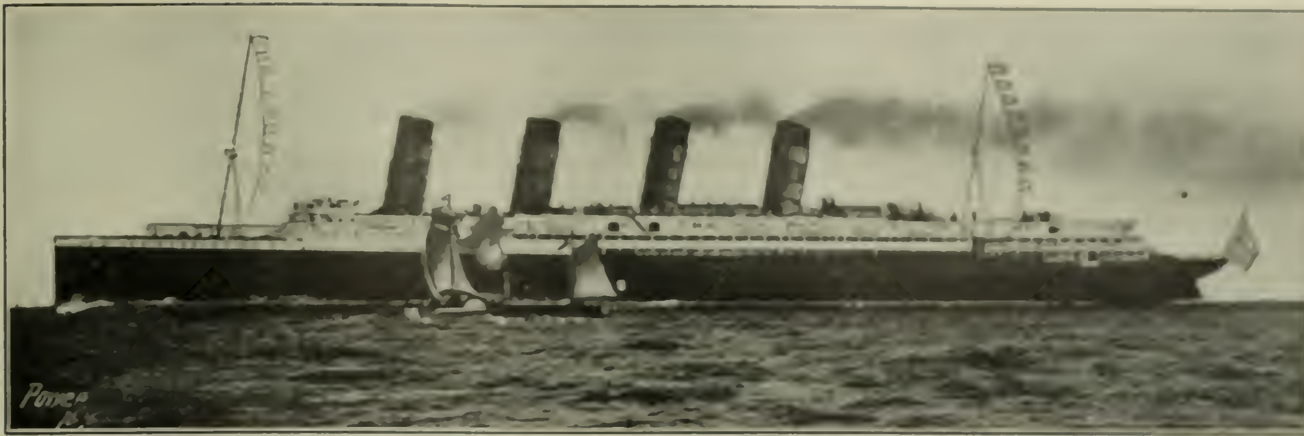


FIG. 9. COMPARISON OF THE "LUSITANIA" (1907) AND "CLERMONT" (1807)

The fame won by Fulton was won by a narrow margin, for a few days later Robert L. Stevens' steamboat "Phœnix" made a trial run on the Hudson. Owing to the monopoly secured in 1808 by Fulton and Livingston from the legislature, the "Phœnix" was put in service on the Delaware river.

Naval Parade

On Friday, October 1, the great naval parade of the celebration will take place. As many naval vessels, merchant marines, excursion boats and pleasure crafts as can possibly go from New York to Newbergh will escort the reproduced "Half Moon" and "Clermont" to the latter city. Thence the two ships of honor will be escorted to Albany by another division of the participating vessels, the division from New York returning to that city.

Another interesting feature will be a remarkable exhibition of flying machines. The *New York World* has offered a prize of $10,000 for the aeronaut who with a mechanically propelled airship sails over the course traversed by Fulton's "Clermont" in 1807.

Without doubt this impressive naval parade and airship flight, which are but two of many features of the week's celebration, will be two of its greatest features. Other attractions of especial interest will be rowboat races in six classes, rowing matches between crews of foreign and American war vessels, canoe races and sailing races. The city of New York alone will spend [illegible] on the celebration.

We are indebted to the Hudson-Fulton Celebration Commission for the illustrations in this article.

Isolated Plant vs. Central Station

Shall the public library of New York City be equipped with an isolated plant or shall it take its electric current from the mains of the Edison company? This question has been occupying the attention of the Board of Estimate and Apportionment for some time, and in regard to the isolated-power-plant side of the question, the following letter and brief, addressed to the board by Percival Robert Moses in behalf of the International Union of Steam Engineers, will undoubtedly be of interest. It will also be of interest to note that the board has decided on an isolated plant.

Letter [illegible]

"I have been requested by the International Union of Steam Engineers, a part of the Central Federated Union, to present on their behalf briefly some reasons why a private isolated plant should be installed in the New York public library for the manufacture of electric current.

"In the New York public library proposition, I understand that the Edison company estimates the maximum use of current at [illegible] kilowatt-hours a year, while the consulting engineers estimate the use at [illegible]. Even on the basis of [illegible] kilowatt-hours a year, the rate of Edison company at three cents per kilowatt-hour would be a mistake. The library commission would undoubtedly operate the plant and manufacture current at less than [illegible] cents per kilowatt-hour, and I understand, in the statement I presented, would be willing to enter into a contract to operate the plant and [illegible]

FIG. 10. MAP OF LOWER NEW YORK SHOWING [illegible]

for this price, in addition, of course, to the cost of heating the building.

"On the basis of the estimate made by your consulting engineer, the difference between 1⅔ cents and three cents per kilowatt-hour would make a difference of $22,000 a year to the library committee. It is proper also to call your attention to the fact that by making a contract with the New York Edison Company or any other member of the combined companies, at three cents per kilowatt-hour, you are sanctioning a discrimination in rate against the small consumer, which is entirely unjustified and which cannot continue to exist. There is no possible justification for a discrimination in rate based on quantity use alone. It is only because the combined electric companies are allowed to charge small consumers 10 cents per kilowatt-hour, giving them an exorbitant profit, that they are able to sell to the large consumer at three cents per kilowatt-hour, which is less than the average cost of production and distribution. The gas companies do not practice any such discrimination and the city, in its sale of water, sells to all alike. Why, then, should the city encourage the electric companies to discriminate against the small user by making a contract at less than a fair rate with the large user, because of their large use, knowing that every such contract made makes it harder to reduce the price to the small consumer.

"Finally, on behalf of the operating engineers, I ask that if your board is not satisfied that a private plant can be operated more cheaply than service can be purchased from the Edison company, they advertise for bids from responsible engineering concerns, asking such concerns to state the price at which they would sell current to the city from a private plant located in the building, such contract, of course, to be subject to the clause about paying the prevailing rate of wages, and to contain any necessary stipulation as to maintenance of the equipment in first-class condition. I am satisfied that if such bids are asked for many offers will be made, backed up by bonds and guarantees offering to sell current from the private plant at from 1¼ to 1⅔ cents per kilowatt-hour, in addition to the cost of heating the building.

"Summarizing: I base my plea for the installation of a private plant on the following grounds:

"1—The cost of current from the private plant would be less than Edison service by $22,000 a year, if your consulting engineer's figures are correct.

"2—You are entering into a contract for an illegal discrimination in rate against the small user, and by so doing you are preventing the small user from obtaining a lower price for current.

"3—You are placing your equipment in the control of a single lighting combine, which may or may not be always run in a fair manner, and you are subjecting yourselves to a far greater possibility of breakdown than would be the case if you had your own plant."

Brief Accompanying Letter

"Discrimination in rates in favor of a consumer of a large quantity of electricity and against the consumer of a small quantity of electricity, is wrong:

"In order to prevent the installation of isolated plants in buildings, the Edison company and its allies have adopted a system of giving low rates; that is, rates below the average cost of production, to large consumers, balancing this by charging excessively high rates to small consumers.

"That this proposition is radically wrong and unjust, is evident from the propositions made to the public library board and to other similar large consumers to sell them 833,000 kilowatt-hours per year at a rate of three cents per kilowatt-hour, or a total of $25,000 a year. For the same quantitative use of current, but divided between 100 stores, the charge would be $83,000, or over three times as much.

"The discrimination is based on the same principle as the freight-rate discrimination which has been universally condemned, and has been pronounced illegal. That is, the rate is fixed not upon the cost of production and distribution, but upon the amount the traffic will bear. This is evident from a consideration of the conditions:

"In the public-library plant there are 17,691 incandescent lights and 443 horsepower of motors. The total connected capacity figures up to approximately 1200 kilowatts. If the maximum demand is figured at two-thirds this amount, or 800 kilowatts, this would probably be approximately correct.

"In the long discussion before the Public Service Commission on the subject of breakdown or auxiliary service, it was shown conclusively by the New York Edison and its allied companies that it cost the Edison company at least $30 per year per kilowatt of maximum demand, $30 for fixed charges alone. This is exclusive of any cost of manufacturing the current; it merely covers the fixed charges on the installation of plant, buildings, mains, meters and connections.

"In the case of the public-library proposition, the offer to sell current at three cents per kilowatt-hour barely covers the fixed charges, making it necessary to make all the profit made by the Edison and its allied companies in some other direction. This profit can only be obtained from the small consumer, and the small consumer is forced to pay the profit not only on his own use of current, but on the use of current by the large consumer.

"The city has recognized the justice of equal charge to large and small consumers in the sale of water, the charge being alike to large and small consumer, no matter what quantity they use. The gas companies do not attempt to discriminate against the small consumer, and everybody has the right to buy gas at 80 cents per thousand cubic feet. The telephone company, it is true, does discriminate between the large user and the small user, but nothing like the extent proposed by the electric companies, and the question of the right of the telephone company to so discriminate has been seriously questioned.

"The objection to discrimination in favor of the user of a large quantity against the user of a small quantity does not necessarily mean that the Edison and its allied companies should be discouraged from encouraging a long-hours use of the equipment. This is quite a different matter. The electric companies claim, and with justice, that the consumer who uses his equipment 10 hours a day should obtain a better rate than the consumer who uses his equipment one hour a day; for the reason that the consumer who uses his equipment 10 hours a day requires no greater plant investment than the consumer who uses his equipment one hour a day. This statement is perfectly correct. A proper basis of charge would be one based on the maximum demand of the equipment, or on the constant capacity, to which should be added a charge for the amount of electricity actually used. But this rate should be open to all consumers alike, no matter whether they use 10 kilowatt-hours a year or 100,000 or 1,000,000. Such a rate has been proposed by the New York Edison and its allied companies in a number of cases recently and is as follows:

"The company makes a fixed charge of $30 per kilowatt of maximum demand, and in addition to this charge receives 1½ cents per kilowatt-hour for all electricity used. This is a perfectly fair form of contract, but it must be open to all consumers alike, and not only to such consumers who have isolated plants installed, or who intend to install such plants.

"If such a contract were proposed for the public library, the cost would be somewhat as follows:

800 kilowatts maximum demand @ $30	$24,000
1,000,000 kilowatt-hours @ 1½c. per kilowatt-hour	15,000
Total cost per year	$39,000

This is the least cost at which the New York Edison and its allied companies can afford to sell current and make a profit. If they sell at anything less than this cost, they must obtain their profit from the small consumer.

"The cost of manufacturing current from a private plant in the public library will be less than purchasing current even at the three-cent rate:

"From the figures given me on the amount of heating surface and the size of the public library, it is evident that during the winter months, that is, during at least one-half of the year, the amount of steam used for operating the electric plant, with a properly designed plant, will be less than the amount of steam required to heat the building. Hence, it may be safely stated, that the operation of the electric plant will not increase the amount of coal required during six months of the year, certainly not more than 10 per cent. I have a number of figures from buildings in New York City which show this to be the fact.

"During the summer months when the lighting load is least, the coal used for operating the electric plant will, of course, be a direct charge on the electricity.

"Insofar as the labor is concerned, a brief consideration of the conditions will show that the amount of labor required for the actual operation of the electric plant is very small. If the electric plant is omitted, there would still be 460 horsepower of motors to be taken care of, and there would still be the boilers to be fired for heating; there would still be the elevators to be looked after; the ventilating fans to be cared for; and the only things that would not be in operation during seven months of the year would be one turbine during the daytime and, perhaps, two at night. These turbines from their very nature cannot be interfered with. The usual instructions are to let the turbines alone, merely seeing that the oil is flowing. They are absolutely automatic in operation and it would not be possible to use more than one man on a watch to see that they were operating correctly. With a storage battery as an auxiliary, designed to supply the night lighting after the plant was shut down, this means that there would be two men required, one from eight to four, the other from four to twelve, in addition to the crew required for heating alone. Besides this, in the summer there would be two additional firemen.

"The other items making up the cost of electricity are the plant supplies, plant repairs, ash removal, water for boilers, oil, etc. A careful estimate of these additional items, gives a total of less than $12,000 a year; or, 1.2 cents per kilowatt-hour. If high-efficiency lighting is used throughout the building, the cost of the plant could be undoubtedly reduced materially from the present estimate. But even on the basis of the present estimate, and allowing 10 per cent. for interest, depreciation, insurance, etc., the fixed charges figure up to one cent per kilowatt-hour; which added to the operating cost of 1.2 cents makes the total cost per kilowatt-hour 2.2 cents, on the basis of one million kilowatt-hours a year. There are a number of companies in New York making a specialty of operating steam and electric plants, and if there is any doubt in the board's mind, as to the comparative cost of operation of central service and of isolated-plant service, I suggest that bids be invited from responsible concerns, subject to a bond, for operating the plant proposed for the library, the contract to contain the usual stipulations as to paying the prevailing rate of wages and requiring maintenance of the plant in accordance with certain standards of inspection. I am satisfied that if such bids are invited, many will be received offering to furnish current as low as 1½ cents per kilowatt-hour, in addition to the cost of heating and maintaining the rest of the equipment.

"The matter of reliability of service is also of moment. In one case the library will have its own plant on the premises with its very large storage of coal available at all times, so that nothing less than an earthquake would be able to stop the service. On the other hand, if the service is purchased from the Edison company or any of its allied companies, even

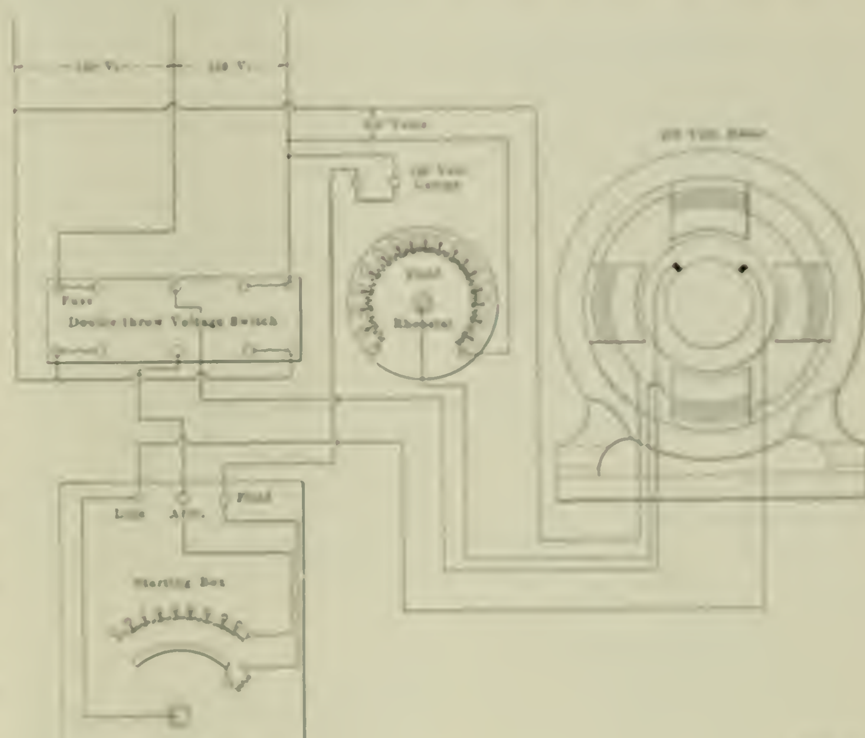


Fig. 1

with many connections, the service is subject to interruptions. It is hardly two years ago now since the Edison company's station at Thirty-ninth street was almost wrecked by the explosion of one turbine after another, with the result that the service had to be disconnected in a large part of the city, and where it was maintained it was only at a greatly reduced voltage. Just the other day, in Baltimore, on account of a blizzard, the whole city was without light and power for 24 hours, and the greater part of the city for 72 hours, or three days. In fact, the whole service was not resumed for over a week, and this only by almost superhuman efforts.

"My third plea, therefore, for the isolated plant in the public library, and other municipal buildings, is that the service will be more reliable than it would possibly be from an outside source."

Emergency Connections for Electric Motors

By C. V. H

Every man who has to do with power installations of any sort realizes that he must sometimes do things in other than the conventional manner. Conditions arise which are unexpected and which demand unusual methods. It is not a good plan to run a steam engine without a governor; yet I know an old steam-traction man who always threw the governor belt off when he was in a hurry to set up or to move to another place. He got along famously, but still it is not advisable for a careless or inexperienced man to do this kind of thing.

One of the largest gasoline-engine companies in the middle West has about 80 motors in operation, ranging from 1½ to 40-horsepower. Series, shunt and compound-wound types are used, though the shunt-wound type is preferred. These motors are used on woodworking machines, boring mills, radial drills and line shafts, and the working conditions are extremely varied and require that material and apparatus be kept on hand rather than order others which may be better adapted to the work of the moment.

Three-wire 220-volt distribution is used, but the dynamos are 110-volt compound-wound machines of different makes and sizes, which makes the use of an equalizer impracticable for parallel operation. To overcome this difficulty, a switch is arranged to short-circuit the series windings of the machines when operated in parallel. This has been satisfactory for power purposes and furnishes fair lighting service, although the voltage is apt to vary perceptibly if the load varies much.

Several boring mills, requiring considerable speed variation, are direct-driven. It was not feasible to use cone pulleys, because there is not sufficient room for them; so it was decided to use

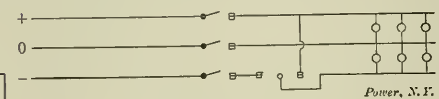


FIG. 2

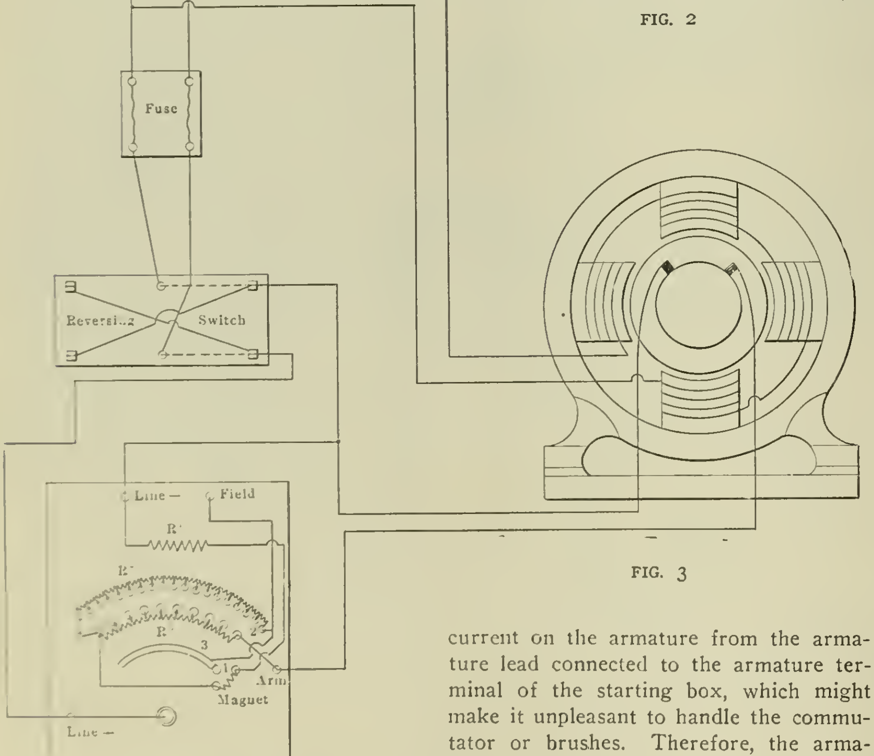


FIG. 3

220-volt motors and run them on either 110 or 220 volts, as speed demanded, with field adjustment for finer gradation. The wiring diagram for this arrangement is shown in Fig. 1. It will be seen that the shunt-field winding is connected directly across the 220-volt mains. This, of course, is open to the objection that there is always current in the field winding, but it was unavoidable because at 110 volts the field winding would not give good results, nor would the retaining magnet on the starting box hold the lever in the running position. It will be seen also that the lead to the armature terminal of the starting box is from one of the wires of the 220-volt main, whether the voltage switch is to the right or left, and the lead from the shunt terminal on the starting box goes through two incandescent lamps in series to the other wire of the 220-volt main. It is evident from the diagram that the starting lever will be held in the running position, whether the switch is thrown to the 110-volt or the 220-volt side, and that the field winding has always 220 volts at its terminals, regardless of the position of the switch or the starting box.

The two lamps burn as soon as the switch is thrown in on either side, and serve as pilot lights to indicate the position of the switch. If connected to the "line" terminal, the lights would not burn brightly until the lever of the starting box made the first contact, although they would burn dimly on 110 volts through the armature. Moreover, there would be current on the armature from the armature lead connected to the armature terminal of the starting box, which might make it unpleasant to handle the commutator or brushes. Therefore, the armature is entirely cut out, by putting the switch lead on the armature terminal of the starting box (which is contrary to rule) as soon as the lever falls down.

To provide for farther speed control a rheostat is put in the shunt-field circuit and is of such capacity as to make it impossible to weaken the field enough to cause sparking. It is evident that this rheostat control demands an excess of motor power; that is, a 5-horsepower load requires an 8- or 9-horsepower motor. But the company had the motors and it was better to use them than to buy new variable-speed motors. There is the added advantage that the 110-volt load can be put on either the positive or negative side of the neutral wire of the main circuit.

There are three dynamos running during the day and until 8 p.m., after which two carry the load. So it was decided to put the unbalanced load on the negative side of the system, running two of the three machines in parallel on that side. One of the larger 110-volt motors, driving a line shaft, is fed from the power-house switchboard through an individual feeder and switch. When three machines are running this motor is connected to the negative side and when only two machines are running the motor is fed from either the positive or the negative side, according to the requirements as to balancing the load. A single-pole double-throw switch was put in the lighting circuit of the machine shop, as shown in Fig. 2. When closed to the right it makes a two-wire lighting system with the load on the two dynamos running in parallel on the negative side of the system when three machines are running. When thrown to the left the lighting circuit is a three-wire system for use when two machines are running, after 8 p.m. It will be seen that the neutral wire becomes negative and the negative wire becomes positive when the machine-shop circuit is on the two-wire plan. Consequently, all arc lamps are connected between the positive and the neutral wires of the three-wire system and the polarity of their supply is not disturbed.

Fig. 3 shows an emergency wireup for a set of reversing rolls used in making wheel rims. A reversing starting box had been ordered, but failed to arrive in time, and an order was sent out that something be "rigged up." The shunt-field winding was connected directly to the line and a reversing switch was wired in the usual manner. At first the type of starting box shown in Fig. 1 was installed, but there was some question as to how to hold the lever of the starting box in the running position. It was not thought best to connect the holding magnet across the main line nor was there any room to put lamps in as in Fig. 1. A few days before the starting box shown in Fig. 3 had been removed from a grinder stand and repaired. This box had a special resistance R^1 in series with the the starting-lever magnet coil and was provided with four terminals, "line positive," "line negative," "field" and "armature." The box was connected as shown and the trouble was over. The resistance R^2 was intended for weakening the field excitation and was not needed for the rolls motor. The starting-box lever was a two-part one and when contact was made at *2* by the outer part of the lever it was broken at *3* and the shoe on the inner part of the lever passed to the dead button *1*.

This is but to show that one can use what he has if he must. Neither this motor nor those operated on the two voltages give any trouble from sparking. This is to some extent due to the fact that all are of ample power; no doubt the 110-220-volt motors would give trouble if used with too large a rheostat.

Domestic Steam-Turbine Development

The General Electric Company in the Horizontal-turbine Field. Recent Progress in Construction and Operation of Westinghouse Turbines

BY C. B. BURLEIGH AND J. R. BIBBINS

Following are abstracts of two interesting papers on steam-turbine development read at the recent meeting, at Boston, of the Association of Electric Lighting Engineers of New England.

Charles B. Burleigh's Paper

The paper read by Charles B. Burleigh, of the General Electric Company, was largely an explanation of the appearance of the General Electric Company in the horizontal-turbine field to an extent which has not been fully appreciated. The use of the Curtis turbine in large sizes and of the vertical type has led to a popular impression that, except in unimportant sizes and for special uses, the Curtis type of turbine was committed to the vertical position, and Mr. Burleigh's claim that there are in commercial service a large number of horizontal Curtis turbines in this country, ranging in size from 20 to 1500 kilowatts, than there are of the horizontal type of any other maker, came as a surprise to the audience.

Between February 1, 1909, and the date of the meeting, March 18, they had sold 278 horizontal-shaft turbines, of which 30,000 kilowatts capacity were of sizes from 500 to 3500 kilowatts each. As an offset to the possible impression that the vertical turbine had been found a failure and that its builders were changing to the horizontal type, Mr. Burleigh announced that the General Electric Company had sold over 230,000 kilowatts capacity in vertical machines during 1908, and that it has no idea of abandoning the vertical-shaft type, although in the early days of Curtis-turbine development, the desirability of its use was somewhat more apparent in certain sizes than is perhaps today the case.

The leading advantage with which the Curtis turbine came into the field was a lower rotative speed, and the designing of a turbine of such shell and wheel dimensions as best met existing conditions resulted in a diameter in proportion to length which readily adapted it to the gyroscopic action of the spinning top. With the vertical arrangement, floor space was economized, friction and bearing wear were reduced to a minimum; disalignment of foundations was of little or no importance; the cost of foundations was reduced, a smaller number of bearings were required and such bearings as were necessary were of smaller dimensions.

The Only Sacrifice Incurred

The only sacrifice incurred in the securing of these benefits was the maintaining of a pressure on one bearing approximately equal to the sum of the pressures necessary to be maintained on the several bearings of a horizontal machine of equal capacity.

Go back with me, the speaker said, some ten years, and ask yourself what you as the prospective purchaser of a steam prime mover of, say, 2000 horsepower would have said to the manufacturer who offered to furnish you at that time with a unit that was designed to operate at 1200 revolutions per minute. I doubt if you would have agreed to install and operate it if he had offered to give it to you.

Five years of experience have demonstrated the fact that in the majority of cases the reliability and economy have been pushed back to make room at the head for low first cost. How can this be attained? We cannot impair the two other necessary characteristics, reliability and economy; we cannot reduce capacity, but we can increase that apparently unnecessarily slow speed and thereby enable physically smaller machines to do more work, and these fast running machines, comparing more nearly in size, will compare more nearly in cost with those of competing manufacturers.

In doing this the work of the moving parts has been reduced to a point at which they have been continuously operated in a horizontal position. The diameter has been reduced in proportion to the length so that the gyroscopic effect of the moving member has been changed so that it can be as well, if not better, operated in certain sizes in a horizontal position. The change in speed entailed a redesign of generators and here again the manufacturers have been able to profit by experience.

Characteristics Adapting the Curtis Turbine to the Horizontal Position

Some of the characteristics adapting the Curtis turbine to the horizontal position are that the rotative speed of the shaft is within control and may be kept within low limits if desirable. The steam travel from admission to exhaust is shorter, resulting in a short steam path which permits of the bearings being placed near together. This again permits of the use of a shaft of smaller diameter to support a given weight without sag, which further reduces the surface speed of the shaft in its bearing. The expansion of metal being in direct proportion to its volume and the temperature changes to which it is subjected, the steam path being shorter and the shaft smaller, the expansion troubles are reduced to a minimum. The lack of end thrust very much simplifies the problem of horizontal operation.

Inasmuch as clearance either in an axial or radial direction has little or no effect on the efficiency of the machine, the necessity for strict alinement and the danger of disastrous contact by derangement of the bearings are very much minimized. And as steam at boiler pressure and temperature is not admitted to the interior of the machine, but reaches the moving parts only after its pressure and temperature have been reduced by expansion in the nozzles, it is possible as well as desirable to supply it with as high pressure and as highly superheated steam as local conditions will warrant without any detrimental expansion troubles being involved.

Alternating-current Generators

Referring to the redesign of generators, Mr. Burleigh said that the General Electric Company was prepared to furnish a line of alternating-current generators which has been designed for use in connection with the Curtis turbine, both horizontal and vertical, which will, when required, have an actual energy output at the generator, at 80 per cent. power factor, equal to the most economical load point on the steam end. These are known as "maximum-rated units" and will give their maximum kilowatt-ampere output at 80 per cent. power factor continuously with a rise in temperature not exceeding 50 degrees Centigrade above that of the surrounding air.

Compare one of these generators of, say, 1500 kilowatts, with the ordinary machine rated at 100 per cent. power factor to operate continuously at full load with a temperature rise not exceeding 40 degrees Centigrade; at 25 per cent. overload continuously (at 100 per cent. power factor), with a temperature rise not exceeding 55 degrees Centigrade, and at 50 per cent. overload for two hours.

The "maximum-rated generator," being capable of a full 1500 kilowatts output at 80 per cent. power factor, is capable of delivering 1875 kilovolt-amperes, which at 100 per cent. power factor, is equal to

1875 kilowatts. It is capable of delivering this output continuously with a temperature rise not exceeding 50 degrees Centigrade. The 1500-kilowatt old-rating generator (which is rated at 100 per cent. power factor, but capable at this power factor of delivering 25 per cent. overload or 1875 kilowatts continuously with a temperature rise not exceeding 55 degrees Centigrade above the surrounding air) is capable of operating two hours with 25 per cent. further overload. But when you think of it, is it any more capable of doing this than is the other? It is already 5 degrees warmer.

Direct-current Curtis Turbines

The General Electric Company has also a comprehensive line of direct-current Curtis turbines, all of the horizontal-shaft type, for which reason the commutators and brushes are accessible from the floor. The 300- and 500-kilowatt units are designed to deliver current at 600 volts and are particularly adapted for railway work. The smaller sizes, ranging from 20 to 300 kilowatts, are designed to deliver current at 125 or 250 volts and are adapted for use as exciters, or for the operation of lights or motors in industrial establishments.

The low-pressure turbine is designed efficiently to utilize the steam energy from 16 pounds absolute to the best vacuum which local conditions make it possible to attain, and finds its most available field where additions are found desirable in power plants operated either mechanically or electrically from either simple or compound condensing or noncondensing engines.

The Low-pressure Turbine Combined with Single and Compound Engines

The installation of a low-pressure turbine in conjunction with a single-cylinder engine practically converts it into a compound unit, and when installed with a compound engine converts it into a triple-expansion unit, with the turbine acting as a low-pressure cylinder. Due to the fact that the area presented by the turbine corresponds more nearly to the added volume of the steam when completely expanded than an engine cylinder could under any conditions, without entailing the use of moving parts of such size and weight as would make their use absolutely prohibitive, the turbine will as efficiently utilize the steam energy below the atmospheric line as the engine cylinders will above it. There being as many foot-pounds of energy in a pound of steam expanded from atmospheric pressure into a 28½-inch vacuum as there is in the same pound of steam expanded from 150 pounds gage pressure to atmospheric pressure, the low-pressure turbine enables us to double the output of a noncondensing engine and add some 30 per cent. or more to the output of a condensing engine without any increase of fuel consumption, and consequently with no increase in boiler plant.

If, however, the load on the engine is intermittent or extremely variable, steam-regenerating devices are desirable for use with low-pressure turbines, which adds to the expense of installation and upkeep. Again, if the desired increase is more than can be obtained by the addition represented by the capacity of a strictly low-pressure turbine with such exhaust steam as is available from the engine, additional apparatus must be installed to supply the deficiency. The mixed-flow turbine, however, overcomes both of these difficulties and the impulse or nozzle-expanding type of turbine is the only type of turbine the characteristics of which will permit of its use under these conditions and obviates the necessity of using regenerating apparatus.

Why the Curtis Mixed-flow Turbine Is of the Horizontal Type

The Curtis mixed-flow turbine is of the horizontal type for the reason that its installation is most always made in conjunction with engines already installed in equipping engine rooms where head room, in many cases, would not be available for the installation of the vertical type. The steam unit is fitted with two separate and distinct chests, each equipped with valves controlled by the governor. The low-pressure steam chest is connected with the engine exhaust and the high-pressure steam chest piped to the boiler. The low-pressure steam chest is fitted with nozzles designed to expand steam from 15 pounds absolute to the first-stage pressure and the high-pressure steam chest is fitted with nozzles designed to expand steam from gage pressure to the same first-stage pressure. The steam admitted from each chest to the interior of the turbine and brought into contact with the buckets is of equal pressure.

The output of the turbine, therefore, is, to a certain extent, independent of the engine, for which reason a mixed-pressure turbine can be installed of such capacity as will furnish the desired addition to the power plant without reference to the size of the existing engine and utilize the engine exhaust to its fullest extent and use only such steam direct from the boilers as is necessary to supply the deficiency. The governing being perfectly automatic, should the engine for any reason stop, it will in no way interfere with the operation of the turbine, for the governor will then operate a sufficient number of high-pressure valves to admit steam from the boiler in a sufficient quantity to operate its load.

On the other hand, if sufficient steam is available from the engine to operate the load on the turbine, all valves in the high-pressure steam chest are closed by the governor and the turbine is operated wholly by the exhaust steam.

J. R. Bibbins' Paper

This paper dwelt in some detail on the progress which has been made within the last two or three years in the construction and operation of Westinghouse turbines. Particular reference was made to the development of the double-flow and low-pressure types, which have been brought about by the necessity of very large units on the one hand, and the increase in economy of existing engine-driven stations on the other. Details of construction were also illustrated of the various improvements made from time to time in the single-flow turbine, which is now manufactured in sizes from 300 to 3000 kilowatts, while the double-flow design covers a range of sizes from 5000 kilowatts upward. In the single-flow type details of the cylinder construction were illustrated, showing the design employed entirely free from longitudinal ribs or ports cast in, and otherwise unencumbered; the whole being supported at the two ends in the form of a perfectly symmetrical envelop, anchored at one end and free to expand and contract.

A new parallel-motion governor was discussed, also other details such as water glands, oil pump, copper-clad blading, etc. Special mention was made of very complete bearing experiments which were carried out at the builder's works at East Pittsburg. These were made with a 70,000-pound dummy rotor, with full-sized bearings. To obtain greater unit pressures, the length of the bearing was reduced. In these experiments the bearing duty was increased to as high as 300 pounds per square inch of projected area and 80 feet per second velocity, without failure, which represents four to five times the bearing duty actually employed in the bearings of Westinghouse turbines. These bearing experiments were conducted with a view to determine the feasibility of solid-babbitted bearings for the double-flow type of turbine, which is essentially a high-speed machine. Units of 5000 to 6000 kilowatts operate at a speed of 1500 revolutions per minute, whereas the original single-flow units in this size operated at half this speed.

Development of Double-flow Turbine

The development of the double-flow turbine and the remarkable reduction in size was shown by a detail sectional drawing of the machine, as compared with a similar section of a single-flow type turbine; the center-to-center line of shaft being from one-third to one-half less, owing to the replacement of the high-pressure stage of the single-flow by means of a velocity element. Typical installations of the double-flow were exhibited; among them the Pittsburg Railways station and the large Kent avenue station of the Brooklyn Rapid Transit Company, where five 10,000-kilowatt double-flow turbines will ultimately be installed, in addition to the five 5500-kilowatt machines now in operation. Two of the former are already in operation. These 10,000-kilowatt units are frequently called upon to sustain loads as high as 18,000 kilowatts, and one of them recently tested sustained the equivalent of 15,000 kilowatts continuously, with a temperature rise considerably below the normal for its actual rating of 10,000 kilowatts. Under these conditions, if supplied with 200 pounds pressure, when operating at 28 inches of vacuum, this turbine would be able to sustain maximum loads of from 20,000 to 22,000 kilowatts; consequently, it is one of the largest machines in existence.

Mr. Bibbins claimed that in the smaller sizes, which do not entail extreme dimensions for rotor and stator, the Parsons type offered particular advantages, and has never been excelled in point of economy. On the other hand, the double-flow machine, by reason of the more favorable design possible with the higher speed, is able to attain economies equal to, if not better than, those of the straight Parsons system, and the double-flow design promises well for the future.

The Low-pressure Turbine

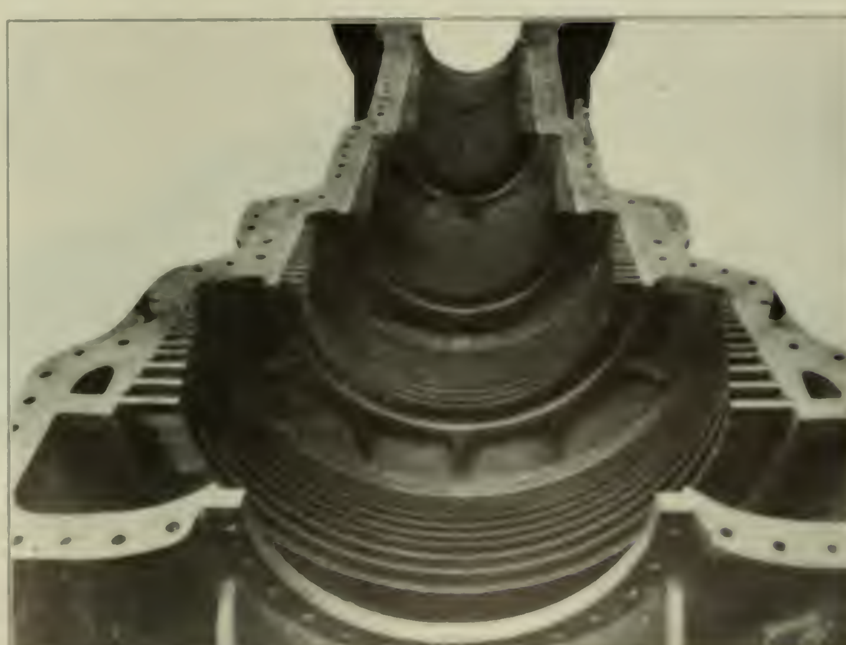
The low-pressure turbine was dwelt upon at some length as a recent development which occupies a unique position in power-plant design, and brought about by the desire for the utmost economy in operation, especially of old engine-driven stations. The low-pressure turbine was shown to be simply the low-pressure stages of a standard double-flow machine, in which the high-pressure velocity element was removed, requiring no nozzles, valves, balance pistons nor governor. This form is of the simplest possible design in turbine work and also very efficient, for the reason that the high speed permits a design of small diameter with blades of ample proportion to obtain efficient working. The secret of the high economy of the low-pressure system lies in the fact that the steam turbine is especially economical in the lower ranges of expansion, while the reciprocating engine is at best in the high-pressure ranges; the combination plant giving a resultant economy far better than could be obtained by either engine or turbine expanding through the whole range. It was shown that with a 1000-kilowatt engine and turbine of normal proportions a water rate as low as 16 pounds per kilowatt-hour could be obtained with saturated steam at 150 pounds boiler pressure and 28 inches of vacuum. This is equivalent to about [illegible] pounds per indicated horsepower-hour in a reciprocating-engine cylinder.

The method of determining the steam consumption of the combined plant from tests of the engine and turbine unit was outlined in the form of curves from which the relative saving in steam and the relative increase in capacity could be readily seen. For a 2000-kilowatt combined plant, an increase in capacity of from 30 to 40 per cent. was shown to be possible for a condensing engine, with a corresponding increase in economy, while for a non-condensing plant an increased capacity of from 80 to 90 per cent. could be realized with the same increase in economy.

Methods of Governing

The two methods of governing were examined; first, the constant-pressure system, such as would prevail in a plant receiving the exhaust from a large number of engines; and, second, the variable-pressure system, in which the low-pressure turbine was connected directly to the engine through the electrical end. In the first case, a turbine governor would be necessary; in the second, the turbine would run without a governor, being locked electrically in step with the engine and operating as the third cylinder of a triple-expansion system. In cases where a shortage of exhaust-steam supply is expected for brief periods during the day, a pressure-reducing valve may readily be installed to make up the deficiency from the live-steam line. This obviates the necessity of a steam regenerator, which is suited only to periods of deficiency of comparatively short duration, such as from one to seven minutes as in rolling-mill practice. For the average electric-

CONDITION OF LOW-PRESSURE BLADES, HARTFORD TURBINE; UPPER ROW, [illegible]

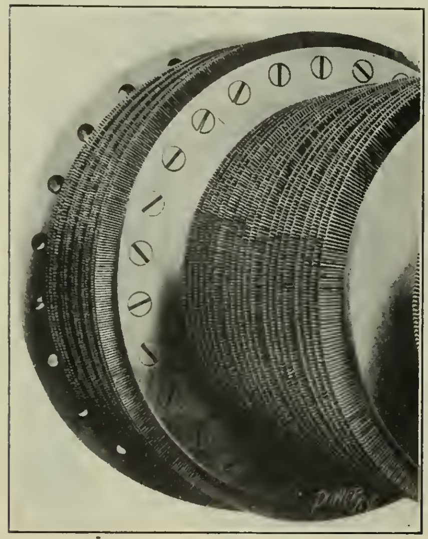


CYLINDER BASE, HARTFORD TURBINE—[illegible] light plant, having reciprocating engines in which the economy could be improved by the use of low-pressure turbines, it was shown that the turbine plant was reduced to its simplest dimensions, with practically no auxiliary apparatus except the condensing plant.

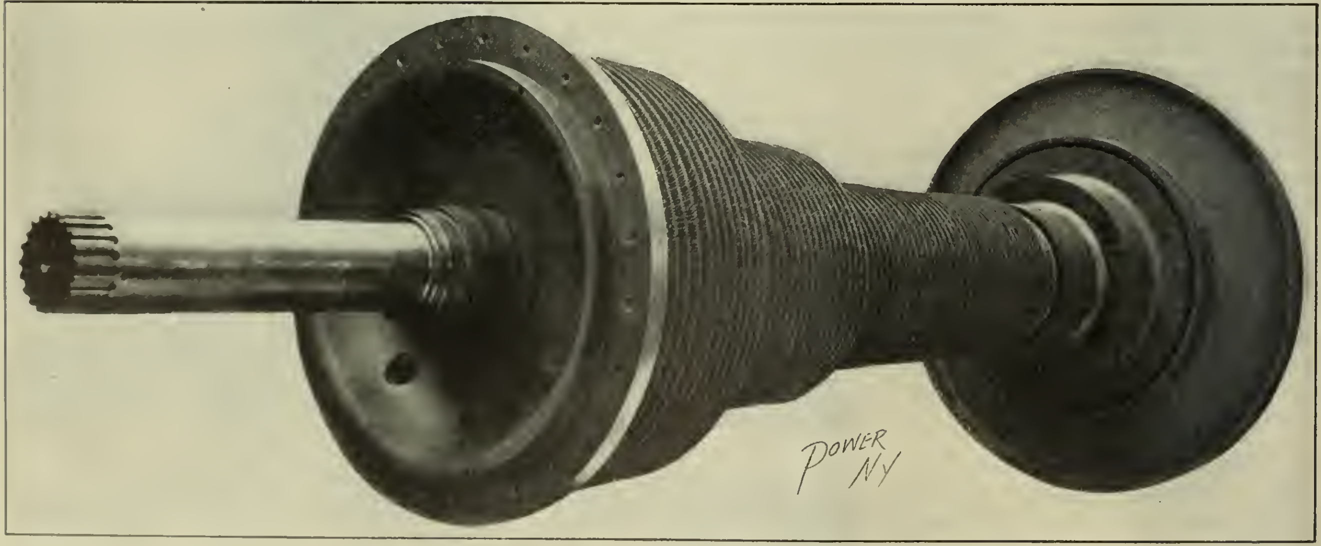
In the matter of central-station design a comparatively new type of station was discussed, the double-deck station, with turbines on the second floor and boilers beneath; the special advantages being extreme compactness, short and direct steam mains, direct-connection to the turbine nozzle by means of barometric condensers and extremely low installation cost. Plants referred to of this design were the Fort Wayne & Wabash Valley Traction Company at Fort Wayne, Ind., the West Point station of the Youngstown & Ohio River railroad at West Point, Ohio, and the Hamilton station of the Cincinnati & Northern Traction Company, Hamilton, Ohio, all of which have been in operation for more than a year, sufficient to prove the merits of the double-deck design.

First Large Turbine Installation

In conclusion, the first large turbine installation was shown, that of the Hartford Electric Light Company, a 1500-kilowatt turbine of the horizontal Parsons type. This machine, the eighth turbine built at the East Pittsburg shops, has been in service until quite recently, when it was removed to make way for a more modern and larger machine. The machine was thoroughly examined as regards blading, bearings, glands, valves, governor parts, etc. The average wear on the journals was about 0.002 inch in diameter, with no greater wear vertically than horizontally. The blading in the two low-pressure barrels was particularly examined for evidences of erosion due to entrained moisture in the steam, but the original blades put in eight years ago were found to be quite intact. These blades were of Delta metal, as used in the early construction, and these results should naturally be duplicated with the copper-clad blading of the present time. As an evidence of the rate of deterioration in turbine machinery, this Hartford turbine is of considerable interest. After six years of daily service, and two years as a reserve unit, it is practically in as good condition today as when first installed, which indicates that the rate of physical depreciation is actually much smaller than is often supposed.



CLOSE VIEW OF ORIGINAL BLADING IN INTERMEDIATE AND LOW-PRESSURE DRUMS



HARTFORD SPINDLE COMPLETE, HIGH-PRESSURE DRUM; LATER BLADED WITH COMMA LASHING

Referring to the view, on page 767, of the low-pressure blading, it should be explained that the few small nicks shown were made in removing the blading. The rough appearance of the blade surface is due to deposits of foreign matter carried over from the boiler-feed water.

Smoke Not Always Wasteful

A "smoke-abatement exhibition" was held at Sheffield, England, recently, at which the opening address was made by Sir Oliver Lodge. Among other things he said that it was customary to regard smoke as wasteful and as indicative of imperfect combustion. If this were entirely true, then in self-interest manufacturers would do their utmost to stop it. Unfortunately, smoke in practice was not wholly wasteful. Under certain circumstances it might be economical. He regretted to say this, but it was a fact. It was economical when fires had to be banked; it was also economical when they had to heat cold surfaces by means of flame, for in such an operation a smoky flame was more efficient than a nonsmoky flame. A luminous smoky flame was better than a nonluminous one for that purpose under present boiler conditions. It was impossible to bring a flame into contact with a cold surface and to have perfect combustion. The heat had to pass through a film of unburnt gas by radiation. That was the real difficulty, but things might be improved. It was possible, for example, to have studs or projections on the boiler plates which would get red hot in the flame and carry the heat in by conduction. It was important, however, that they should realize that they had to deal with radiation and should strive to obtain the best possible radiation.

Ten years ago gas and petroleum engines were not used in Japan, but within that period they have become so popular that they now represent nearly 15 per cent. of the total motors adopted by manufacturers.

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Power Plant Accident

A few weeks ago a very peculiar accident happened in the power plant of the Hotel Racine. The general arrangement of the plant is illustrated in Fig. 1. There are two return-tubular boilers 56 inches by 14 feet, a 10x14 Ideal engine running at 247 revolutions per minute and belted to a bipolar generator, of 200 amperes capacity at 125 volts, running at 1330 revolutions per minute.

This plant has been in operation about fourteen years, during the first twelve of which a workbench was located in the corner now occupied by the desk, and within about 4 feet of the commutator of the generator. Yet in all that time with the large amount of work that has been done at that bench, there never had been any accident by any substance, metallic or otherwise, coming in contact with the generator.

About two years ago the chief engineer, desiring to have a better location for his workroom, removed the bench to a suitable room on the other side of the boilers from the engine (not shown) and put his desk in its place, as illustrated.

On the night in question the night engineer on watch, a most careful man, desired to trim off the ragged corners of his scoop shovel, and not caring to go into the work room to the bench (away from the engine) he laid the coal pick on the floor in front of boiler No. 1 at about the same spot marked *X*, and proceeded with the trimming by means of hammer and chisel, but with his back *toward the door* leading to the engine room, and in such a position that as the pieces were severed they would in all probability fly across the fire room toward boiler No. 2.

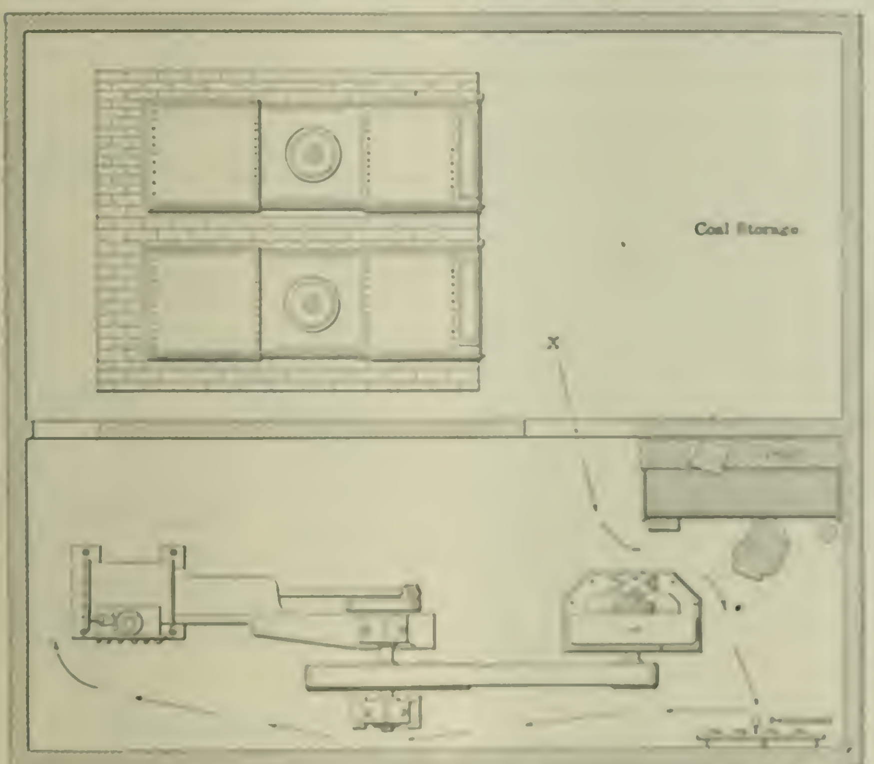
It is usually the unexpected which happens and in this case "the cussedness of inanimate things" was again exemplified by the severed piece of the scoop flying up and striking somewhere. It made a "three-ball combination play for the corner pocket," flew over the engineer's head through the door and into the air gap of the generator with the usual accompaniment of electrical display. At the next flash the engineer made a dash for the switchboard and threw the double-throw main switch over onto the city current, and continued on past the board, as indicated by the arrows, and closed the throttle.

Upon making a closer examination he found that the binding wire of the armature had been severed near the commutator end, and the insulation was also badly cut. A spare armature for this machine is kept on hand for just such emergencies. Taking the telephone from the desk he called up the chief engineer, who resides a short distance from the hotel, and upon his arrival the old armature was removed, and the spare one inserted and the machine placed in operation again in just an hour and a half.

Now, while the old one is undergoing repairs, spare moments are put in by all hands in trying to figure out just what course the last chips off that scoop shovel took to dodge the engineer, pass through a doorway and get into that dynamo.

S. H. WALLACE.

Racine, Wis.



GENERAL ARRANGEMENT OF HOTEL RACINE PLANT

Safety of Pipe Fittings

A. L. Dixon and W. G. Perkins have me "guessing." Mr. Dixon recently figured the original factor of safety on a valve-bonnet joint and presented a [illegible] of 42,120 pounds per inch tap acting, exerted in holding the bonnet on [illegible] against a stress of [illegible] pounds per inch [illegible] tending to blow the bonnet off. He admits that the joint leaked and I can't seem to figure out how it ever could be tight under those conditions. I have made several joints in my time and it has always been my endeavor to have the means of holding joints together overcome the tendency to pull apart.

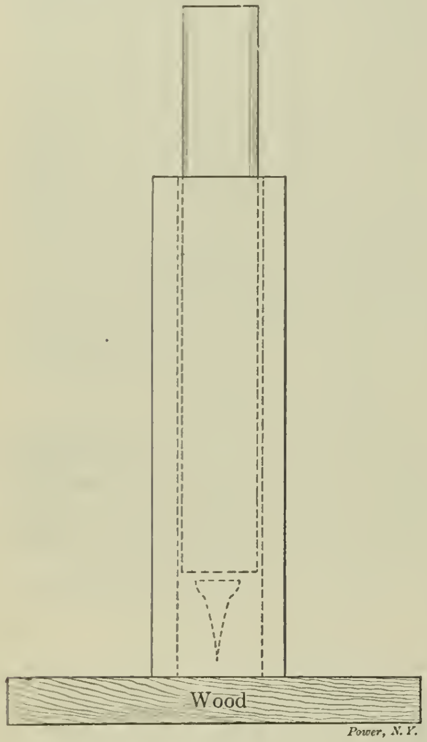
When I came to Mr. Perkins' article afterward I thought someone else had seen the error of Mr. Dixon's ways, but he only adds confusion to what I thought I knew, for he says that the stresses tend to balance each other. When the steam pressure and the screwing-down pressure are equal, are we to assume there is no pressure on the joint? It seems to me that as the steam pressure and the screwing-down pressure both tend to strip the thread, both forces must be acting in the same direction and must be added.

L. A. TRUMAN.

South Boston, Mass.

A Nail Driver

The accompanying sketch shows a little device for use in corners not easily reached with a hammer. The rod should be almost the same size as the inside diameter of the pipe. The method of operation is to put the pipe over the place where the nail is to be driven; then drop the nail into the pipe and place the rod in the pipe on top of the nail. Then pull



A NAIL DRIVER

the rod up and down until the nail is driven home.

WILLARD G. PURDY.

Elgin, Ill.

Electrolysis and Superheat

Mr. Sawyer's article in the March 2 number, in regard to pump corrosion, is in some respects interesting and at the same time very amusing. Pumps do not show the conditions of which he speaks, except in rare cases.

There is no good reason for the "one pump" in question to be eaten away any more than any of the other pumps, and if the contents of this "one pump" was circulated through some one of the other pumps, I think that the same condition would exist in it, regardless of its location; and the only way to determine the result would be to try it. As it is not stated that all the pumps handle the same solution, it cannot be known why the electrolyte in this "one pump" should be any more active than in any of the other pumps, and the only way to determine this would be to make a very thorough test, which must be carried out as follows: Tap the discharge line from each of the pumps with a small pipe, and allow them to flow into a containing vessel, say for twenty-four hours, as it is stated that "at certain portions of the day some sewage which possibly might contain nitrates is carried through the different pumps in the condensing system." A portion of each of these solutions should then be given a test to determine what per cent. of alkali or acids they contain, and if this "one pump" had an electrolyte of a different character, it could then be noted. If they all show the same percentage of elements present, it would seem quite natural that each pump would be affected in the same manner.

To determine, then, if the iron and brass in this "one pump" was of a higher electromotive force, in comparison with the other pumps, take some of the decks or valves and a portion of the brass lining as positive and negative elements to make a cell, using a glass container and some of the solution as the electrolyte, having it as hot as when circulating through the pump. The connections to the piece of brass and iron should be very secure in order to reduce the resistance of the connections. With the cell thus made, as a voltaic cell, use a millivoltmeter or a galvanometer to determine what the electromotive force is, if any. This would tell if there was any local action taking place within the "one pump." The other pump parts and electrolyte should be likewise tested, to determine if there was a difference. It is possible there might be some marked difference in the composition of the pump parts, although hardly probable.

As to electrolysis taking place due to the wiring system of the plant being grounded, such a condition would be almost impossible to exist where there is a network of piping for water and steam. For electrolysis to take place, there must be a difference of potential, and in the case of the "one pump," there is no condition which would cause a difference of potential between the pump parts and the water or solution handled.

If, for any reason, the piping to and from the "one pump" was carrying any stray current, due to the wiring of the plant being grounded, there is no reason at all that the current should disobey the laws governing electrical energy, and take the course via the water route. As for the "electric-car line half a mile away" affecting the "one pump," it need not be considered at all.

The electrolysis due to electric-railway service is well known and thoroughly understood. Its effects are confined to gas and water trunk mains, and is carried on upon a grand scale when not properly guarded against.

I would feel perfectly safe in saying that the "one pump" trouble was due to the water or solution handled, and not to any electrical effects.

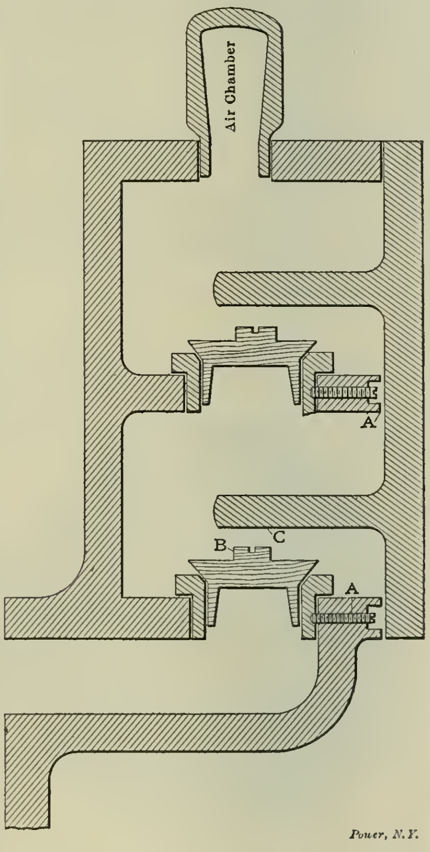
L. EARLE BROWN.

Ensley, Ala.

Loose Valve Seat

One day the oil pump on our turbine, after three years of faithful service, suddenly refused to work, and no amount of persuasion would start it. This pump circulated the oil through the cooling coils and up into the governor case, and then flowed by gravity to the bearings. As a temporary remedy we drew the oil in a pail from the base of the machine and poured it into the reservoir and in that way managed to keep going until noon, when we shut down to investigate.

After drawing all the oil from the system and removing the valve plate, the only thing that could be discovered was that a piece of gasket was gone from the partition between the suction and discharge



LOOSE VALVE SEAT

chambers, as at *A* in the illustration. The valves and seats seemed to be in perfect condition, with the exception of conconsiderable wear on the button on the valve at *B*, caused by the valve continually striking the stop bar at *C*. But as everyone was of the opinion that the trouble was caused by the gasket, we renewed it and started up.

Our oil level held up finely for two or three days, when it commenced to fluctuate. It would be first up and then down, keeping a man busy with a pail most of the time.

A final examination showed that the suction-valve seat was loose. This seat was fastened with a set screw, but had worn the metal away from the point of the set screw so that the valve and seat could lift together and check or shut off almost entirely the amount of oil that could pass through.

The remarkable part of it was that when the seat was down in position it fitted so tightly that it would not be noticed as being loose, and could only be raised by the use of some sharp-pointed instrument, and now the oil pump runs as of old.

C. E. Ryan.

East Hampton, Mass.

Pipe Sizes Without Figures

The above is the title of an article in a recent number by J. E. Bates. Mr. Bates bases his method on the fact that the square of the diameter of a circle equal in diameter to two other circles is equal to the sum of the squares of their diameters.

For many purposes this method would be sufficiently accurate, but there are conditions under which pipes so calculated will not have equal capacities. It is true that if the velocities in the pipes are equal the capacities will be equal, but take the case of an elevated tank from which water is conveyed by a 2-inch pipe to the place of use, 300 feet away. Suppose this 2-inch pipe is replaced by its equivalent in 1-inch pipes. By Mr. Bates' method this would require four 1-inch pipes. Upon trial the flow from four 1-inch pipes will not be found equal to one 2-inch pipe, due to the increased friction of the smaller pipe. Correctly to proportion the sizes of the pipes for equal capacities the friction head should always be considered. Let

q = Volume of water delivered by a pipe,
d = Diameter of pipe,
h = Initial pressure head,
g = Gravity constant = 32.16,
f = Friction factor usually taken = 0.02 for new iron pipes,
L = Length of pipe line in feet,
V = Mean velocity of flow in feet per second.

The volume, in cubic feet, of water delivered by a pipe is equal to the product of its sectional area in square feet into its mean velocity.

$$q = 0.7854\, d^2\, V$$

but

$$V = \sqrt{\frac{2\,g\,h}{1.5 + f\left(\frac{L}{d}\right)}}\ ;$$

hence we have for full pipes:

$$q = 0.7854\, d^2 \sqrt{\frac{2\,g\,h}{1.5 + f\left(\frac{L}{d}\right)}} = 0.7854 \left\{\frac{2\,g\,h\,d^5}{1.5\,d + f\,L}\right\}^{\frac{1}{2}}.$$

From this we see that the relative discharging powers of pipes are nearly as the square roots of the fifth powers of the diameters. Or, in other words, the diameters required for equally effective deliveries will vary nearly as the fifth roots of the squares of the volumes.

The accompanying diagram was designed to facilitate the proper proportioning of piping systems. From it to determine the relative capacities of different-sized pipes and their equivalents

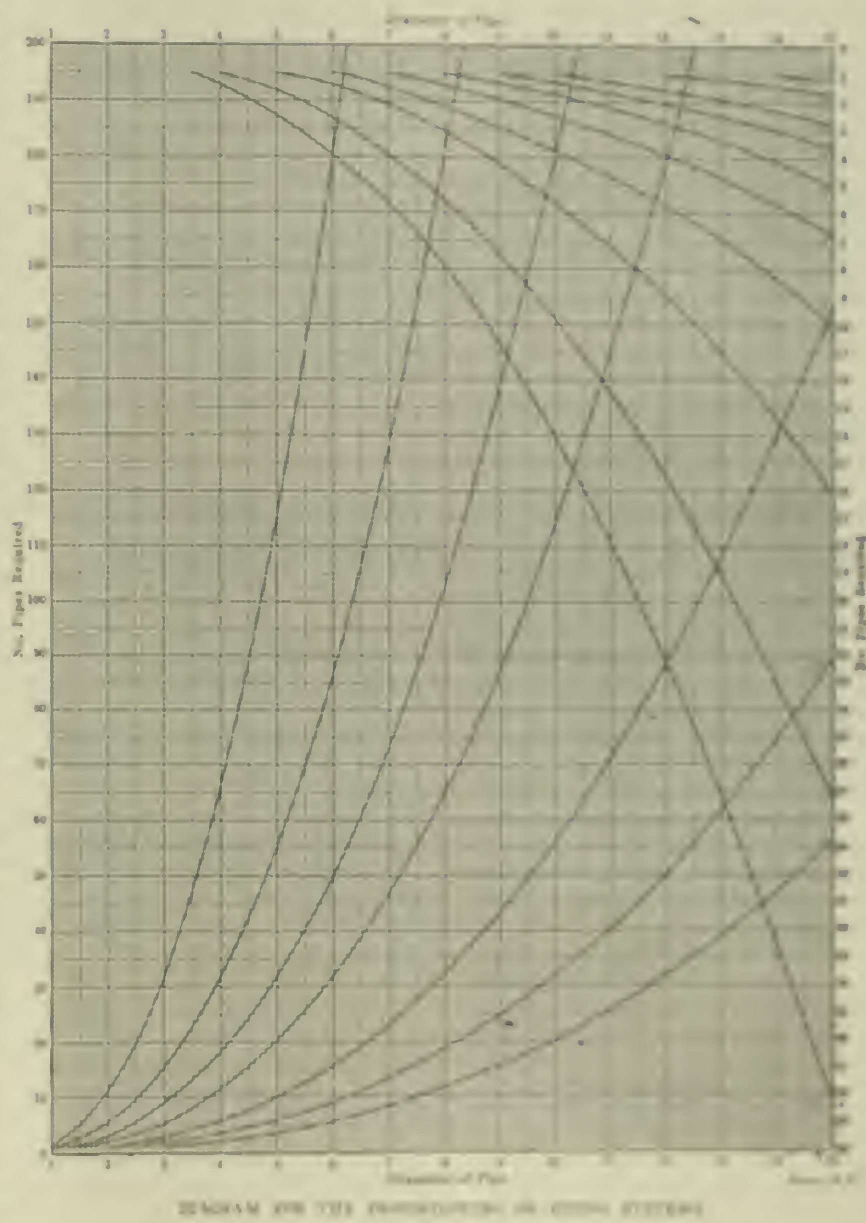


DIAGRAM FOR THE PROPORTIONING OF PIPING SYSTEMS

can be found. The usefulness of the diagram can best be shown by the solution of the following problems:

Problem 1.—From a centrifugal pump having one 8-inch suction opening with which to pump water from two wells, find the size of the suction pipes.

Solution: Start at 8 from the upper margin and proceed down two spaces (the number of suction pipes required), following the curve, and find the pipe to be a little larger than 5 inches. The difference is so small that it will be sufficiently accurate to use 5-inch suction pipe.

Problem 2.—Water is to be piped from four tanks at the same height, each tank having a 4-inch outlet. What size of pipe equal in carrying capacity to the four 4-inch pipes?

Solution: From where the 4-inch pipe curve crosses the "four" line from the upper margin, and proceed up to the top, where the size is found to be 7 inches.

Problem 3.—Find the size of pipe equal in capacity to one 3-inch pipe and one 6-inch.

Solution: By inspection we find that one 6-inch pipe is equal to 8¼ three-inch pipes. The capacity of the combined pipe must then be equal to 9¼ times that of a 3-inch pipe. By referring again to the diagram, we find the diameter to be 7.4 inches. If the velocity is not given, the 7-inch pipe would then be increased, but as a rule it would be better to use an 8-inch pipe.

Problem 4—This is Mr. Bates' problem. Find the size of pipe equal in capacity to one $3\frac{1}{2}$-inch, one 5-inch, one 2-inch, one $2\frac{1}{2}$- inch and one 6-inch.

Solution: The smallest pipe is 2-inch. From the diagram we have:

One 2 -inch pipe	= one	2-inch pipe.
One $2\frac{1}{2}$-inch pipe	= two	2-inch pipes.
One $3\frac{1}{2}$-inch pipe	= four	2-inch pipes.
One 5 -inch pipe	= ten	2-inch pipes.
One 6 -inch pipe	= sixteen	2-inch pipes.
Carrying capacity	= thirty-three	2-in. pipes.

From the diagram, the diameter is found to be 8.1 inches, or an 8-inch pipe. Mr. Bates, by his method found 9 inches to be the diameter.

Problem 5—This problem is the one given at the first of this letter. Find the number of 1-inch pipes equal in carrying capacity to one 2-inch pipe.

Solution: From the diagram this is found to be 5.7, or six 1-inch pipes.

John B. Sperry.

Aurora, Ill.

Criticism of a Criticism of Turbine Installation

In Power for October 13, 1908, there was a description of a mammoth turbine for Buenos Aires. In a somewhat later number, E. H. Lane calls attention to the amount of water the circulating pumps are capable of delivering per hour. In the Buenos Aires plant there are two circulating pumps designed to operate in parallel, each having a capacity of 112 gallons per second. Normally, it is the intention to operate the pumps in this manner at peak loads, giving a circulation of 224 gallons of water per second. According to Mr. Lane this amounts to 6,693,120 pounds of water per hour, he making the assumption that a gallon weighs 8.3 pounds "(critics, excuse the figure)". Now, there is only one country in the world where a gallon means 8.3 pounds of water, the United States. In every other part of the globe a gallon is 10 pounds of water or 4.543 kilograms or liters, and very, very few know of the gallon Mr. Lane uses. Right here there is an error of over 20 per cent. in the weight of water, which should be 8,064,000 pounds per hour, nearly 64 tons more than Mr. Lane's figure. So that Mr. Lane's figure of 47 for ratio between the weight of the circulating water and the weight of the steam should be changed to nearly 55 pounds.

Another discrepancy in Mr. Lane's figures arises from his comparing the normal rating of the circulating pump with the two-hour overload of the generating unit. The normal rating of the circulating-pump units is 90 horsepower each, and they are undoubtedly able to carry some overload. The normal rating of the steam turbine is 9000 kilowatts, which is equivalent to a steam consumption per hour of 124,800 pounds. Therefore, the normal ratio between the weight of the circulating water and the weight of the steam is nearly 65 instead of 47.

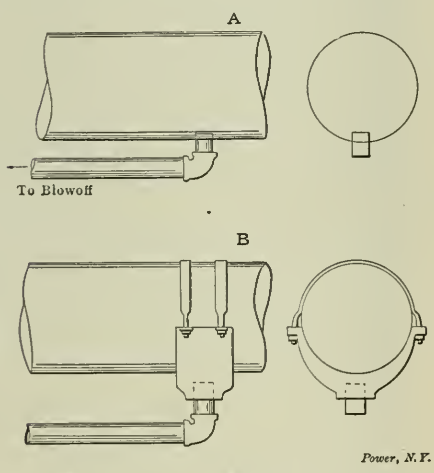
From the foregoing it is very easy to see that the deficiency in circulating-pump capacity cited by Mr. Lane is due entirely to his misconception of the weight of a gallon. It is true Signor Tosi did not state which gallon he meant in his article, but it is in the highest degree unlikely that he would think of the United States gallon of 8.3 pounds, which is given only the most casual sort of mention in foreign engineering handbooks, and is omitted entirely in many.

A. D. Williams, Jr.

Pittsburg, Penn.

Method of Draining Steam Pipe

I have had considerable trouble with water in the cylinders of my engines.



METHOD OF DRAINING STEAM PIPE

When a sudden load was thrown on considerable water would sometimes be drawn over and cause a click in the cylinders for quite a while.

The steam was supplied by four 72-inch by 16-foot horizontal return-tubular boilers, the steam passing through a 12-inch header to the engines. The boilers were not fitted with steam domes or dry pipes, but the header was fitted with a 2-inch diameter pipe which connected to the boilers through the blowoff pipe.

The nipple which was made into the header was screwed in so far that it extended up into the header about ⅝ inch, as at *A*, so it was necessary for the water to stand high enough in the header to run over the end of the nipple before the bleeder would carry it off; consequently when a sudden demand for steam came, part of the water in the header was carried over with the steam.

I took the nipple out and attached it to the header by a "service clamp," as shown at *B*. Since doing this I have had no trouble.

R. L. Rayburn.

Decatur, Ill.

Dashpot Troubles

In reading the comments by Messrs. Westerfield and Harding, as to the cause for Mr. Davis' dashpot troubles, I do not think that they have given all the causes for the failure of the dashpot's seating. As far as they have gone, well and good, but any engineer will naturally look at the dashpot leathers when they begin behaving badly, and if they are in bad condition, it will be seen at once and remedied.

There are other causes which, I think, deserve attention, in addition to the causes already given. A good working dashpot has a certain strength, and if it is loaded beyond that strength it will not seat; any air leak in the vacuum pot will weaken it, also.

Many of the old-type dashpots have a gasket at the point where the air valve is located, which is very narrow, and air leaks in at this point, destroying the vacuum. The pot will not close, but will have to be pushed down by the hook.

The dashpot and rod may not be in perfect alinement, causing too much friction, but I do not think this is the cause of the trouble under discussion.

I think there is an excessive friction at some point in the mechanism. If the bonnet is removed, I think it will be found that the head of the stem is rubbing on the bonnet, causing an excessive load on the dashpot. When the engine is running the tendency of the steam would be to force the head of the stem against the bonnet and cause binding. The distance between the head of the stem and bonnet should be at least as great as the thickness of heavy brown paper, and this distance is adjusted by the collar on the stem. I have had this kind of trouble with all types of dashpot. And from the fact that Mr. Davis' valves seat when the gear is worked by hand and no steam is acting on the head of the stem leads me to believe that friction is the cause of the trouble.

The packing on the stem frequently causes excessive friction and gives a similar trouble. A little water should at all times leak around the stem so that the packing may get lubrication from the steam. In addition to the above causes, the air valve, or flap button, which closes the air port when the plunger rises, may be leaking air, in which case the plunger will act badly and not seat.

John Jones.

Hamilton, Ohio.

In a recent number Elsworth Davis gives an account of trouble with nonseating dashpots. I had the same kind of trouble two years ago. I took the dashpots apart and releathered them, giving them a thorough cleaning, but still had the same trouble.

An additional amount of cylinder oil helped a little and gave me an idea that the steam valves were binding in their seats, but this, on investigation, proved otherwise. I found, however, that the trouble was in the valve stems. The oilways on the flange of the valve stem that seats against the bonnet of the bell were worn smooth and ground into the bonnet.

If Mr. Davis finds his trouble here, he can have temporary relief by taking a small diamond-pointed chisel and cut oilways in the flange on the valve stem.

J. R. Boyd.

Rogers, Ark.

Faulty Piping

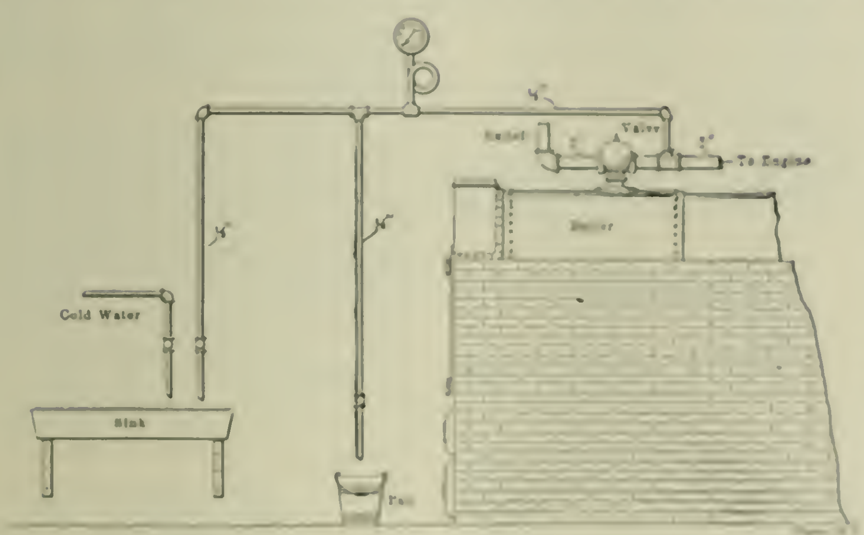
I have often seen faulty piping diagrams and poor connections of various kinds illustrated in Power, but some piping I saw the other day puts everything else in the shade.

Referring to the sketch, it will be seen that the steam pipe to the engine leads from the safety valve. Never having seen such an arrangement, I inquired how it worked without blowing off when the engine was running and was told that there was a partition inside the valve. If this is so it would be well for someone to explain this type of valve, for it must be an old style.

The small ½-inch pipe was tapped to the engine steam pipe, passes along the wall to the steam gage and extends down to a sink, another pipe leading to a pail. It can be readily seen what the effect on the steam gage must be when the valve leading to the sink or pail is opened.

Ernest Hall.

Saco, Me.



FAULTY PIPING

Increase of Salary

In the March 23 number, page 561, Charles W. Mitchell mentions an employer who is evidently willing to pay his engineer less than the engineer may actually be worth to him, in which respect this particular employer is not at all different from many others. As to the query: "Should the engineer ask for a raise, or should he refrain from asking, because he prefers to have increases come unsolicited and as a recognition of merit?" I believe that the greater part of the readers will agree that since the boss delighted in telling about paying the former man less than he might, it is clear that he will not offer the desired increase until asked, and not then unless he has to.

The salary of $25 per week and the fact that a visible saving of $30 per week may be made around the power house indicate that the plant is no backwoods sawmill or country lighting station, and suggests that the boss is very probably a man of at least a little experience in hiring men. If so, he probably has sense enough to know about where he can find another engineer without much delay, should it become necessary. Or, he may have a man or two in the power house who are, perhaps without knowing it, understudies for the job of engineer, and these men may have family, property or other ties that make it fairly certain that they will stay, especially in case the town is of but moderate size and there are no similar jobs to be had without going away.

If it is in a large town or city the important point is, what are other engineers of equal ability and in similar plants receiving? Also, is there anything unusual about this particular power house or the requirements of the industry it serves, making it difficult to break in a new man to the special duties required, no matter how good an all-round engineer he may be? Does the job require considerably closer attention to business or a higher degree of ability, technical knowledge or skill than is to be found in the ordinary available engineer who might be called in to take our friend's place?

After going on the boss and the conditions, does he think that a mere request not backed up by a better offer elsewhere will be favorably acted upon, and can our friend so back up his request, or, if not, is he prepared to hunt out a kind if it does not work? In other words, since the information given indicates that this concern, like some others, is not paying any larger salaries than it has to, and, furthermore, since the boss is probably willing that this fact be known, the question comes right down to the usual one: "Can he fill my place for the same money or does he think or know that he can't?" Until our friend can answer this to his own satisfaction he may as well consider his mind about asking for increases.

A. S. Williamson.

Urbana, Ill.

In answering Mr. Mitchell's query I should say yes, but the engineer should first study well the questions: "Am I worth more to my employer? Am I doing all I can to further his interests? Is my work good enough to justify my employer to increase his expenses by giving me more money? Have I his entire confidence as to my ability to run my part of his business on an economical basis?"

An engineer may save $30 per week for a few weeks, but he should be careful to see that he does not do so at the expense of a future shutdown, for a good reputation is worth as much in this business as in any other. Having decided to ask for more money, do not make the mistake of banking too much on another position you may have in view. Your employer may have another man in view as well.

I have found it best to approach my employer in a gentlemanly way, state the facts in the case, keep my temper and remember that he has more to worry and think about, and knows better what his own needs are, than I. It is well to remember that the goodwill of a former employer has been known to help a man get a position where he could get more money if his former place did not justify it.

D. L. [illegible]

Scranton, Penn.

My answer is that it depends on the type of employer and the fitness of the employee. Employers, generally speaking, are quick to recognize ability and reward it. Sometimes, however, there are employers who, although they realize the ability of a man, do not increase his wages until asked to.

I know of an instance where a young man entered the drafting room of a large electrical manufacturing company. He was a technical-school graduate, but had

had very little practical experience in drafting. For this reason, he accepted a lower salary than was paid to a new draftsman. Being a smart young fellow he soon grasped the work and was doing as good work and as complex drawings as men who were receiving 50 per cent. more salary. When he entered the drawing room he had made a resolution that he would never ask for a raise. He thought that if he did his best work his employer would reward him. After he had been working in the same drawing room for two years, although the chief draftsman recognized his ability, he was still working for the amount he received when he entered the employ of the company.

One day, when he spoke to the chief draftsman about his salary, that dignitary was painfully surprised. He was thinking by this time that our young friend was pretty easy. He agreed with the young man that he thoroughly deserved an increase and gave it to him.

Of course, many an employer would have recognized his ability and rewarded him, but there are quite a few employers who still wait until an increase is asked for before considering it. This is especially true in the case of large companies.

PAUL H. KERR.

McKeesport, Penn.

Criticism of Indicator Diagrams

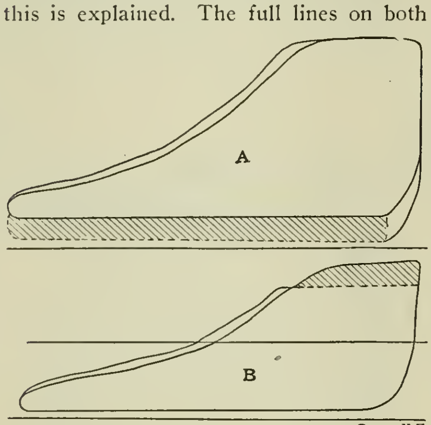
In regard to Lindon A. Cole's cross-compound engine indicator diagrams, I should say that, on the high-pressure side, the head end shows a higher mean effective pressure, and is consequently doing more work than the crank end. He can remedy this by changing the length of the governor reach rods. If changed very much the position of the safeties should be noted when the governor is in its lowest position, to see that the valves do not pick up. Changing the governor rods will change the position of the safety.

The crank-end diagrams show late release, which can be made earlier by changing the right and left exhaust rods. By doing this, the compression will start a trifle later on the crank end, which is not a bad condition to have.

The high-pressure diagrams show slight wiredrawing on the steam line, which is due either to insufficient steam pipe or port area. As to the low-pressure, I should first equalize the cutoff, with the precautions already mentioned, after which advance the eccentric to give a perpendicular admission line, and horizontal steam line to the point of cutoff. If the engine is single-eccentric, the compression will have been increased greatly by this act, which can be decreased by changing exhaust valves to suit.

Unless Mr. Cole has some particular reason for carrying a high receiver pressure of 15 pounds, I should advise him to cut it down by lengthening the low-pressure cutoff, or it may be that he is admitting live steam to the receiver, to get more work out of the low-pressure cylinder. If he will note the position of the governor on the high-pressure cylinder before and after lengthening the low-pressure cutoff, he will find it riding a trifle higher on an average, of course cutting off later in the low-pressure cylinder. Reducing the receiver pressure will decrease the amount of work done by the low-pressure cylinder and cause the high-pressure cylinder to do more, but the decreased resistance due to high receiver pressure, which is back pressure on the "high-pressure cylinder the entire length of the stroke," has a more favorable effect from an economical standpoint than does the high receiver pressure, from the fact that the low-pressure cylinder only gets the benefit of it a fraction of the stroke, while the high-pressure piston is pushing it out of the way all the time.

By referring to the diagrams *A* and *B* this is explained. The full lines on both



MR. WALDRON'S DIAGRAMS

the high- and low-pressure diagrams represent running with high receiver pressure; the dotted lines represent the diagrams after the receiver pressure has been lowered. On *B*, the part that is cross-hatched represents the decrease in the receiver pressure due to lengthening the low-pressure cutoff. It will be noticed that this loss of pressure is only on a portion of the stroke, say one-fourth, whereas the effect of decreased resistance on the high-pressure cylinder, as shown by the cross-hatching in *A*, is for the entire length of the stroke. It is not absolutely necessary for each cylinder to do an equal amount of work, as experience has shown that a compound engine will work satisfactorily, and the water consumption will be reduced per horsepower with low receiver pressure unless extreme conditions of load require the low-pressure cylinder to do an extra share of work.

A. C. WALDRON.

Lynn, Mass.

I should say that an improvement can be made with very little trouble. As far as steam distribution and valve adjustment are concerned, I think the following changes may be made with satisfactory results: The cutoff requires equalizing in the high-pressure cylinder by either shortening the cutoff at the head end, or lengthening it at the crank end. Both head- and crank-end exhaust valves should open a little earlier. The other features of the high-pressure diagrams are good, sufficiently so as to require no change.

For the low-pressure cylinder diagrams the following changes are necessary: The cutoff requires equalizing as in the case of the high-pressure diagrams. Both crank- and head-end steam valves require more lead, as shown by the rounding corners of the diagrams at the intersection of the admission and steam lines; the compression may also be changed to give less than that shown at present on both the crank and head ends.

I am of opinion that the receiver pressure may also be increased, which would tend to correct the sloping steam lines in the diagrams. If this is done, less lead will be required to reduce or do away entirely with the rounding corners referred to. It seems to me that the receiver pressure may be increased to 20 pounds with good results all round, in the case referred to.

I am simply judging from a number of cases I have in mind, and from my own experience with compound engines covering a period of fifteen years. Of course, surrounding conditions largely govern the things to which I have alluded, and judgment must be brought into play when contemplating any change at all. But speaking in general about receiver pressures, I think that in many cases a too low rather than a too high pressure is carried.

CHARLES J. MASON.

Scranton, Penn.

Use of Wooden Wedge Rings

The writer is amazed that any man claiming to be an engineer, either mechanical, steam or civil, would resort to such an expedient as inserting wooden wedges in a pipe line simply in order to get the pipe to "line up." How long does he expect these wooden wedges to last in the line? Could they possibly last one-fourth or one-third the life of the main iron pipe? How will he repair the line, in a few years, when these numerous wedges begin to rot and leaks appear at every joint? Probably by cutting out the service on the water main and again resorting to his famous "wooden-wedge idea."

Mr. Kavanagh evidently had no regard for his employers' interest, or for the permanency of his work, but simply got the line together so it would hold water until he could get away from it.

ROBERT L. RUDDELL.

Glenville, W. Va.

Some Useful Lessons of Limewater

How the Direction of Electrical Current Can Be Caught without Chemical Means; Introduction to the Study of Carbon Compounds

BY CHARLES S. PALMER

In the last lesson we studied the simple electric current, not with the purpose of going into electricity, but simply to show that chemical action is essentially electrical, and also that electrical action may be chemical. The two sets of facts which will be worth while to remember are that in the primary battery the current goes from the zinc to the copper in the battery, the hydrogen appearing at the copper pole or cathode, as the metals do generally, and when the connecting wire is cut anywhere in the circuit, the wire, or the end of the wire, leading from the cathode becomes itself an anode, and the end of the wire leading back to the anode becomes itself a cathode. You can easily clinch this last group of facts by remembering that acid and oxidizing properties are shown at the anode, and basic, metallic and reducing properties are shown at the cathode. It must be recollected that we are also speaking of the positive current, mainly; and to show how the direction of the current can be caught without chemical means, it will be well for you to try the simple experiment shown in Figs. 1 and 2.

The Direction of the Current

Take the simple zinc-copper couple, connected by the coiled insulated wire, and bend the middle part into several parallel

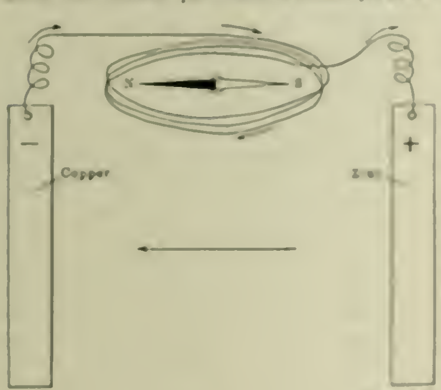


FIG. 1

turns, making a coil. Fix this coil so that in looking at it from one side the positive current from the copper plate goes in at the upper left and out at the lower right, in the direction of the hands of a clock, as shown by the arrows. This coil must be large enough to be held over and around any simple pocket compass. Let the compass lie with the needle pointing north and south. Then place the coil so that it lies north and south and looking from the west, with the current going around clockwise. We will suppose that the coil has been made and the compass needle and coil adjusted before the zinc and copper are dipped into the dilute acid. The moment the zinc-copper couple begins to act as the simple primary battery, the compass needle will swing around to the east (Fig. 2), so that the small elec-

FIG. 2

tric currents which are always rotating in and around the compass will have the needle with its currents parallel with the current in the coil from the battery. As stated, the compass needle will swing to the east, and you can see how this is from the simple rule of Clerk Maxwell that when looking at the compass needle from south to north, the direction of the small currents in the compass is clockwise. This is shown in Fig. 3. All this is given here mainly to show that chemistry is essentially electrical, and that in spite of its being a gas, hydrogen is chemically a metal, just as much as iron, or silver, or calcium, the lime metal which lies hidden in lime and its compounds.

The great advantage of clearing all this up is that we want to use these lessons as the basis for the broad and thorough introduction to chemistry. In this study it will be very handy to have some simple system to guide one in keeping the facts well classified. Now, it happens that one of the clearest and easiest of methods is first to study a few of the typical elements, with the aid of the natural contrast furnished by the hydrogen and the oxygen compounds of the elements in question. Thus, if we are studying such common things as the compounds of carbon, or sulphur, or nitrogen, it is easy to group and remember many hundred facts by making a sort of table, or chemical map of carbon, or sulphur, or nitrogen; and in each case, by writing down the compounds in order from the hydrogen or reduced compounds to the oxygen or oxidized compounds. You would not think of going off to travel or roam in an unknown country without a good guide, or at least a good map to rely on; and so, in the same way, the mapping or tabling of the more common and important compounds of each element in order is the guide map of the right road to an easy acquaintance with hundreds of important and valuable facts.

That is why we have been spending so much time in getting the chemistry of oxygen and hydrogen cleared up; they are not only important in themselves, but they are also important in serving as leaders to much other chemistry. I wish to make this clear, in regard to these ways of using hydrogen and oxygen. Make the tables and study them as they are given, week by week; but do not forget that the tables themselves are not chemistry. The tables merely serve to remind

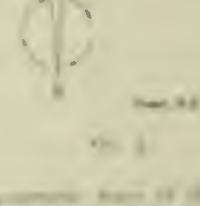


Fig. 3

you in systematic ways of the facts that you get at by your experiments.

Carbon

We will begin this more careful study of some of the commonplace or acid-making elements, by taking up the element carbon. You are fairly familiar with some of the more facts about carbon. You have made carbonic acid gas (CO_2) by burning some coal in the bowl of that tobacco pipe, when you sucked it through some filtered lime-water, and threw down the plain calcium carbonate. You also made some of this same carbonic-acid gas by decomposing some carbonate, like soda, or limestone (lime or calcium carbonate) by some acid such as hydrochloric acid. You also noted that carbon has another common oxide besides carbonic-acid gas, and that is called carbon monoxide (or one-oxide, CO); but you did not make any of this carbon one-oxide.

Yet this lower oxide of carbon is very common in some compounds right about you, as in the common city gas, of which it makes up from 30 to 40 per cent. This lower carbon mon-oxide (CO) is also always found burning in certain flames where you note the peculiar blue or bluish-green color: as in the furnace when you throw on fresh hard coal, or in the lower part of a common candle or kerosene-lamp flame, or in the flame of a common gas stove, or in the lower part of the common gas flame. This gas is found almost everywhere where there is any common burning; and yet it is not easy to make in the pure form, nor is it so easy to test as some of the other gases; but we will try to get at it in some practical way. Of course, you are familiar with plain carbon itself; you know that coal, charcoal, soot, lampblack, coke, etc., are all only so many kinds of carbon. Further, you have read that the so-called "lead" or graphite, "black lead," of "lead pencils" is carbon; and, of more remarkable interest, that the diamond itself is only very pure and hard-crystallized carbon.

Now it is easy to take such facts, and they are facts, it is easy to take such facts without testing them; but if one wants to keep his mind clear, he will ask such questions as these: How would anyone prove that such things as graphite or lead-pencil stuff and diamond are forms of carbon? Someone must have tried the proof. How did he do it? And what did he do? The answer comes back clear and satisfying. Someone burned these infusible and refractory things, graphite and diamond, and all that he got was so much of our old friend, carbonic-acid gas. Then carbonic-acid gas is only the oxidized form of graphite and diamond, just as carbonic-acid gas is only the oxidized form of coal. Then coal, graphite and diamond are all only so many different forms of the same one thing, carbon.

But more than this, if one had pure forms of coal, graphite and diamond, then the same weight of each would give exactly the same quantity of the oxidized form, carbonic-acid gas. Thus one ounce of pure coal, graphite or diamond would each give the same quantity of carbonic-acid gas, or carbon dioxide (or two-oxide). That is, in burning, one ounce of either pure coal, graphite or diamond would unite with just 2⅔ ounces of oxygen, making in all 3⅔ ounces of carbon dioxide from one ounce of pure coal or graphite or diamond. Just how the apparatus would be constructed, how one would weigh his different forms of carbon to be burned and, harder still, just how one would weigh the gas from the burning of the different forms of carbon, all this suggests much interesting material for cross-questioning; but it may be said that the carbonic-acid gas is absorbed in little tubes part full of caustic soda, which are weighed before and after the test, also the burning is done in pure oxygen which, you have already seen, is able to burn such hard things as iron.

But there are other forms of carbon compounds, such as the various kinds of "hydrocarbon," that is, compounds of hydrogen and carbon. There is "marsh gas" or methane, which has one atom of carbon and four of hydrogen in the molecule, thus, CH_4; there is its brother, ethane, C_2H_6; there is its cousin, ethylene, C_2H_4, not very common in large supply; and there is another cousin, acetylene, C_2H_2, now very common in the acetylene lamps of automobiles, where it is made from the action of water on calcium carbide, another product of electrical action and intense heat. Then there are hosts of things like benzine, and benzene or benzol. Do not get these mixed up; for benzine (*ine*) is a mixture of things which are only larger brothers of methane and ethane, and which come from natural petroleum. In refining crude petroleum, benzine and gasolene are only so many mixtures of kerosene-like things, all members of the so-called "paraffin" series; because paraffin wax is only a mixture of several of the still larger brothers of methane and ethane.

But benzene (*ene*) or benzol (C_6H_6) is a hydrocarbon, or compound of hydrogen and carbon, from coal tar mainly, although it is also found in some native petroleums from the Caucasus. This benzene or benzol (C_6H_6) is the first of a class of its own, just as marsh gas or methane (CH_4) and ethane (C_2H_6) and the gasolenes, the benzines, the kerosenes, etc., are in a class by themselves. Now you begin to get restless, and you feel like throwing this blind chapter right out of the window. But, wait a minute and see how easy it is to put it all in clear form so that you can see it and remember it. Just look at the accompanying simple table of these compounds arranged in regular order from the hydrogen or reduced end to the oxygen or oxidized end. Now you see the advantage of getting hold of oxygen and hydrogen as a basis for rounding up hundreds of other compounds of other elements.

But here is the table. Let us look at it for a few moments. It is one of the most wonderful condensations of information in a nutshell ever made; and if you master it, you have simply clinched the chemistry of carbon. First, at the left, come methane, ethane, the gasolenes, benzines and kerosenes; then come the ethylenes, represented by common ethylene (C_2H_4); then the acetylenes, represented by common acetylene (C_2H_2); then such things as the "aromatic" hydrocarbons, represented by benzene or benzol (C_6H_6), and so on, for we have merely put down here some of the more common and important of the hundreds of hydrocarbons, or compounds of hydrogen and carbon. And let us not complain at the deceptive appearance of complexity here. It is Mother Nature who has made all these things, and we are taking up only some few of them as types of the others which you may, or may not, study later; but, if you wish to go on, this simple scheme will guide you through many a maze into clear light.

TABLE OF CARBON COMPOUNDS.

Reduced Extreme. Paraffin Series.	Ethylene Series.	Acetylene Series.	Benzene Series.	Carbon.	Carbon Monoxide.	Oxidized Extreme. Carbon Dioxide.
Marsh Gas CH_4 Ethane C_2H_6 Gasolene Benzine Kerosene	C_2H_4	C_2H_2	C_6H_6	Coal Graphite Diamond	CO Formic Acid H CO_2H Acetic Acid CH_3 CO_2H	CO_2 Carbonic Acid. H_2CO_3

Now comes carbon itself, with its various forms; then, carbon monoxide or one-oxide, related to formic acid, the "red-ant" acid (that is no joke, but simple truth); then carbon dioxide or carbon two-oxide, the type of carbonic acid, and there you have the whole story of what it would take a whole library to tell.

There is one other point which you will want to notice here and that is that the chemistry of water is very closely related to many of the compounds noted in this table of reduced (or hydrogenized) and oxidized forms. You remember that we have mentioned repeatedly that carbonic-acid gas is the anhydride of carbonic acid proper; that is, the difference between carbon dioxide (CO_2) and carbonic acid proper (H_2CO_3) is only a molecule of water. You can see this clearly by noting this simple equation:

Carbonic Acid.		Water.		Carbonic Anhydride or Carbonic Acid Gas.
H_2CO_3	=	H_2O	+	CO_2

This relation between carbon dioxide and carbonic acid is noted in the table;

and here and elsewhere in other tables similar relations imply similar equations which you can readily work out for yourselves by simply adding the number of atoms in the formula of water (H_2O). A little practice in writing such equations will show you just what is the relation between any acid and its anhydride. This tendency of many compounds to unite with water or to give up the ingredients of water is one of the great characteristics of the chemical conditions under which we live; and it is no exaggeration to say that we live in the midst of a water chemistry. To show this, suppose you step right here and take a lump of quicklime and slack it with water. You have already done this repeatedly in making limewater and the equation for this is

Quicklime or Calcic Anhydride.		Water.		Calcium Hydrate or Hydroxide.
CaO	+	H_2O	=	$Ca(OH)_2$

Similarly, you made carbonic acid, as when you treated marble with hydrochloric acid and the equation for this reaction is:

Calcium Carbonate.		Hydrochloric Acid.		Calcium Chloride		Water.		Carbon Dioxide.
$CaCO_3$	+	$2HCl$	=	$CaCl_2$	+	H_2O	+	CO_2
						Carbonic Acid.		

Thus, we see that a base may exist in the form of the base proper combined with the ingredients of water, or it may exist as the base anhydride, and, similarly, an acid may have the ingredients of water, or it may exist as the acid anhydride, that is, without the water. There is one point which must be noted here and that is that it is only oxygen acids (that is, acids containing oxygen) that show this relation between acids and their anhydrides or waterless forms.

As you look at this table you will note that many common compounds of carbon, such as wood, paper, starch, sugar, fats, etc., do not seem to have any place in the table. We shall take up some of these substances later, but here we will perform one or two simple experiments to show that they do contain carbon, and also to show that they illustrate other aspects of this same water chemistry just mentioned. Thus, for instance, pour into a common fruit jar about an inch of common molasses. Then pour over this about an inch of strong sulphuric acid and stir the two together with a glass rod. You will remember that the sulphuric acid is very thirsty, and you will see it attack the molasses by taking out the ingredients of water and leaving the molasses as a black, foamy pudding of carbon. Also, if you pour a drop or two of the strong sulphuric acid on some common wood, you will notice at once the black inky spots produced by the acid, as though it had charred the wood; which it has done, not so much by direct burning as by removing the ingredients of water, leaving the carbon. That is, the wood and the molasses, and similarly starch and sugar and paper, act as though they were made up of plain carbon with the ingredients of water; and for that reason such substances are called "carbohydrates," that is, carbon-water compounds.

This is only the introduction to the study of the compounds of carbon. If you begin to wonder where your friend limewater comes into all of this, just be patient and remember that sometimes "the longest way around is the shortest way home," and though calcium the lime metal may not form many compounds directly with all the other elements, yet it does form a few. In these compounds we shall find that hydrogen is the same sort of thing, chemically, for a gaseous metal that calcium is for a solid metal. We did not include in the list of chemicals and apparatus any calcium carbide, but if you happen to know any chauffeur among your friends, perhaps before the next lesson he will give you a little piece (say an ounce or two) of the calcium carbide which he uses in his automobile searchlight. We will use some of this in the next lesson, but meanwhile be sure to keep it in a dry jar, for it will not stand long in contact with moisture.

Now that we have a simple chemical map of the carbon compounds it will be easy to master the relation of the more important ones, which we will consider in the next lessons.

The Illinois Coalfield

This is the title of a paper presented to the Western Society of Engineers, of Chicago, April 7, by A. Bement. Among other things the author stated that the Illinois coalfield has produced [illegible] tons of coal having a total value of at least $1,[illegible], during which time, on a basis of 57 per cent. recovery, approximately 270,518,101 tons of coal has been wasted. Illinois is the second largest coal-producing State in the country, having a coal area of 37,486 square miles, or 66.4 per cent. of the entire area of the State. Also, according to best recent calculations, it would appear that it contains more unmined coal than any other in the country.

Mining in Illinois has been a very simple proposition. Wasteful extravagance and crude methods have prevailed, but the general awakening of the people of the whole country to the necessity for the conservation of natural resources, and the fact that Illinois mining is advancing into territory of thick seams which lie at considerable depth and produce a dangerous amount of gas, present many new problems of an engineering as well as of a commercial nature.

From the standpoint of future prosperity it is probably fair to say that one of the misfortunes of the Illinois coalfield was the great abundance of cheap coal available in the past, as this led to extravagance and wasteful mining methods.

While Illinois contains a very large amount of coal, it is not all available for mining under present conditions, that as a matter of fact the thinner and deeper coal will always be at a disadvantage as long as it must meet competition with more cheaply mined coal from this or other fields. This is a fact that is usually not understood in its full significance. Really the question is not how much coal we have, but how much is there that may be mined to advantage in competition with other fields.

Thus far Illinois has not suffered to the extent that other States have from large mine disasters, because there is only a comparatively small amount of gas generated, although operation in the deep mines in the No. 7 seam in Franklin county has been attended thus far with very disastrous results, notwithstanding that only three mines have reached a fair stage of development. The reason therefor is that a larger quantity of gas is given off in these mines, which together with the reckless disregard of safety that prevails, changes what would otherwise be a good safe field to a very dangerous one, giving promise that if present disregard for safety continues, it will surely distinguish itself by such appalling disasters as have occurred recently in Pennsylvania and West Virginia. The chief cause of such accidents is the excessive use of powder, which is on the increase and threatens to become still more serious unless proper corrective measures are enforced.

Calculation shows that about one-half of 1 per cent. of the amount of coal in Illinois has been exhausted, and such figures as this is liable to cause one to feel that the supply will last a very long while. In the past people have been led to believe that our coal would last almost "forever," which gave rise to such expressions as "inexhaustible supply," "coal to serve us for untold ages," etc. In this connection Dr. I. C. White has recently shown that when the Pittsburg coal seam is exhausted, [illegible] with present mining methods, the industries dependent thereupon will suffer seriously, and it seems reasonable to conclude that [illegible] these localities of the industrial [illegible] they now enjoy. In Illinois the [illegible] per cent. of coal produced from the [illegible] and [illegible] is wasted [illegible], and the Illinois [illegible] practically dependent [illegible] for fuel [illegible] which contained originally about [illegible] tons of which [illegible] has been exhausted [illegible] the supply available [illegible] of one per cent. of the original, but while this coal remaining is about [illegible] the [illegible] one-half of one per cent.

Turbines vs. Reciprocating Engines

From 10:45, April 12, and continuing to the same time on April 13, the 24-hour speed test of the U. S. scout cruisers "Chester," "Salem" and "Birmingham" was conducted. This is the last of a series of tests under the personal supervision of the Board of Inspection and Survey of the Navy Department in Washington and completes the data for a thorough comparison of the three types of prime mover installed in these vessels. As previously mentioned in these columns, the "Chester" is equipped with Parsons turbines, the "Salem" with Curtis turbines and the "Birmingham" with reciprocating engines. The "Chester" was a winner by about 14 miles over the 24-hour course and during the trial covered a distance of 601.92 nautical miles, an hourly average of 25.08 knots. The "Salem" made 589.12 miles, or an hourly average of 24.54 knots, and the "Birmingham" unfortunately was obliged to retire from the race at the end of the twelfth hour, due to an accident to one of the crosshead boxes. When the test had been in progress for about 11 hours, the babbitt metal in this box suddenly shifted to one side, tearing away the oiling gear. By using a syringe on the crosshead pin the engine was retained in service for another hour, when a brass liner suddenly flew out and necessitated that the engine be shut down. As it was impossible to continue the trial under full speed the "Birmingham" was withdrawn from the race. During the 12 hours she made an average of 24.02 knots per hour, and estimating a continuance of this performance, she would have covered a total distance of 576.48 nautical miles in the 24 hours.

Previously, tests of 24 hours' duration at speeds of 10, 15 and 20 knots per hour were made, and the consumption of the finest steaming West Virginia coal for the entire series of four tests for each vessel is given in Table 1. The results of the full-speed test are given a little more in detail in Table 2. The figures are unofficial, and when the data have been worked up by the commission and analyzed, which will probably be within the course of a few weeks, the results will be published in these columns.

TABLE 1. COMPARATIVE COAL CONSUMPTIONS OF THE FOUR TESTS.

Vessels.	Coal Consumption in Tons.			
	10-knot.	15-knot.	20-knot.	Full Speed.
"Birmingham" (reciprocating engines)....	30	70.2	154.5	364*
"Chester" (Parsons turbines)............	40	83.8	157	415
"Salem" (Curtis turbines)................	49	105.6	209	420

*Estimated from 12-hour run.

In all four of the tests, the data on coal consumption is much in favor of the "Birmingham." This was expected for the slow cruising speeds, but at the higher speeds and especially on the full-speed run, it was predicted that the turbines would easily win in this regard over the reciprocating engines. It must be remembered, however, that the speed of the "Birmingham" was approximately one-half a knot slower than that of the "Salem" and the difference in speed between the "Chester" and the "Birmingham" was a little over a knot. The amount of coal required to gain this last knot or even half a knot of speed is out of all proportion to the increase in speed, and perhaps when the tests are analyzed and the official figures are given out, the figures on coal consumption will be much closer together than they appear to be in Table 2.

TABLE 2. DATA ON FULL-SPEED 24-HOUR RUN.

Vessels.	Nautical Miles Covered.	Average Speed, Knots per Hour.	Tons of Coal.	Coal per Hour, Tons.	Coal per Hour, Lb.	Nautical Miles per Ton.
"Birmingham"............	576.48	24.02	364	15.166	30,333	1.58
"Chester"...............	601.92	25.08	415	17.291	34,583	1.402
"Salem".................	589.12	24.54	420	17.500	35,000	1.45

All data for Birmingham estimated on 12-hour run.

It will be of interest to note that the "chester" developed 26,000 indicated horsepower during the test, and the "Salem," which in her trial test had developed 20,000 horsepower, could attain only 17,000 horsepower upon this occasion. It was reported that something had gone wrong with her starboard turbine and as a consequence, this machine made 15 revolutions less than the port turbine. Previous to the test it was thought that water was being carried into the turbine, but during the trial special precautions were taken to drain the separator on the steam pipe, and it was concluded that there must be some other defect which could be determined only upon an internal inspection. This difference in revolutions undoubtedly slowed up the vessel, and it is asserted that the results of the test might have had a different outcome with the starboard turbine in first-class condition.

From the data in Tables 1 and 2 it is apparent that in the four tests the reciprocating engines had all the best of it as regards coal consumption, and this is all the more surprising when a comparison is made with the trial tests of the three vessels. Table 3 gives a brief summary of these tests in which a screened Pocahontas coal was used, and it will be noted that in the 12-knot 24-hour run, the coal consumption of the turbines was less than that of the engines. It is true that the engines had a little the best of it in the four-hour full-speed run, but why there should be such a difference in coal consumption of the three vessels in the recent tests and not in the trial tests is a question that may perhaps be answered by the commission.

TABLE 3. COMPARATIVE DATA ON TRIAL TESTS.

	"Birmingham."	"Chester."	"Salem."
Full-speed, 4-hour Run.			
Mean speed..........................	24.32	26.52*	25.94
Coal per hour, pounds...............	29,904	38,332	38,502
Miles per ton of coal...............	1.82	1.54	1.51
12-knot, 24-hour Run.			
Mean speed..........................	12.22	12.2	11.93
Coal per hour, pounds...............	4,629	4,091	4,051
Miles per ton of coal...............	5.96	6.68	6.60

*Estimated and probably too high.

As regards construction, the three cruisers are said to be identical in everything except their motive power. They are of a highly creditable design and are greatly superior to the "Attentive" class of scouts in the British navy. The "Salem" measures 420 feet between perpendiculars, has a breadth of 47 feet 1 inch at the water line and an official normal displacement on a draft of 16 feet 9 inches of 3750 tons, the full-load displacement being 4687 tons. She has two masts, four funnels and carries a light armament of two 5-inch and six 3-inch rapid-fire guns. The vessel is also provided with two 21-inch submerged torpedo tubes and has been given a water-line belt of 2 inches of nickel steel. The maximum coal-storage capacity is 1250 tons. The "Salem" and "Birmingham" are twin-screw vessels, while the "Chester" with her Parsons turbines required four screws.

Due to the slower speed of rotation of the Curtis turbine, when compared with the Parsons, it was possible to use larger propellers and develop the power in two turbines working on two shafts. With this arrangement the two turbines operate economically, both at high speed and at low cruising speed, and develop a large percentage of the total power when going astern. As no additional turbines were required for the lower speeds, the engine space required was considerably less than that of the equipment of the "Chester," which contains six Parsons turbines operating on four shafts. When running at high speed, steam is admitted to the two high-pressure turbines, from which it is exhausted to the two low-pressure turbines and thence to the condensers. For low cruising speeds of 10 to 12 knots an hour this arrangement could not be economically used and it was necessary to provide a pair of cruising turbines. When these machines are in service, steam is admitted to them direct from the boilers, then passes to the high-pressure turbines, is exhausted to the low-pressure turbines and finally discharged to the condensers. With this arrangement the "Chester" showed a better economy at cruising speeds than the "Birmingham" in their trial tests, but the arrangement, of course, is subject to the disadvantage that two extra units have to be employed, which ordinarily are idle.

In the Curtis turbine, steam at high-pressure is fed through a series of nozzles placed around the circumference of the casings and the power is reduced by simply closing down the proper number of nozzles, instead of reducing the pressure of the steam supply by throttling it at the valve. For this reason the cruising turbines required in the Parsons system to obtain reasonable economy at low speeds are not necessary with the Curtis turbine installation.

From the standpoint of propellers, the Curtis turbine has the advantage. For the best results, the propeller requires a moderate speed of revolution and a turbine, especially of the Parsons type, gives its best economy at high speeds of revolution. It is usually necessary to effect a compromise, making the propellers smaller and running them faster, and the turbines larger, the design calling for a speed less than is desirable for the best economy.

With the reciprocating engine, this difficulty is not experienced, for large-diameter propellers and slow speeds of revolution may be adopted without reducing the efficiency of the engine. Between the Parsons turbine and the low-speed reciprocating engine, the Curtis turbine occupies a middle position, and on this account it was possible to equip the Salem with propellers of unusually high efficiency. At the contract speed of 24 knots their efficiency equaled 62.8 per cent. and at 12 knots only dropped to 55 per cent. As a comparison it may be noted that the propellers of the "Lusitania" have an efficiency of 48 per cent.

A feature of the race which adds to the interest of the full-speed test was the performance of the two turbines recently in running for 24 hours on conditions above that required by the guarantee. Usually full-speed tests have a duration of only four hours, so that continuation of the performance attained in a four-hour test for a period six times as long is worthy of note and goes to show what may be expected of this type of cruiser in actual service.

Spring Meeting of the American Society of Mechanical Engineers

The American Society of Mechanical Engineers will hold its spring meeting in Washington, D. C., May 4-7. Professional sessions will be held, at which papers on the conveying of materials, gas-power engineering, steam turbines, the specific volume of saturated steam, oil-well pumping and various other subjects will be discussed.

The papers to be presented are as follows:

"A Unique Belt Conveyer," Ellis C. Soper.

"Automatic Feeders for Handling Material in Bulk," C. Kemble Baldwin.

"A New Transmission Dynamometer," Prof. William H. Kenerson.

"Polishing Metals for Examination with the Microscope," A. Kingsbury.

"Producer Gas vs. Steam for Marine Service," C. L. Straub.

"Operation of a Small Producer Gas Power Plant," C. W. Obert.

"A Method of Improving the Efficiency of Gas Engines," T. F. Butterfield.

"Offsetting Cylinders in Single-Acting Engines," Prof. T. M. Phetteplace.

"Small Steam Turbines," George A. Orrok.

"Oil Well Tests," Edmund M. Ivens.

"Safety Valve Discussion."

"Specific Volume of Saturated Steam," Prof. C. H. Peabody.

"Some Properties of Steam," Prof. R. C. H. Heck.

"A New Departure in Flexible Staybolts," H. V. Wille.

Correction

In the description of the [illegible] steam turbine, in the April 6 number, it was incorrectly stated that this turbine is handled in America by the [illegible] Company.

Eccentric Firemen's Local No. 56 Has Grown

On Saturday evening, April 10, the Eccentric Firemen's Association, Local Union No. 56, of Greater New York, held a "housewarming" to celebrate its removal to the new headquarters, 12 St. Mark's place. While the hall is quite large, it proved inadequate to accommodate the attendance, and consequently was overcrowded, although everybody had a good time.

Timothy Healy, general president of this organization, gave an address of welcome and his remarks proved most interesting. He said that 10 years ago, when they first occupied the premises at 195 Bowery, they had 300 members, and now it is next to impossible to find a hall conveniently located to accommodate its membership of 2500.

The entertainment given by the "bunch" was warmly received. Refreshments were served during intermission.

The State University of Illinois, among all the American universities, ranks fifth in attendance, but it has no school of mines nor department of mining engineering, although Illinois is the second largest coal-mining State in the country. Therefore the Western Society of Engineers, through its president, Andrews Allen, has appointed the following committee to draft a memorial for presentation to the State legislature petitioning for the establishment of a department of mines at the State University: A. Bement, chairman; F. A. Delano, Prof. J. Arnold, John M. Ewen, Isham Randolph, Capt. R. W. Hunt.

The executive committee of the Museum of Safety and Sanitation, of 29 West Thirty-ninth street, New York, has detailed Dr. William H. Tolman, the director, for field work, and he will start May 1 on a lecturing tour. Chambers of commerce, manufacturers' associations, engineering, insurance and architectural societies, schools and other clubs may avail themselves of this illustrated exposition of devices and methods for reducing damage risks and preserving efficiency, for the cost of the lecturer's expenses [illegible]

Another old-time engine, "still in the ring," is about to be replaced by an up-to-date machine. The engine in question is a [illegible] built by George H. [illegible] in [illegible] and installed in the plant of the [illegible] Company, [illegible], N. Y., where it has been in daily operation ever since. It is to be replaced by a [illegible]-horsepower Rollins engine built by the Rollins Engine Company, Nashua, N. H.

POWER AND THE ENGINEER

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Contents PAGE

Air in Feed Water Heaters

The recent papers by D. B. Morison and others upon the effect of air in condensers suggest a similar investigation of its effects in heaters. These papers point out the fact that the deleterious effect of air is not confined to the diminution which its pressure produces upon the vacuum, but that the fact that more or less of the cooling surface is air-drowned seriously interferes with the access of steam to that surface and with the efficiency of the condenser.

In the open heater the steam mingles freely with the water and is condensed, while the air escapes by the vent, and no steam will get away until the water is heated to the full temperature of the exhaust if the construction is such that the mixture is sufficiently intimate. When the steam is condensed the air which is carried is left behind and simply crowds out an equivalent amount of other air, to be itself crowded out in its turn with air which will come in with other steam. As long as the heater is so well vented that air pockets cannot form through which water shall shower without coming in contact with the steam, the presence of the air will make no difference.

In the case of the closed heater the air left by the condensation of the steam would fill the shell and drown the heating surface, just as a condenser would fill up with air without an air pump, were it not that it were swept out by the steam; and unless there is enough of the surface still accessible to condense it all some of the steam will escape, although the water which it was designed to heat may be considerably below the temperature at which it would cease to condense steam. This, rather than the effect of deposits upon the heating surfaces, may be the reason for the low rate of heat transmission in some heaters, and for the fact that more steam is required in them to raise a given amount of water to a given temperature than when the steam and water are directly mingled. The steam has not only to do the heating, but enough of it must be left to do the air scavenging.

Boiler Inspection and License Laws Desirable

A recent boiler explosion, followed by fatal results, occurred at Farmingdale, Me. Newspaper reports say that the boiler was considered safe, although it had been in use for thirty or more years and had passed through one fire.

Maine, as is well known, has no license or inspection law and it is stated on what is believed to be good authority that all attempts to call public attention to the necessity of such legislation through the daily and weekly papers of the State were promptly and effectively checked.

Boiler inspection and engineers' license laws are regarded by a great many power-plant owners and users as a species of class legislation which must be discouraged, and the press has almost invariably echoed this sentiment.

To the average business man a boiler is a boiler, and he resents the idea that another should dictate whether he shall or shall not use a certain boiler and, if used, what pressure shall be allowed. He seems to forget that the community has an interest in the matter greater than his. His interest is primarily a financial one, while that of the community is one of public safety, which should outweigh any private interest.

It is not assumed that anyone would knowingly purchase, install and operate a dangerous piece of apparatus, but, unhampered by legislative restrictions, one would be very liable to take the chance that a boiler which was old and apparently defective would be safe for a few years longer.

This kind of guesswork should not be allowed and the public, which is usually inert, should be protected from the probability of loss of life or destruction of property by the intelligent administration of proper inspection laws. As an example of what may be expected in a community where inspection laws are intelligently administered may be cited New York City, where but three boiler explosions have occurred since the adoption of inspection ordinances forty-three years ago. Furthermore, it is a fact that where license laws prevail myriads of defects have been found in boilers and their effacement ordered.

Of course, inspection will not make a dangerous boiler a safe one, but it will bring to light all discoverable defects and render the operation of boilers and engines a comparatively safe occupation by eliminating as far as possible all doubtful elements.

Society makes its roads and bridges safe and will not allow the erection or occupancy of unstable or unsanitary buildings and it should not permit in the use of machinery anything that through carelessness or ignorance on the part of one person may cause another to be maimed or killed.

There is one class in society which should be actively engaged in the work of agitating for the enactment of boiler-inspection and engineers'-license laws where there are none, and for the improvement of those which are already in force. This class is composed of the great body of stationary engineers, whose interest in the matter should be impersonal.

If increased wages and better working conditions result from the enactment of laws and ordinances so much the better, but these results should come as a sort of by-product of the operation of rules of action which are founded in a desire to secure public safety and aim for the good of all.

Engines of High Efficiency

In the leading article of this number appear some remarkable figures on the steam consumption of the noncondensing Corliss engines installed in the West Point plant. One of these units is a 300-horsepower simple engine and the remainder of the engine installation consists of two 600-horsepower cross-compound engines. It will be noted that the steam consumption per indicated horsepower-hour of the simple engine is given as 20.98 pounds, and that one of the cross-compounds consumes but 18.33 pounds of steam for the same unit of power. It is not necessary to say that these figures are good. Such a performance on either engine is excellent, and is seldom equaled on units of much larger capacity.

Using the data of the test and bearing in mind that the steam was without superheat and assumed to be dry, it is an easy matter to compute the amount of heat chargeable to the engines, the equivalent heat of a horsepower-hour, and from these figures the potential efficiency, or in phraseology more common, the efficiency ratios of the engines. For the 300-horsepower simple engine the proportion of available heat converted into work proved to be 69.6 per cent., and 79.2 per cent. for the 600-horsepower cross-compound.

As a basis for comparison it may be stated that standard compound engines of 5000 horsepower using dry steam and running condensing on a vacuum of 25 to 27 inches rarely exceed an efficiency of 73 per cent. Their range of temperature is, of course, greater, and as a perfect vacuum is never attained it is hardly possible to convert into work as large a proportion of the available heat as in the case of the noncondensing engine, in which the steam will expand approximately to 212 degrees Fahrenheit. With noncondensing compound engines approximating the capacity of those under discussion, an efficiency ratio of 75 per cent. is high, and a ratio of 65 per cent. for a simple noncondensing engine of medium capacity would be considered good performance. For turbines the efficiency ratio is lower, and will vary from 50 per cent. for the smaller sizes up to 70 per cent. for turbines of the largest capacity, and only when using superheat of 100 to 150 degrees and employing a vacuum of 29 inches.

From the previous data a fair idea will be obtained of the unusual performance of the engines in the West Point plant, and of the two the steam consumption of the simple engine is perhaps the more remarkable. It should be borne in mind that the figures were obtained in a test performance with all conditions favorable. A duplication of the results in ordinary everyday practice would scarcely be expected. It is not our purpose, however, to detract from the exceedingly good showing made by the engines, for even as test figures the values obtained are of the best and the performance of the engines highly commendable.

Engineer Heroes

In the distribution of hero medals individuals in the humbler walks of life, whose title to the honor of being classed among real heroes is unquestioned, have been overlooked. Two possible boiler explosions have recently been prevented, one in Massachusetts and the other in Rhode Island, by the prompt and heroic action of the men under whose charge the boilers were being operated.

In general features the incidents were identical. Passing along the side of the boiler the men noticed steam issuing from the brickwork covering the top of the boiler. Seeing the source of this unusual steam flow, bricks were removed until the entire seam was uncovered, when it was seen that the steam came from a crack extending along a row of rivets in the boiler shell. Fires were drawn, pressures reduced and then, and not until then, when all possibility of danger had been removed, the owners and others were notified of what had taken place.

When each of these men saw the steam issuing from a part of the boiler where there was no legitimate opening, they knew that it was something more serious than a leaking rivet. They knew that a crack in the shell was to be expected and they knew, too, that if a crack existed the boiler was dangerous. They did not run; they did not lose their heads and raise an alarm. They calmly investigated and when the investigation was finished did the right thing, not with flourish of trumpets and a splurge, but so quietly and sensibly and in such regular order that no one knew what was going on until the danger was passed.

Perhaps neither of these boilers would have exploded immediately, but might have held on for some time, until some morning, just as the operatives were gathering for work, the explosion would come and another "golden-crack" boiler explosion, with its attendant loss of life and destruction of property, would be telegraphed across a continent.

There are many human beings alive and well today in Massachusetts and Rhode Island, who owe their lives to these two [illegible] engineers, whose names have never been heralded in the daily papers nor slated for hero-medal awards.

Boston Meetings of the Mechanical Engineers' Society

Nearly 200 engineers of Boston and vicinity assembled in the auditorium of the Edison Company, at 39 Boylston street, Boston, on Friday evening, April 16, to consider the advisability, or, as it turned out, to express their unanimous approval, of holding local meetings in that city of the American Society of Mechanical Engineers. The meeting was called to order by Irving E. Moultrop, of the Edison Company, who stated that about 10 per cent. of the entire membership of the American Society of Mechanical Engineers resided within an hour's ride of Boston and that the meeting was a result of numerous expressions on the part of members of the engineering profession that frequent local meetings of the society should be held in that city.

President Jesse M. Smith and Secretary Calvin W. Rice were present and explained the policy of the council of the society to encourage local meetings and announced the fact that the St. Louis members had just inaugurated the practice. Remarks in favor of local meetings were made by Mr. [illegible], of the Boston & Maine Railroad; Mr. [illegible], vice-president of the civil engineers; Paul Winsor, of the Boston Elevated; Professors Marks, [illegible], Swain, Lanza and Anthony; Mr. Jackson, of the electrical engineers; Frank W. Dean and others, and a committee was appointed to carry that purpose into effect.

"Some Nice Warm Spring Morning"

"You see," said the central station man, "if we can't get the building manager to close down his private plant and buy electricity from us in the winter time, we don't give it up." And then as [illegible] smile [illegible] into a hard smile he said: "We just call on him on some nice warm spring morning and suggest that he had better [illegible] for a few months to prove our [illegible] our claims regarding the economy of central-station service. [illegible] running down [illegible] necessary, [illegible] early closing hours, [illegible] by the time the cold weather [illegible] so that it won't cost very much for low-pressure steam during the following winter, and if we are smart enough he'll figure it the same [illegible]."

"Yes," said I, "when the dark days come on, when the people return from the country, and when the heating season starts the bill will be on, doesn't he?"

"Well, hardly," said the central-station man, "sometimes they have sense to see through it."

[illegible]

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MUST BE NEW OR INTERESTING

The Elliott Mechanical Stoker

The Elliott mechanical stoker, manufactured by the Ridgway Manufacturing Company, Ridgway, Penn., mechanically grinds and regulates the feed of coal to the furnace, distributes it over the grate and removes the ashes from under the grate. The coal is fed, from a storage bin over the boiler, to what is termed a crusher and regulator, the crushed coal passing to either side of the crusher *A*, Fig. 1, into the worm conveyers *B B*, which carry it into the rotary turbines *C C*, located at either side of the boiler front, as shown. These turbines distribute the coal to the grates through the delivery chutes *D D*, Figs. 1 and 2. The passage of the coal is assisted by a small jet of steam, a ⅜-inch pipe supplying sufficient steam to operate the two stokers. The steam jets are arranged as shown in Fig. 1. There are two wheels for regulating the amount of steam for each delivery tube, only one being used under ordinary operating conditions, however.

"Crusher and regulator" is a term properly applied to the device shown at *A*, as it not only crushes the coal but regulates the amount fed, through the turning of the handwheel *E*, which throws the gears into position to operate the crusher faster or slower, as desired. At the same time the worms revolve at increased or decreased speed in response to the speed of the crusher and regulator. The worm

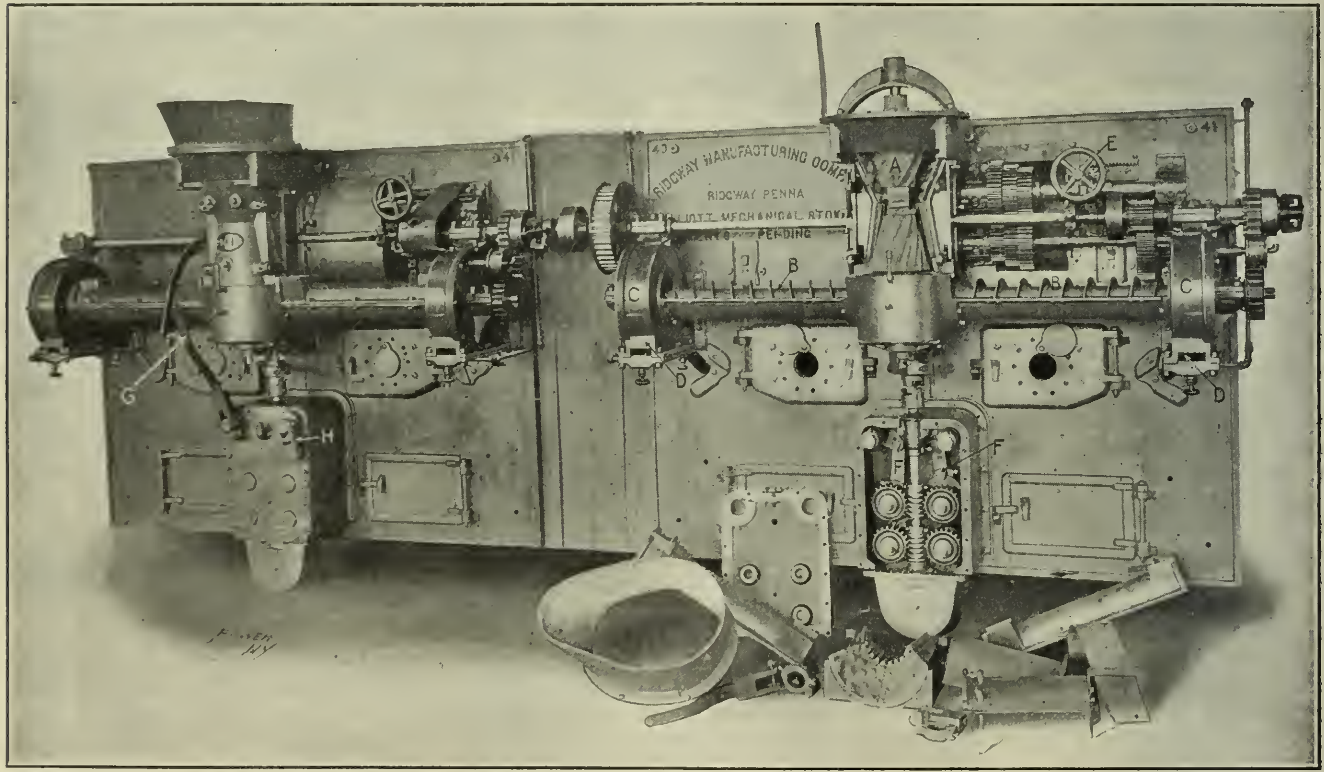


FIG. 1. ELLIOTT MECHANICAL STOKERS, WITH AND WITHOUT CASING

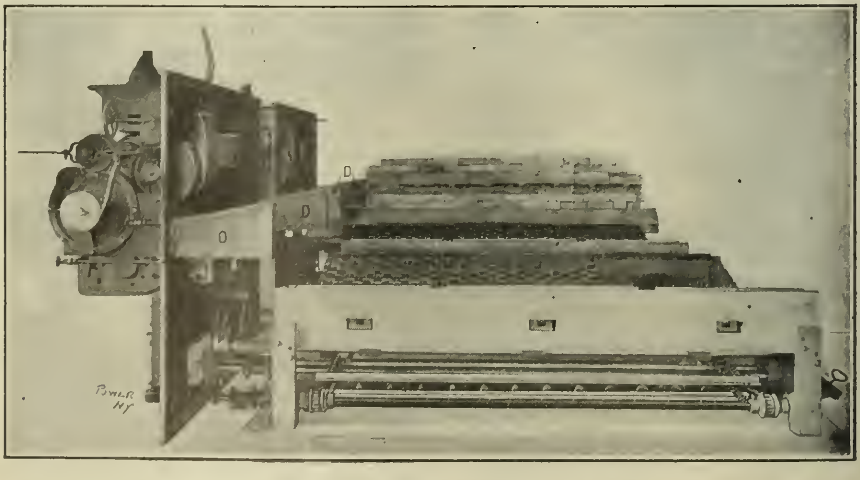


FIG. 2. SIDE VIEW, SHOWING DELIVERY CHUTES, ETC.

FIG. 3. ELLIOTT MECHANICAL STOKERS AT THE RIDGWAY DYNAMO AND ENGINE COMPANY'S PLANT

is operated by a noiseless chain belt as shown. Fig. 1 shows stokers with and without the casing in place. The driving shaft which extends across the front may be coupled to as many stokers as desired. The stokers are usually motor driven, but may be operated by a small steam engine. Fig. 3 shows an installation at the boiler plant of the Ridgway Dynamo and Engine Company, Ridgway, Penn.

The grates are inclined toward the center, Fig. 4, and are actuated slowly by the eccentrics *F F*, Fig. 1, designed to provide a constant, slow opening-and-closing movement, thereby keeping the fire in a clean, bright condition, at the same time spilling the ashes and preventing the fuel from coking and the dead ash from interfering with the air supply.

Provision has been made in case of extremely poor fuel, to dump the larger pieces of clinker and refuse as found, by means of levers, one of which, *G*, is shown at the left of Fig. 1. As shown, the lever is in proper position to dump the lower section of the grate, so as to rid it of accumulated clinker, etc. After the refuse has been dumped the lever is removed and the lever holder drops downward, causing that section of the grate to be interlocked with the rest in position to be operated by means of the eccentrics. At *H* is shown one of the lever holders in the locked position. In this manner every square inch of grate area can be made available to handle its proportion of fuel. The ashes not spilled by the grate are gradually worked to the center, by the constant movement of the grate, and fall into a worm conveyer, as shown in Fig. 4. Under the grate (Fig. 4) will be seen four shafts, two for each side of the furnace, each set being connected by means of chain belts, to which are secured angle irons which scrape the ashes from top of the level concrete flooring of the ashpit. As the frame of the worm is imbedded in the cement there is no possibility of its being thrown out of position. The worm conveyer is operated by means of a gear driven by the upright shaft shown in Fig. 3.

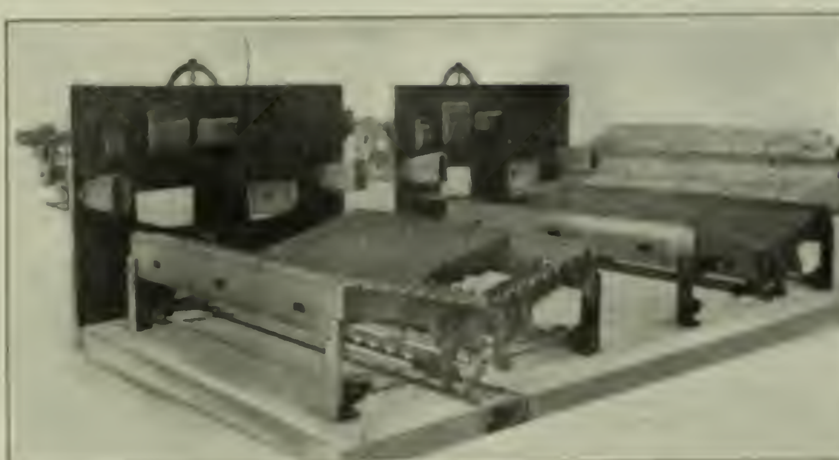


FIG. 4. SHOWING POSITION OF GRATES, WORM CONVEYOR, ETC.

The grates are set at an angle of 28 degrees, each section being removable by operating similarly to the links and lifting them from the frame. As the grate bars are provided with round projections at each end, there being no bolts, rivets, etc., the renewing of the grate is easily accomplished. Top and bottom views of a grate bar are shown in Fig. 5. That the design is eminently suitable for this type of furnace was evident from the appearance of an old grate, which the writer saw, which had been in use in a stoker of different design for two and a half years and showed no indications of warping or burning.

FIG. 5. TOP AND BOTTOM VIEWS OF A GRATE BAR

Obituary

We regret to record the death of Ira Watts, who died of Bright's disease, on April 15, at Spokane Falls, Wash. He was 49 years of age, and was born in Malden, Mass. Early in life he was connected with the Bell Telephone Company and, being an earnest student, became an expert electrical engineer when quite a young man. He served two years in the engineering department of the United States Navy. He was for many years chief engineer of the Knickerbocker building, corner of Broadway and Thirty-eighth street, New York, and superintended the many plants belonging to the Goelet estate. About three years ago he removed to Spokane Falls, where he was engaged as consulting engineer. Mr.

THE LATE IRA WATTS

Watts was for 12 years secretary-treasurer of the Life and Accident Department of the N. A. S. E. and a member of James Watt No. 7, of the same organization. He also instituted an association of this order at Spokane Falls. Mr. Watts was an ardent worker toward the betterment of engineers and he will be mourned by a great many friends.

The late John McKay, chief engineer and superintendent of the City Investing building, New York City, whose death we announced in the April 20 number, was 50 years of age. His death occurred on April 10, after a brief illness and following an operation for appendicitis. The funeral services were held at his late residence, 1429 Forty-eighth street, Brooklyn, on Tuesday evening, April 13. Mr. Mckay was a charter member of Phœnix Association No. 24, N. A. S. E., and a member of Sandalphon Lodge No. 836,

THE LATE JOHN MCKAY

F. and A. M. He was one of the most prominent engineers in New York and had a host of friends.

Marine Engineers' Annual Dinner

The fourteenth annual dinner of the Marine Engineers' Beneficial Association No. 33, of New York City, was held on Wednesday evening, April 14, at the Broadway Central hotel. The inclement weather did not damper the ardor of the members and friends and the large dining room was well filled, there being fully 250 seated at the banquet. Among them were many prominent in the engineering world. The subjects chosen by the speakers were of a nature to engage strict attention and to impart important knowledge to those present. During the evening William Du Boise introduced the following: John E. Berry, president of No. 33; Captain John H. Pruett, national president of the Master Mates and Pilots Association; Captain John M. Cherry, marine superintendent, Lehigh Valley Railroad; J. L. Du Broque, assistant superintendent of motive power, Pennsylvania Railroad; L. B. Dow, general manager of Harbor No. 1, Mates and Pilots Association.

An enjoyable entertainment was given by Herbert Self, Henry Elder, "Joe" McKenna, William Murray, Frank Corbett, Edward Campbell, Robert Webb, John L. Wilson and "Jack" Armour.

Help Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

WANTED—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. Address "M. M. Co.," POWER.

AN ENGINEER in each town to sell the best rocking grate for steam boilers. Write Martin Grate Co., 281 Dearborn St., Chicago.

WANTED—By manufacturer, thoroughly experienced man to sell hangers, shafting and transmission machinery in New York City and vicinity. Must be capable, energetic. We want the best man in this line of business. "J. C. D.," Box 36, POWER.

WANTED—One or two experienced salesmen in line of engines, boilers, tanks, pumps, etc., thoroughly acquainted with market in and around New York City. Only experienced men wanted. Good positions open for right men. Box 37, POWER.

WANTED—First-class salesman, must have established trade among steam users in engineers' and factory supplies in Greater New York and vicinity. Fine position for right man Box 35, POWER.

WANTED—By manufacturer, thoroughly experienced man to sell hangers, shafting and transmission machinery in New York City and vicinity. Must be capable, energetic. We want the best man in this line of business. "J. C. D.," Box 36, POWER.

WANTED — AT ONCE, one practical engineer suitable for a large power plant, equipped entirely with gas engines which furnish current for electric railroad and lighting purposes. Plant located in a western town. First-class reference must be furnished from last employer. "K.," Box 38, POWER.

Situations Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

POSITION as fireman or assistant electrician by young man of 20 Student I C S. Two years' experience with small boilers and engines. Box 93, R. F. D. No. 1, Deshler, Ohio.

EXPERIENCED GAS ENGINE MAN wants position with manufacturer, contracting engineers or take charge of large gas engine plant. Has technical education and experience as salesman, erector and repairman "H K. W.," Box 178, Edgartown, Mass.

POSITION—Single man, eight years' experience, steam-electric plants as chief and assistant. Good references, speak Spanish, prefer Mexico, Hawaii or Spanish country Employed steam turbo-electric plant in Mexico. Address "R," Box 184, Seneca Falls, Kans.

POSITION with large company as traveling or supervising engineer of power plants and machinery. Hold such position at present with large corporation, having charge of power plants and machinery upkeep, boiler tests, engine indications, etc. Box 40, POWER.

WANTED—Position by an experienced engineer and electrician capable of handling a large proposition, now holding a responsible position with a large corporation; will give good reasons why change is desired to interested parties; would like a hard proposition. Box 39, POWER.

POSITION wanted by a mechanical graduate of a leading Western university. Experienced in drafting, two years' practical experience in machine shop, and two as assistant master mechanic with a company operating sixteen iron mines Prefer similar position, but will consider any good mechanical engineering work. Can furnish references from above company and present employer. Box 41, POWER.

Miscellaneous

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

PATENTS secured promptly in the United States and foreign countries Pamphlet of instructions sent free upon request. C L. Parker, Ex-examiner, U. S. Patent Office, McGill Bldg., Washington, D. C.

For Sale

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

150 HORSEPOWER tandem compound Corliss engine in good order; 16' wheel; 24 in. face F. W. Iredell, 11 Broadway, New York.

GET THE MEAN PRESSURE of diagrams by "Bill," the best planimeter; $1.50 to P. Eyermann, Consulting Engineer, Du Bois, Pa.

FOR SALE—20x48 Wheelock engine and two 72"x18' high pressure tubular boilers in good condition cheap. Address "Engineer," Box 2, Station A, Cincinnati, Ohio.

An Exhaust-Steam Turbine Installation*

With No Additional Steam Net Output of Noncondensing Engine Plant May Be Increased 75 Per Cent. by the Use of Exhaust-steam Turbines

BY W. S. TWINING AND W. C. KERR

While the title of this paper is a general one, it really deals with the exhaust-steam-turbine plant recently installed in connection with the Thirteenth and Mt. Vernon streets power house of the Philadelphia Rapid Transit Company. This station is part of the original Philadelphia Traction Company's power equipment and was built some years ago when the system was smaller and the problem economy, as far as the operation of the plant was concerned. The cost of the feeders and the money invested in them was a much larger item to be considered than any increase in economy which might be obtained from operating the station condensing. The station was therefore located in the central part of the city, where no water supply was available and consequently was operated noncondensing.

After a time, however, new stations were in course of construction which were equipped with steam turbines and in every way more modern appliances and promised very much better economy. At the same time the output of the Mt. Vernon station was increasing steadily and no facilities were at hand for increasing the amount of power at this point. These two facts combined caused the condensing

FIG. 1 LOW-PRESSURE 800-KILOWATT TURBINES INSTALLED BY PHILADELPHIA RAPID TRANSIT COMPANY

of distributing by means of high-tension feeders and rotary-converter substations had not been satisfactorily solved. The station was equipped entirely with direct-current machinery and the location was determined more with the idea of shortening the length of the feeder cables than with the idea of securing a maximum

the engine cylinders being proportioned for this condition. The load conditions at this station are very constant, and even though it operated noncondensing its records compared quite favorably with the possible results obtained in other stations which operated condensing, but under poorer load conditions. For a considerable period of time no thought was given to changing it to a condensing station, as this involved numerous difficulties.

problem to be considered again. As no water was available it was necessary to install cooling towers, or some other means of cooling the water. The layout of the station is not such as to adapt itself readily to the installation of condensers, as all available space had already been used. The engines and generators also were of insufficient size to stand any great increase of load for a long period of time. This increase of load could

*Paper read before the American Institute of Electrical Engineers, Philadelphia section, October 12, 1908.

readily be obtained by running the engines condensing, but it was felt that this would overtax them, and the generators could probably not stand this increase of load, which the engines would be capable of driving, as they would be operating at all times under an overload condition. Another difficulty which presented itself in connection with the changing of the plant to noncondensing was the exhaust piping. This piping had been in service a number of years and no provisions were ever made to make it vacuum tight, as it exhausted directly into an open exhaust stack without any back-pressure valve. To place condensers on the engines meant tearing out all the exhaust piping and rebuilding the system to operate under vacuum, and as this station is in service at all times, it would have been a more or less difficult and expensive undertaking.

About this time the exhaust-steam turbine proposition presented itself, and while it was considered theoretically possible, it had not been tried on a large scale. However, it was finally decided to try an experimental installation at this plant. The cost of the equipment was estimated and the probable operating expense as well. There appeared to be a decided advantage in favor of the turbine from the fact that the station output could be increased, even though the total station economy was not materially improved. Investigation finally resulted in the purchase of two 800-kilowatt direct-current machines, which were placed on the top of part of one of the foundations provided for a future engine unit.

Original Noncondensing Plant

The original design of the station provided for six Wetherill twin tandem compound Corliss engines, 26x40x48 inches, operating at 80 revolutions per minute with 160 pounds initial steam pressure. Each pair of engines is direct-connected to a 1500-kilowatt direct-current generator. Part of the exhaust steam was used in a system of open heaters for heating the feed water. All the auxiliaries were steam driven and exhausted direct into the main exhaust stack of the station. The layout of the station provided for six units, three on each side, with the high-pressure cylinders facing each other, making two lines of three engines; the generators facing the east and west walls of the station. Four of these units were installed at first. The original heater equipment was located in the boiler room, but this, after a short time, proved to be insufficient for the requirements, and provisions were made for installing a large heater and purifier plant. As the space required was considerable, the only available location was in the engine room, and in order to do this it was necessary to take half of the space allotted to the sixth unit. About this time, the fifth unit was installed, which then completed the station as far as the original building was concerned; it being impossible to place a sixth unit as originally intended.

The boiler-room equipment had also reached its maximum at this time, which consisted of nineteen 375-horsepower Babcock & Wilcox boilers, and one 400-horsepower Parker boiler, making a total of 7525 boiler horsepower. This would not permit of any farther increase, as all available space in the boiler room had been used.

The main exhaust system consists of two exhaust lines, one on each side of the engine-room basement, each designed to take care of three units. These lines join at the center of the station and enter the exhaust stack by means of a 36-inch main. The stack is placed at the end of the engine room and is 8 feet in diameter by 125 feet high. It is designed to take care of the exhaust of the entire plant. Three tees are placed in the main exhaust line just before it enters the stack and these connections turn upward and supply steam to the three feed-water heaters, which have been referred to. This will give a general idea of the arrangement of the exhaust connections of the plant previous to the installation of the exhaust-steam turbines.

Exhaust-steam Turbines Installed

In placing exhaust-steam turbines in this plant very few changes were made in the general scheme of exhaust piping. The east and west mains in the original design were left exactly as they were. The only change made necessary to install the turbines was to replace an ell by a tee in the 24-inch exhaust line on the east side of the station. Steam in passing from the 24-inch line is carried into an oil and water separator placed in the basement, from either side of which a 16-inch connection carries steam up through the throttle of the turbines. As

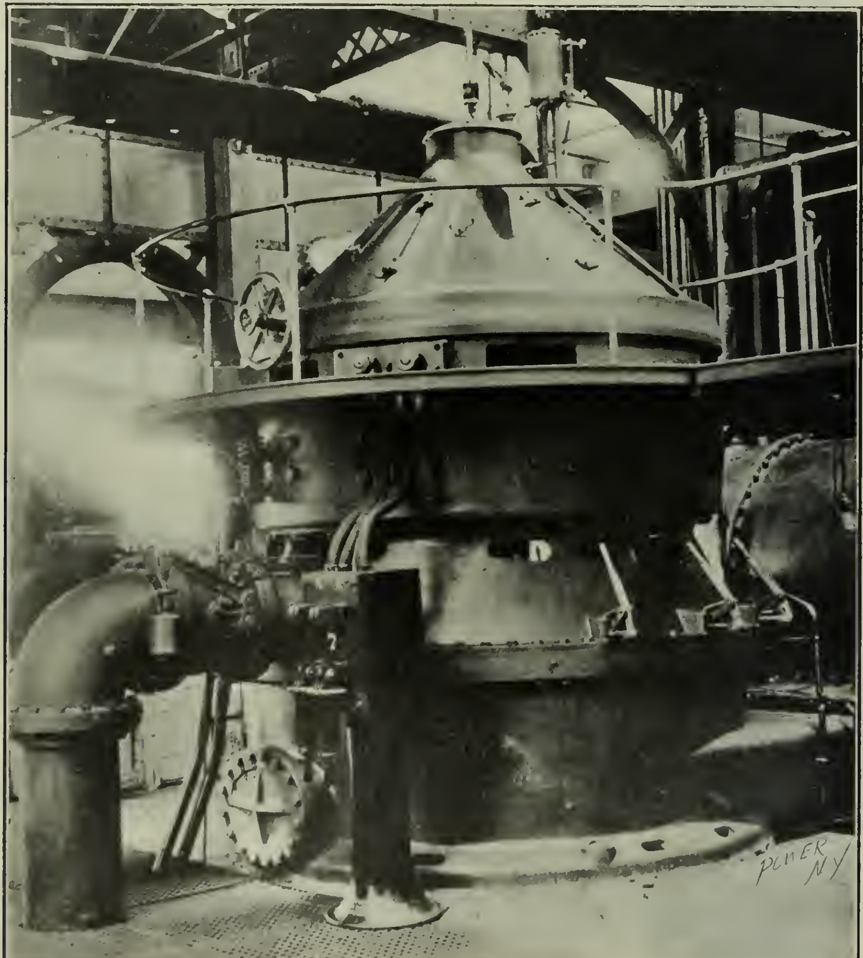


FIG. 2. ADMISSION SIDE OF TURBINE

the plant, under ordinary conditions, operates with an excess of exhaust steam, it was not necessary to place any atmospheric valve on the main exhaust line, there always being sufficient steam going up the exhaust stack to form a seal and so prevent drawing air back from the stack or heaters into the turbine. After the change was made there was no difference whatever in the general operating conditions of the engines, there being no exhaust back pressure and, in fact, if anything, there was a reduction in pressure on the main adjacent to the turbines; at times there has been noted to be ½ inch of mercury below the atmosphere when the station load was comparatively low and the turbine loads heavy. This arrangement gives extremely simple conditions, and the turbines can be put into service, or taken out, by simply opening or closing the throttles, as no other valves are required to be manipulated, the only change in the plant consisting in the amount of steam which is going up the exhaust stack.

Condensing Equipment

The condensing equipment of the plant consists of two 8000-square-foot counter-current Alberger surface condensers, each connected directly to the turbine by means of a short makeup piece. The condenser and turbine are placed on the engine-room [illegible] side valve gear and with Corliss valves on the vacuum cylinder.

The water circulation through the condensers is maintained by means of a [illegible]-inch Kingsford centrifugal pump placed on the outlet side of the condenser, so as to reduce as much as possible the pressure from the towers. This pump is operated by a variable-speed [illegible]-volt direct-current motor, so designed that the pump may be operated at anywhere between [illegible] and [illegible] revolutions. This permits of the adjustment of the circulating water required to give the vacuum under different atmospheric conditions. One pump and motor are provided for each condenser, but no provisions have been made for cross-connecting them, owing to the lack of space for water piping.

On the bottom of each condenser is [illegible] the throttle of the pump and regulates it so as to hold the water at a fixed point in the hotwell, preventing the possibility of the pump running dry and becoming filled with steam.

Water-cooling Plant

As before stated no water was available at this station for condensing purposes and it was necessary to install a plant of [illegible] cooling towers. These cooling towers were located against the north wall of the building and [illegible] on an elevated platform built entirely of reinforced concrete, the floor of this platform being [illegible] feet above the street level and [illegible] feet wide by [illegible] feet long. The structure for supporting the platform consists of eight reinforced-concrete columns, braced by means of a system of struts and tension [illegible]

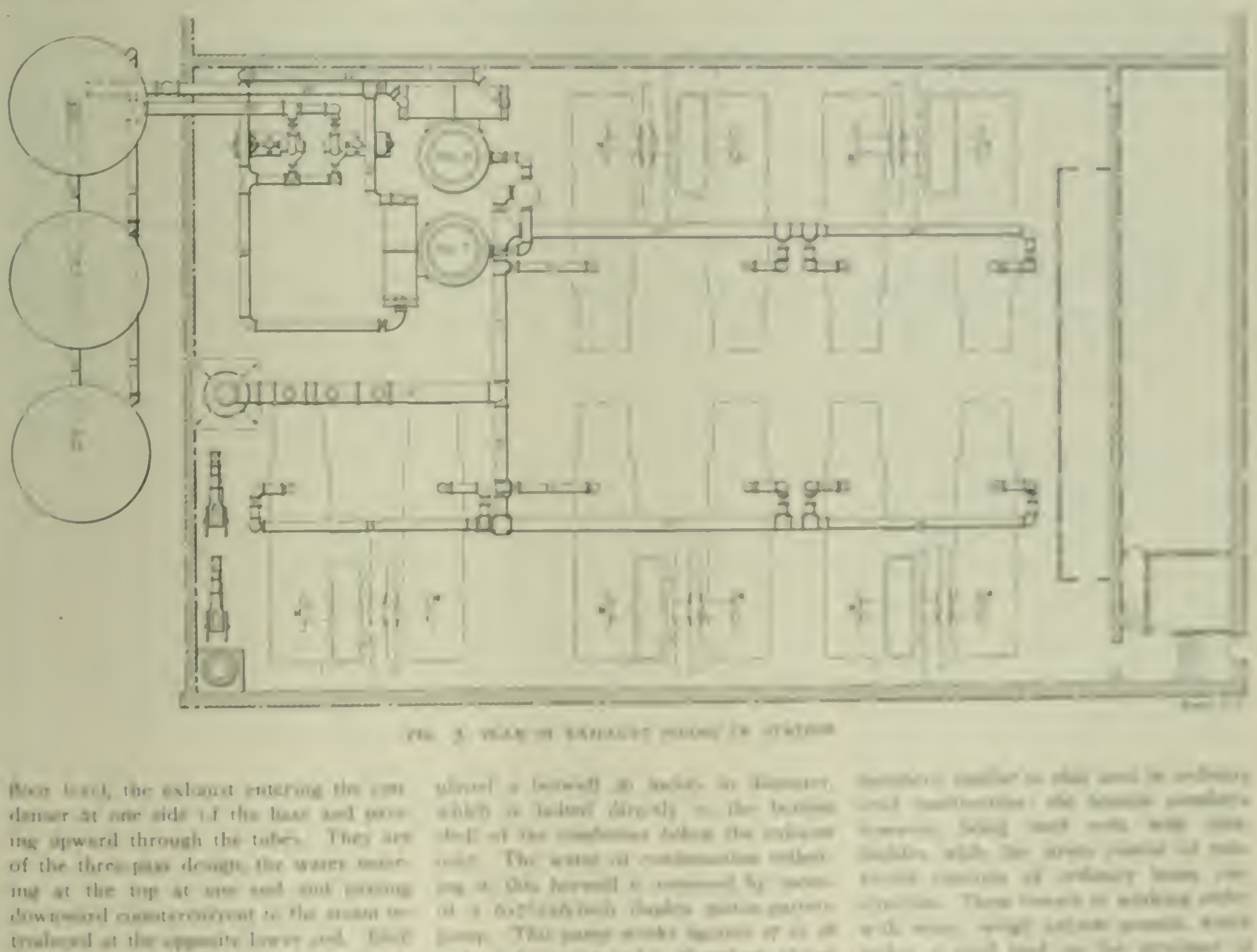


FIG. 3. PLAN OF EXHAUST PIPING IN STATION

[illegible] load, the exhaust entering the condenser at one side of the base and passing upward through the tubes. They are of the three-pass design, the water entering at the top at one end and passing downward countercurrent to the steam, [illegible] at the opposite lower end. Each condenser is equipped with a [illegible]-inch horizontal rotative single-stage dry-vacuum pump. They are, however, cross-connected in such a manner as to permit of interchanging the vacuum pumps on the condensers, or running the two condensers together on one of the pumps. The suction for the dry-vacuum pumps is taken from the top of the condenser and is passed through a moisture separator, preventing any possibility of water entering the vacuum cylinder. These pumps are of the center-crank pattern having slide [illegible] placed a hotwell [illegible] inches in diameter, which is bolted directly to the bottom shell of the condenser below the exhaust inlet. The water of condensation collecting in this hotwell is removed by means of a [illegible]-inch duplex piston-pattern pump. This pump works against [illegible] inches of vacuum and is therefore placed considerably below the bottom of the condenser, thus having advantage of the [illegible] head of water on the suction. As the water coming from the condenser is almost entirely free from oil it is discharged directly into the feed-water heater, the temperature of the water being within one to two degrees of the theoretical steam temperature in the condenser. The pump is controlled by means of a float placed in the hotwell. This float is connected by a system of levers [illegible] [illegible] similar to that used in ordinary [illegible] construction; the [illegible], however, being [illegible] with [illegible], while the [illegible] consists of ordinary [illegible] construction. These towers [illegible] with water, weigh [illegible] pounds, which makes a small load on the [illegible] of [illegible]. The [illegible] floor [illegible] tower [illegible] is covered by a series of [illegible] beams, [illegible] of [illegible] depth, the beams being so placed as to carry the [illegible] load and also to make room [illegible] the [illegible], which [illegible] [illegible] of the [illegible]. The towers are [illegible], being [illegible] feet in diameter by [illegible] feet high. Each tower is equipped with two [illegible]-inch fans, [illegible] and operated by [illegible] shaft. These fans run at approximately 310 revolutions and are driven by means of 40-horsepower variable-speed 550-volt direct-current motors, which are placed on the floor directly beneath the main platform and drive upward by means of belts. The motors are controlled by variable-speed automatic starters placed in the engine room and operated by the remote-control system.

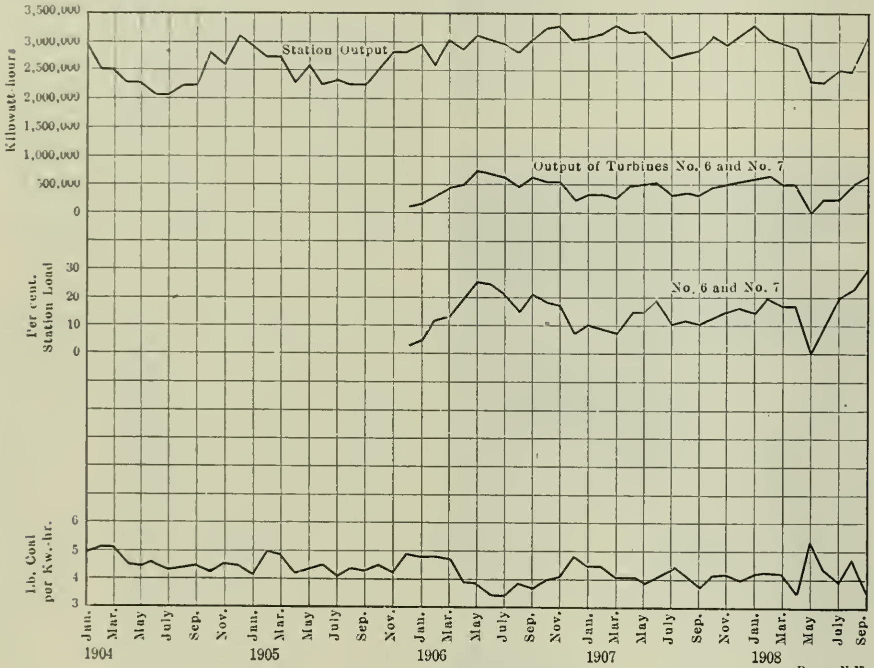


FIG. 4. TOTAL POWER OUTPUT AND PER CENT. OF LOAD CARRIED BY EXHAUST-STEAM TURBINES

The warm water from the condensers is discharged upward through a 20-inch main and is carried along beneath the base of the towers, one connection going up to the top of each tower and supplying the distributor. The distributor consists of an eight-arm revolving spider which is propelled by reaction jets. This distributes the water over the filling of the tower, which consists of a latticework of 1x6-inch boards filling about the middle third of the tower. The outlets from the bottoms of the tower are manifolded together by a 20-inch header and carried down to the engine room, one 14-inch branch going to each condenser.

The feed water for the entire steam plant is taken from the discharge side of the circulating pumps and delivered to the feed-water heaters through regulating valves, which makes it necessary to make up the shortage of water in the towers about once every half hour. This is accomplished continually by means of an automatically controlled variable-speed motor-driven pump. This pump is operated by means of a float placed in the towers. The discharge of this pump is put into the down line from the towers so as to take advantage of the cold water running through the condensers.

Exhaust-steam Turbine Detail

These turbines are of the Curtis vertical type and are of the same general design as the low-pressure end of the high-pressure Curtis turbine. They have, however, only three stages with 10 admission valves controlling the admission of steam to the upper stage. These valves are operated by hand by means of levers placed at the side of the turbine casing. The machine operates without any speed-regulating governor and the load is regulated entirely by the number of admission valves which are open. A safety-stop mechanism is provided automatically to cut the steam off from the turbine in case of the opening of the circuit-breaker. This governor trips a butterfly valve which is closed by a weight. Under ordinary conditions the valve is held wide open by means of a latch. Should the turbine run above normal speed for any reason, the speed-limit governor comes into play, trips the latch and shuts the butterfly valve, thus preventing racing. The generators are shunt wound, but provided with commutating poles between the main field coils; otherwise the generators are of the same design as ordinarily used on direct-current turbine work.

Operation of Turbine

The method of operation of the exhaust-steam turbine is somewhat different from the ordinary high-pressure machine. These particular machines operate at a normal speed of 1200 revolutions and 575 volts without any governor-control mechanism, and the generators are placed directly across the line in a manner similar to a storage battery, and carry a very nearly constant load depending upon the number of admission valves which are open. In these particular machines, each valve opened increases the load approximately 150 kilowatts, and when once set the turbine will hold very close to this load as long as the valve setting remains unchanged. There is a slight fluctuation in the load which is in direct proportion

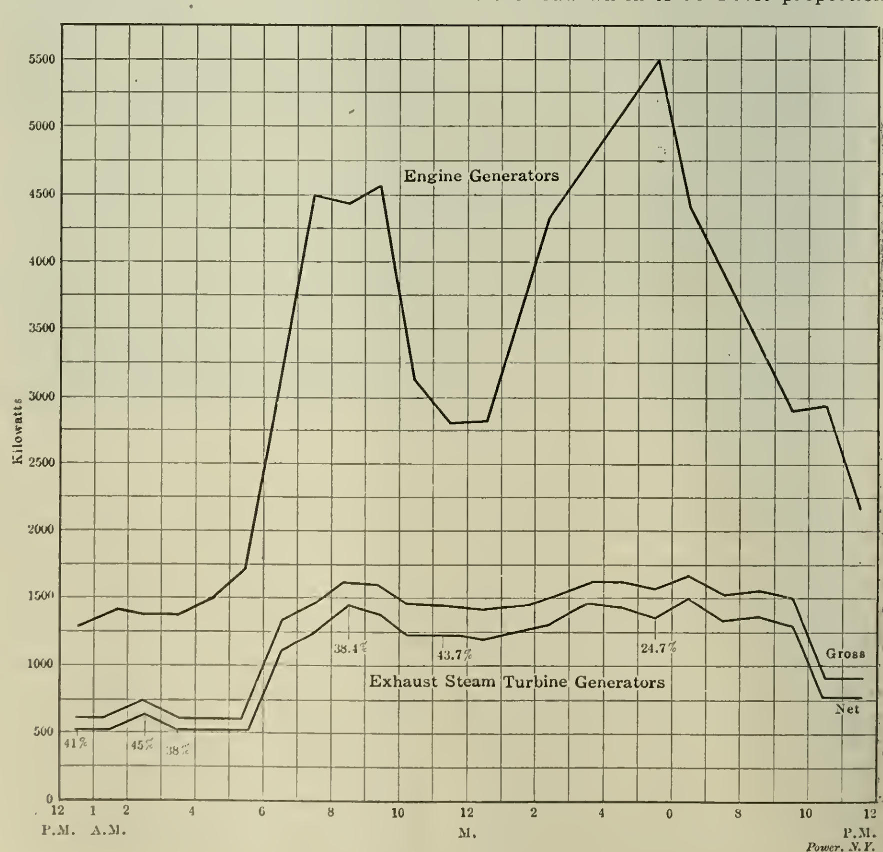


FIG. 5. RELATIVE LOADS OF EXHAUST-STEAM TURBO-DRIVEN AND ENGINE-DRIVEN GENERATORS, SEPTEMBER 4, 1908

to the entire station output, the turbines always holding a very nearly constant percentage of the station load.

One peculiarity in these turbines is the fact that the switchboard operator cannot change the load of the turbine, which is quite contrary to general station practice for high-pressure machines. This is due to the fact that the amount of steam is fixed by the admission valves, which are hand regulated. Should the switchboard operator move the field rheostat so as to increase the voltage of the turbine, this will result merely in a decrease in the turbine speed, and the result in voltage will be the same as before. This condition of affairs seems to be rather peculiar at first sight, but it appears perfectly reasonable after giving the matter some thought. The man at the turbine cannot increase nor decrease the speed, but can only increase or decrease the load by opening the admission valves, and the man at the switchboard can increase or decrease the speed of the turbine by the field rheostat, but he can by no means change the load. These statements are made in a general way, but, of course, there will be some slight variations due to characteristics of the machine, but a discussion on this particular topic will not be taken up at this time.

The method of placing the turbines in service is as follows: After the condensers are in operation and the turbine brought up to speed on the vacuum and the voltage adjusted, the admission valves are opened one by one and the machine picks up its load in proportion to the number of valves open and continues to operate with this load as long as the machine is in service. At times of light load, when the amount of exhaust steam available is lessened, the load is taken off the machine by gradually closing down the admission valves, and it is taken out of service by tripping the automatic stop which shuts the butterfly valve controlling the admission of steam to the machine.

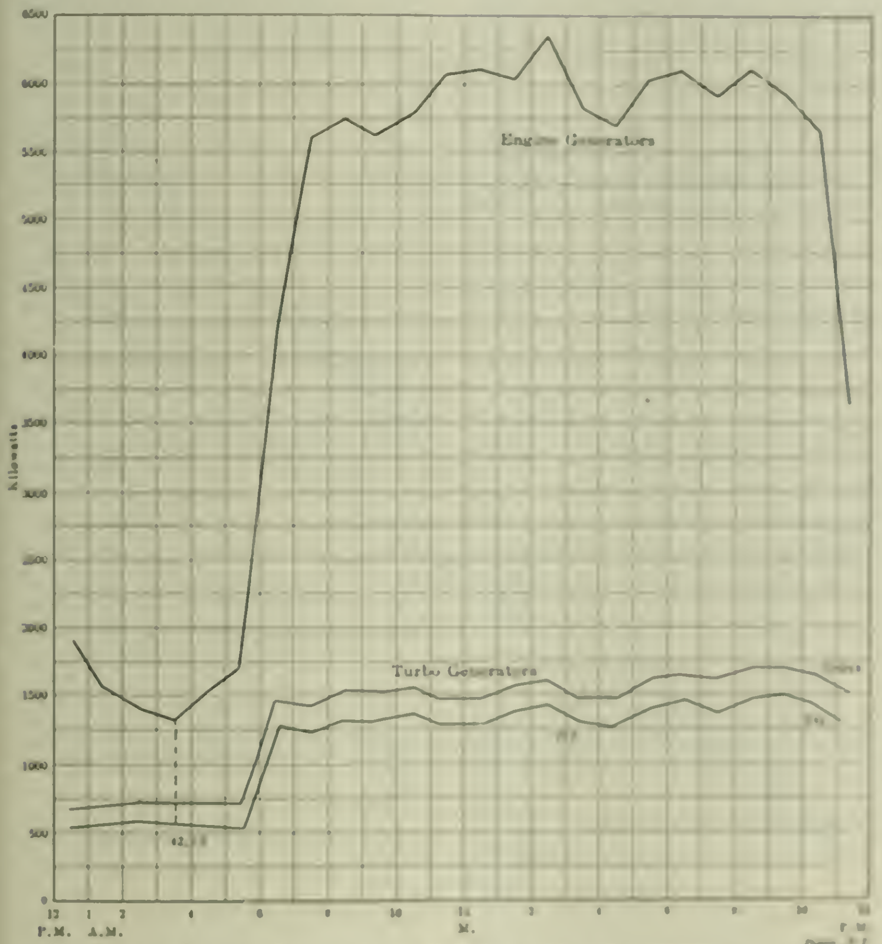


FIG. 6. RELATIVE LOADS OF TURBO-DRIVEN AND ENGINE-DRIVEN GENERATORS, OCTOBER 6, 1908

Operating Record

In the latter part of 1905 the plant was installed in a more or less experimental way, as at that time it was comparatively a new idea and some doubts were expressed as to its success. Everything seemed to be favorable from a theoretical standpoint, so it was decided to take up the matter in a small way at the start. Two machines of 800 kilowatts capacity were placed on one-half of the engine foundation originally designed for the 2600 unit. The first turbine went into service on December 16, 1905, and the second one at a somewhat later date. Fig. 3 shows the record of these machines from that time up to September, 1908. For a considerable period of time some trouble was experienced with the generators of the machines, principally with the commutators, but this is a very common trouble with high-speed direct-current generators. This, together with the fact that the possibilities of these machines had not been fully demonstrated, is responsible for the comparatively poor record which they made during 1906-1907; but even so, there was a considerable increase in the output and economy of the plant during that time. The average output of the turbines during the years mentioned amounted to 14.8 per cent. as much as the engine load. By referring to the curve in the lower part of Fig. 4, the line showing the pounds of coal per kilowatt-hour, a marked decrease can be seen during the period in which the turbines were putting out their maximum power. The best records of the station were always made when the turbines were in service the greater part of the time.

To show what can be done in regular service, a number of charts have been prepared, showing the regular station operating conditions at the present time. Fig. 5 shows the output curve for the Mt. Vernon street station on September 2, 1908, and is a typical output curve for this station during the summer months. Starting at midnight on September 2, the turbine carried a maximum net load of [illegible] kilowatts with 1725 kilowatts on the engine, one engine being in service at this time. Under these conditions, the turbine was pulling 47 per cent. as much load as the engine with no additional increase in steam consumption. As approximately 100 kilowatts are required to drive the auxiliaries of the station, it shows that the turbine is capable of increasing the gross output of the engine approximately 50 per cent. This would be the ideal condition for the station, but by following the output curves, it will be seen that the percentage drops, owing to the fact that there are insufficient turbines to take care of all the available exhaust steam. Through the morning hours, when the station load is comparatively heavy, the two turbines were in service and at that time delivered a net output of 36.4 per cent. as much as the engines, three engines being in service at that time. Following the curve until the noon hour, when two engines and two turbines were in service, it will be seen that the turbines were delivering a net output equivalent to [illegible] per cent. of the engine output, which again approaches very close to the ideal condition. It will then be noted by referring to the peak between 5 and 8 o'clock, that the turbine capacity is again insufficient, two turbines still being in service, and at that time the net output is equivalent to [illegible] per cent. of the engine output, [illegible] engines being in service at that time. By following a similar ber of turbines equivalent to the number of engines, between 40 and 50 per cent. as much load could be carried on the turbines as on the engines; all of this increased power being gained without any increase of coal consumption.

The labor item at this station is increased somewhat by the use of these turbines, but up to the present time this is less than 5 per cent. This is the only increase in the station operating cost. As far as the cost of the turbine installation is concerned, it may be sufficient to estimate that the cost per kilowatt will be about the same as the original boiler, engine and generator equipment; so this need not be considered.

Fig. 6 shows a different loading condition for the same station. It was taken on October 6, and shows the load conditions as the result of the heavy traffic on the streets on that date. In the early morning hours one turbine was in service and gave a net output of 42.3 per cent. of the engine output; one engine and one turbine being in service. From 6 a.m., and all through the balance of the day, two machines were in service, carrying approximately full load. The engine output, however, increased considerably, being in the neighborhood of 6000 kilowatts for the entire day. But even so, the two turbines gave a net output of 24 per cent. of that given by the engines. It can readily be seen by referring to the curves that four turbines could have been operated all through this period.

If it would be possible to operate this station with two engines and two turbines at all times, the coal consumption could undoubtedly be decreased to approximately 70 per cent. of its original figure when noncondensing.

Fig. 4, which showed the records of the turbines during 1906-1907, is somewhat misleading. While the turbines were operating under difficulties they still showed a gain of 14.6 per cent. The records of last year should surpass this in every way. In order to show the reliability of the machines under present operating conditions, Fig. 7 has been prepared. These curves show the record of the machines taken during September of 1908. The practice at this station now is to keep the turbines in the greatest period of time possible; one turbine being in service the entire 24 hours and two turbines being in whenever the load is heavy enough to permit it. This means that two turbines are in service at all times, excepting the hours between midnight and 6 a.m. They are taken out alternately for examination and cleaning the armatures, one machine being taken out of service each night. Fig. 7 shows the record which these two machines have made. The curve for No. 6 machine shows it has been in service 74.9 per cent. of the entire time during the month and No. 7 machine 80.4 per cent. of the time. The maximum line shows the conditions for the 24 hours per day operation. The two lower curves, one for No. 6 and one for No. 7 show the load factor during the period in which they were in service. No. 6 averaged 91 per cent. full load for the entire month and No. 7, 90 per cent. full load for the entire month. By combining these load factors and the operating factors, it will be seen that No. 7 machine developed 72.36 per cent. of its maximum output for the entire month and No. 6 developed 68.16 per cent. of its maximum output. This gives an average of 70.26 per cent. for the two machines for the entire month of September.

This operating record is a good one and is even better than expected, but, under the present conditions, there is no reason why the same record or a better one cannot be maintained for an indefinite period of time. The records of the preceding months of this year are about in accordance with these results, but this one has been selected as giving conditions at the present date.

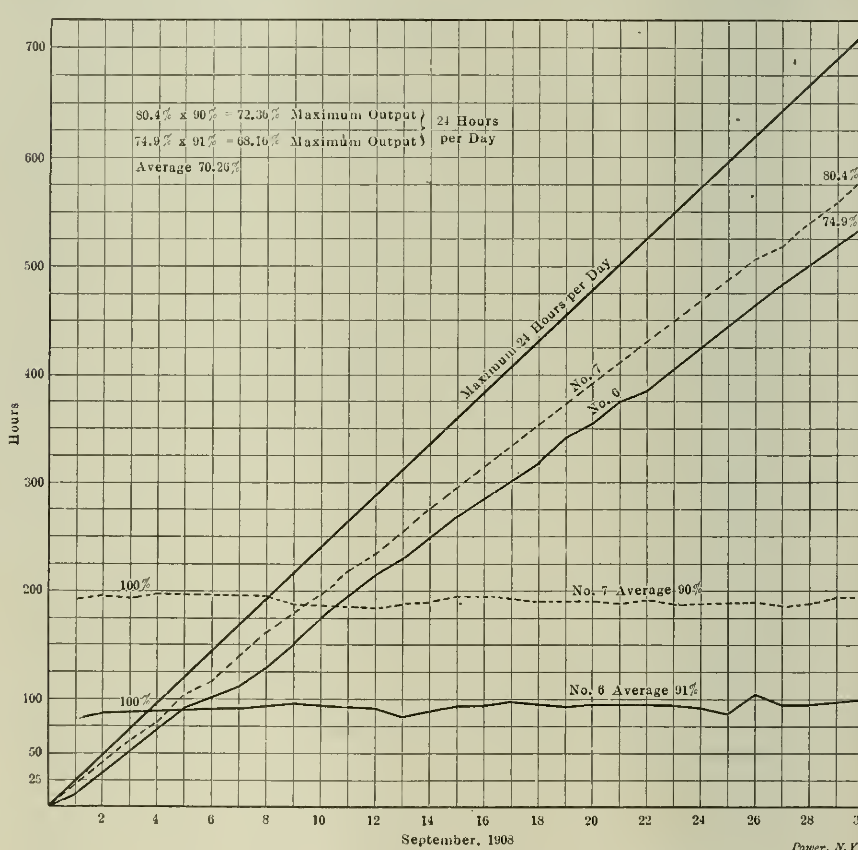


FIG. 7. OPERATING RECORD OF EXHAUST-STEAM TURBINES

Number of Exhaust-steam Turbines Required

In order to get some exact figures as to the performance of these machines with the idea of determining just how many can be used at any given plant, it was decided to make a series of tests with this in view. These tests were carried out last July and the results are gratifying. Complete tests of the entire turbine and condensing plant were made and the results are shown in Tables 1, 2 and 3.

Each of the turbines being equipped with surface condensers, it was very easy to determine the steam consumption. The test was conducted in the ordinary manner, by weighing the water discharged by the hotwell pumps. As the portable tank scales were of insufficient size to take care of the condensation from both turbines, it was decided to make the test on one turbine only, and No. 7 machine was selected for the purpose. Before commencing the test the condenser was overhauled and the glands tightened. The circulation was then started through the condenser, running the pumps at normal speed so as to maintain the same pressure conditions as when operating in regular service. The steam space of the condenser was then exhausted by means of the dry vacuum pumps until 27 inches of vacuum was obtained. The outlet from the hotwell was carefully closed off and a record kept of the rise of water in the gage glass on the side of the hotwell. The rise in inches of water per hour was noted in the hotwell and it was afterward calibrated for the amount which it contained. The scheme of testing out the condenser was carried out before beginning each test and immediately after closing down, the mean leakage being taken as the amount of water which came through from the water space. In most cases this leakage was zero; however, in one or two cases there was a slight leak in the condenser, which at no time amounted to more than 2 per cent. of the water of condensation, but allowance was made for this in figuring up the results.

Several tests were made under somewhat different conditions, the general scheme being to run for a period of eight hours, taking check readings on the wattmeter and amount of water condensed every hour during the run. These results were surprisingly uniform, and as there was so little variation in the steam consumption, some of the tests were stopped at the end of the fifth hour. The results of the tests made on different days were extremely close, and if any variation occurred it was always in the direction

TABLE 1. DATA ON TURBINE.

Average load on turbine (corrected), kilowatts	805.85
Total water from turbine per hour, pounds	31,918
Moisture in steam—0.3 per cent., pounds	92
Water used by step-bearing per hour, pounds	1402
Net steam used by turbine (dry) per hour, pounds	30,424
Steam per kilowatt-hour (dry), pounds	37.75
Steam pressure, pounds abs.	14.53
Barometer, inches	29.16
Vacuum, inches	27.50
Absolute pressure, inches	2.66
Temperature of exhaust steam, degrees F. (2.65 inches abs.)	110.8
Swing of load, amperes	1350-1550

which would naturally be expected from the difference in vacuum or load conditions on the machines.

Test No. 80, the results of which are given in Tables 1, 2 and 3, is a fair sample of the performance of these machines and the results were quite interesting. This test was conducted for a period of eight hours and the turbine carried an average load of 805.85 kilowatts, No. 6 turbine being shut down at this time. These conditions gave the turbine a uniform rating as far as the percentage of the load carried was concerned, as two turbines could have been operated in connection with the station load throughout the entire period.

Table 1 shows part of the results obtained during this test. It can be seen by inspection that the dry steam per kilowatt was 37.75 pounds, the absolute steam pressure being 14.53 pounds, which is slightly below atmospheric pressure. The pressure of the steam was taken at the throttle of the turbine by means of a U-tube filled with mercury, and this at all times was a fraction of an inch below the atmosphere. The absolute pressure in the turbine exhaust pipe was 2.66 inches, which gives a difference in pressure between the inlet and exhaust of 26.6 inches. It will be noted that the load was varying between 1350 and 1550 amperes. The swing was in direct proportion to the total station swing during the period of the test.

Table 2 shows that the total power absorbed by the auxiliaries throughout the test was 172.81 horsepower. This, however, is somewhat large, as atmospheric conditions were such as to require two of the cooling towers to be in service to give the required vacuum, and as each of these was driven by a 40-horsepower motor, it was found that there was about 18 horsepower extra charged against this turbine. Under actual conditions of the test 22.0 per cent. of the output of the turbine was required to drive the auxiliaries, but making corrections for one-half the power of the motor on the second tower brings this figure to 14.6 per cent., which would be the conditions had two turbines and three towers been in service at the time. Referring to Table 2 it will be seen that even with the one turbine in at the time nearly 20 per cent. of the load was carried by this machine as compared to the engines, which amounted to 18.88 per cent. of the entire station load.

Table 3 shows the condenser results obtained during the test. This shows a good performance, as the temperature of the water taken from the hotwell was within 2 degrees of the temperature of the exhaust, thus taking advantage of all the available heat to return to the feed-water heaters. The cooling towers showed a reduction of approximately 11 degrees in the temperature of the water and these conditions remained the same throughout the entire test. Since that time experiments have been conducted to determine the amount of evaporation and loss of water from the towers and to determine the best possible conditions for the speeds of the fans and circulating pumps to reduce the power absorbed by the auxiliaries to a minimum. Progress in this line of work has not advanced sufficiently to make any definite statement in this paper.

Again referring to the tables, it will be seen that the steam consumption of the turbine is 37.75 pounds per kilowatt-hour, which under the conditions of vacuum and steam pressure at the throttle, places this turbine within the guarantee made by the General Electric Company, which is as follows:

TABLE 2. AUXILIARIES.

Power absorbed by motor-driven auxiliaries (estimated horsepower)	128.40
Power absorbed by dry-vacuum pump (horsepower)	8.01
Power absorbed by hotwell pump (horsepower)	5.18
Power absorbed by step-bearing pump (horsepower)	8.12
Total power absorbed by auxiliaries (horsepower)	172.81
Percentage of auxiliaries to total output (2 towers)	22.0
Percentage of auxiliaries to total output (corrected)	14.6
Average load on engines (4 hours), kilowatts	403.7
Percentage of turbine to engine load, per cent.	19.57
Percentage [illegible] load to station load, per cent.	18.88

With atmospheric pressure on throttle, full load, 2 inches absolute pressure, 38 pounds per kilowatt; full load, 4 inches absolute pressure, 45 pounds per kilowatt.

Assuming that the Corliss engines in this station required 15 pounds of steam per indicated horsepower and allowing 1.5 indicated horsepower per kilowatt [illegible], it can be seen that if the entire amount of exhaust steam from these engines was used, 1 kilowatt could be developed on the turbine for each kilowatt output of the engine generators. From this it would seem that the gross station capacity could be nearly doubled by the use of the exhaust steam turbines. [illegible]

[illegible] per cent. of the exhaust steam is required for the feed heaters and [illegible] per cent. of the turbine output is required to operate its auxiliaries. This would cut the net output of the turbines to approximately [illegible] per cent. of the engine capacity. These figures, however, will be modified to a certain extent by the amount of exhaust steam which is available from pumps and other steam-driven auxiliaries. It might be safe to make the general statement that with the above assumptions the net output of

TABLE 3. CONDENSER RESULTS.

Temperature of air, degrees F.	[illegible]
Temperature of injection water, degrees F.	[illegible]
Temperature of discharge water, degrees F.	[illegible]
Temperature of hotwell water, degrees F.	[illegible]
Total head on circulating pump, ft.	[illegible]
[illegible]	[illegible]
Pressure of water on step-bearing, pounds	[illegible]
Speed of circulating pump, r.p.m.	[illegible]
Speed of dry-vacuum pump, r.p.m.	[illegible]
Speed of step-bearing pump, strokes per minute	[illegible]
Speed of turbine, r.p.m.	[illegible]

the station could be increased from [illegible] to [illegible] per cent. by use of exhaust-steam turbines, provided the back-pressure valve was tied and provision made for operating the station-exhaust main at times under a partial vacuum.

The results obtained on the tests of this turbine are exactly in accordance with what was expected from the regular station operating records, and only confirm the belief that the exhaust-steam turbine proposition is worth considering as a means of increasing the economy and output of a noncondensing station.

Rubber Foundations for Steam Turbines

A [illegible]-kilowatt steam turbine recently installed by Willans & Robinson, Limited, of Rugby, for the [illegible] of St. [illegible], has been mounted on special rubber foundations on the Pracht system. The turbine set is bolted to a special slab of concrete, a foot thick, reinforced with a steel grid. This large block rests on a series of circular rubber blocks standing on the ordinary concrete foundations. The upper block is not connected with the engine room floor in any way. A trench is provided round the top slab to permit of the [illegible] of the rubber blocks. Each rubber block is a cylinder about [illegible] inches in diameter and [illegible] inches in height when compressed by the weight of the turbine set. Each rubber block is removable independently of the rest, it being possible to withdraw them for [illegible] by tightening up the jacks, by which they are held by means of screws. These rubber blocks have, however, a life of considerable length, and needed to [illegible]. The turbine in question is said to be the largest [illegible] to rest on the [illegible] system.—Engineering.

Jonathan Hulls and His Steamboat

Sketch of the Inventor and Description of One of the Earliest Patented Systems of Vessel Propulsion by Means of the Steam Engine

BY EDWARD P. BUFFET

If the great-great-great-grandfather of any POWER reader chanced to spend his boyhood at the village of Campden, in Gloucestershire, England, about 170 years ago, he must often have seen plodding along the roads a poorly clad but intelligent-faced clock tinker carrying his box of tools as he went from house to house to seek those little jobs which totaled the means for only a scanty subsistence. It might have been noticed that this man had a more earnest and far-away look in his eyes than is usual for the country mechanic, that he seemed ever to be inwardly wrestling with deep problems, and that he wore the expression of a man who has failed in some great ambition of life, yet who has not broken off, and never could break off, the habit of performing ambitious labors in his head. Shy and diffident in his manner, he would gladly have shunned the sight of passers-by, and well he might, for youths of wanton disposition were relentlessly pursuing him with the refrain:

"Jonathan Hulls, with his paper sculls, invented a machine to go against the stream; but he, being an ass, could not bring it to pass, and so he was ashamed to be seen."

We have recognized in this portrait of Jonathan Hulls the typical unsuccessful inventor. If you are bound to be an unsuccessful inventor and value your peace of mind, by all means be one in some large city, and not in the country among your friends and neighbors.

Jonathan Hulls was born, it is said, at Hanging-Aston, near Campden, in 1699, but his father, Thomas Hull, or Hulls, removed to the latter place and there the boy received his academic training in an ancient grammar school. A man's real education, however, is that which he gives himself by outside study, or, best of all, by interested reading, for it is chiefly what interests us that we remember and that does us good. It is probable that if Jonathan's education had been limited to his perfunctory lessons at school he would have remained through life half illiterate like the other boys of his class; but he had a natural bent for mathematics and in some way made himself fairly proficient in the principles of mechanics. He was also able to write in a decent English style.

The trade of "clockmaker" which he took up was in reality that of an itinerant clock mender. He was accustomed to make a circuit through a certain district curing the ailments of any farmhouse or church timepieces that chanced to be under the weather. Hulls married early and removed to the hamlet of Broad Campden about 1729. His studious habits and mental ability, far superior to that of his neighbors, readily won him a local reputation for intelligence. That particular work of genius which has earned him belated fame in the world is said to have seethed in his imagination from his youthful years. To realize so ambitious a project as a steamboat, either in the water or in print, was an audacious attempt for a country clocksmith of those days, with a family to support. He therefore did what aspiring authors of his time were accustomed to do and sought the aid of a patron. This was a Mr. Freeman, of Batsford park, near Aston, who was so much impressed with Hulls' invention that he put up the money for a trip to London to embody it in a patent and a pamphlet.

That monograph appeared in 1737. Its publication was the high-water mark of Hulls' success, for there is no record that anyone ever took enough notice of tne work to build a steamboat on the lines suggested. Mr. Freeman was reasonably loath to support any additional venture for exploiting the invention, and Jonathan was abandoned to his fate of failure and ridicule.

For a long time no more is heard of him, but a real inventor, especially an unsuccessful inventor, is insuppressible though he live a thousand years, and the bee of ambition continued to buzz in Hulls' bonnet. Eventually he cropped out in print with new products of his brain.

His final known attempt was in 1754, when, in partnership with two fellow-townsmen, R. Darby and William Bradford, schoolmaster, he had patented a "Statistical and Hydrostatical Balance" and a "Sliding Rule for Artificers." The former was "an instrument for detecting frauds by counterfeit gold, which gives the weight and shews the alloy of that metal in coin and all utensils made thereof, and if adulterated, the nature and extent of the alloy." This instrument displayed much ingenuity and at least one actual specimen of it has survived to our day. The sliding rule, which probably was not a logarithmic slide rule, is described in a pamphlet entitled: "The new Art of Measuring made easy by the help of a new Sliding Rule. Coventry: Printed by T. Brooks in Broadgate, 1754."

Little or no financial return was destined to attend any of Jonathan Hulls' efforts and, finally, unable to meet the gaze of his neighbors, he hid himself in the London crowds. At a date which is unknown, he died the death of an inventor.

Down to comparatively recent times his descendants have remained in his own village, mechanics, like himself, and with his modesty if not with his genius. The widow of their last survivor in the district died in 1865, not long after which the family cottage at Broad Campden in which Jonathan Hulls had dwelt, was torn down.

It would be too much to claim for Jonathan Hulls that he was the first man who ever designed a steamboat. The idea seems to have been a favorite one for inventors in the first part of the eighteenth century. Neither can he receive the credit which attaches to one who has made the invention commercially practical. But assuredly he deserves always to be remembered as one of the most important forerunners of steam navigation. There is no telling what would have resulted from his efforts could he have secured the pecuniary coöperation of a Boulton or a Livingston.

Of the book published in 1737 by Jonathan Hulls, a few copies are still extant and from one of them, or rather from a fac-simile, extracts are here reproduced.

It will be noticed that Hulls did not invent a marine engine, but merely the application of power from a Newcomen engine to propel a towboat. (See illustration.) Most of this 48-page pamphlet is taken up with demonstrating mechanical and hydrostatic principles involved in his mechanism. Like Euclid, he seems to take nothing for granted, but to develop, step by step, even the simpler and more obvious propositions in his theory. This part of the work shows that he had put himself through a pretty good mathematical training.

But let Mr. Hulls tell his own story:

Extract from Jonathan Hulls' Pamphlet

In some convenient part of the Tow-Boat, there is placed a Vessel about two 3ds full of Water, with the Top close shut, this Vessel being kept Boiling, rarifies the Water into a Steam, this Steam being

ORIGINAL APPLICATION OF JONATHAN HULLS' PATENTED METHOD (1737) OF STEAMSHIP PROPULSION

convey'd thro' a large Pipe into a Cylindrical Vessel, and there condens'd, makes a Vacuum, which causes the weight of the Atmosphere to press on this Vessel, and so presses down a Piston that is fitted into this Cylindrical Vessel in the same manner as in Mr. *Newcomen's* Engine, with which he raises Water by Fire.

Vid. fig. 30.

P. The Pipe coming from the *Furnace* to the *Cylinder.*

Q. the *Cylinder* wherein the Steam is condensed.

R. the Valve that stops the *Steam* from coming into the Cylinder, whilst the Steam within the same is condensed.

S. the Pipe to convey the condensing Water into the Cylinder.

T. A Cock to let in the condensing Water when the Cylinder is full of Steam and the Valve *P* is shut.

U. a rope fixed to the Piston that slides up and down the Cylinder. *Note,* This Rope *U* is the same Rope that goes round the Wheel *D* in the Machine.

It hath been already demonstrated, that a Vessel of 30 Inches Diameter, which is but two Foot and a Half, when the Air is drawn out, the Atmosphere will press on it to the Weight of 4 Ton 16 Hundred and upwards; when proper Instruments for this Work are applied to it, it must drive a Vessel with a great force.

Note. The Bigness of the Machines must be proportioned to the Work that is to be performed by them; but if such a Force as is apply'd in this first Essay be not sufficient for any Purpose that may be required, there is room to make such Additions as will move an Immense Weight with tolerable Swiftness.

In my Opinion it will not be found Practicable to place the Machine here recommended, in the Vessel itself that is to be taken in or out of the Port, &c. But rather in a separate Vessel, for these Reasons:

1. This Machine may be thought Cumbersome, and to take up too much Room in a Vessel laden with Goods, Provisions, &c.

2. If this Machine is put in a separate Vessel, this Vessel may lie at any Port, &c. to be ready on all Occasions.

3. A Vessel of a small Burthen will be sufficient to carry the Machine to take out a large One.

4. A Vessel will serve for this Purpose the more, Tho'ry, after she is thrown off and is not able to be taken far Abroad.

THE EXPLANATION OF THE MACHINE:

1. Represents the Chimney coming from the Furnace.

2. The Tow-Boat.

3. 3. Two pieces of Timber framed together to carry the Machine.

4. 4. At each end are three Wheels of one Axis to receive the Ropes, *M F E* and *&c.*

Note. *M* is the same Rope that goes into the *Cylinder*, *Vid.* &c.

H a and *H b* are two Wheels on the same Axis with the Fans *I I I I I* and move alternately in such a manner, that when the Wheels *D a, D D b* move backward or forward they keep the Fans *I I I I I* in a direct Motion.

F b is a Rope going from *H b* to *D b*, that when the Wheels *D a, D* and *D b* move forward, moves the Wheel *H b* forwards, which brings the Fans forward with it.

F a is a Rope going from the Wheel *H a* to the Wheel *D a*, that when the Wheels *D a, D* and *D b* move forward the Wheel *H a* draws the Rope *F* and raises the weight *G*, at the same time as the Wheel *H b* brings the Fans forward.

When the Weight *G* is so raised, while the Wheels *D a, D* and *D b* are moving backward, the Rope *F a* gives way, and the Power of the weight *G* brings the Wheel *H a* forward and the Fans with it, so that the Fans, always keep going forward notwithstanding the Wheels *D a, D* and *D b* move backwards and forwards as the Piston moves up and down in the Cylinder.

L L, are Teeth, for a catch to drop in from the Axis, and are so contrived that they can catch in alternate Manner, to cause the Fans to move always forward, for the Wheel *H a* by the power of the weight *G* is performing his Office, while the other Wheel *H b* goes back in order to fetch another Stroke.

Note. The weight of *G* must contain but half the weight of the Pillar of Air pressing on the Piston, because the weight *G* is raised at the same time as the Wheel *H b* performs its Office, so that it is in effect two Machines acting alternately by the weight of one Pillar of Air of such a Diameter as the Diameter of the *Cylinder* is.

If it should be said that this is not a New-Invention, because I make use of the same power to drive my Machine that others have made use of, to Drive theirs for other Purposes, I *Answer*, The Application of this power is no more than the Application of any common and known Instrument used in Mechanism for new invented Purposes.

Answers to some Queries that have been made, concerning the Possibility and Usefulness of this Undertaking

Query I. *Is it possible to fix Instruments of sufficient Strength to move so prodigious a Weight, as may be contain'd in a very large Vessel?*

Answer. All Mechanicks will allow it is possible to make a Machine to move an immense Weight, if there is Force enough to drive the same, for every Member must be made in a proportionable Strength to the intended Work, and properly braced with Laces of Iron, *&c.* so that no part can give way and break; if the Braces, *&c.* necessary for this Work had been put in the Draught, it would have been so much crowded with Lines that the main Instruments could not be so well perceiv'd.

Query. II. *Will not the Force of the Waves break any Instrument to Pieces that is placed to move in the Water?*

Answer. First, it cannot be supposed, that this Machine will be used in a Storm or Tempest at Sea, when the Waves are very Raging; for if a Merchant lyeth in a Harbour, *&c.* he would not choose to put out to Sea in a Storm if it were possible to get out, but rather stay untill it is abated.

Secondly. When the Wind comes a Head of the Tow-Boat the Fans will be protected by it from the violence of the Waves, and When the Wind comes Sideways, the Waves will come Edge-ways of the Fans, and therefore strike them with the less Force.

Thirdly. There may be pieces of Timber laid to swim on the Surface of the Water on each Side of the Fans, and so contriv'd as they shall not touch them, which will protect them from the Force of the Waves.

Up in-land Rivers where the Bottom can possible be reach'd, the Fans may be taken out and Cranks placed at the hindmost Axis to strike a Shaft to the bottom of the River, which will drive the Vessel forward with greater Force.

Query III. *It being a continual Expence to keep this machine at Work, will the Expence be answered?*

Answer. The work to be done by this Machine will be upon particular Occasions, when all other means yet found out are wholly Insufficient: How often does a Merchant wish that his Ship were on the Ocean, when if he were there, the Wind wou'd serve tolerably well to carry him on his intended Voyage, but does not serve at the same time to carry him out of the River, *&c.* he happens to be in, which a few Hours work of this Machine wou'd do: Besides, I know Engines that are driven by the same Power, as this is, where materials for the Purpose are dearer than in any navigable River in *England*; therefore Experience demonstrates that the Expence will be but a Trifle to the value of the Work perform'd by those sort of Machines, which any Person that knows the Nature of those things may easily Calculate.

Repairing a Damaged Armature Winding

By R. H. Fenkhausen

Although there are still many motors in use with ring-wound armatures, this style of winding is fast becoming obsolete due to its high internal resistance, high armature reaction and poor speed regulation, and nearly all armatures are now made with some form of drum winding, the coils of which are usually form-wound. There are two general types of winding in use, the lap-connected winding (Fig. 1), which necessitates cross-connection of the commutator when two brushes are desirable on a four-pole motor (Fig. 3), and the wave-connected winding (Fig. 2), in which the coils are connected so that external cross-connections are not required, and also serve to neutralize the effects of an unbalanced field due to worn bearings, etc.

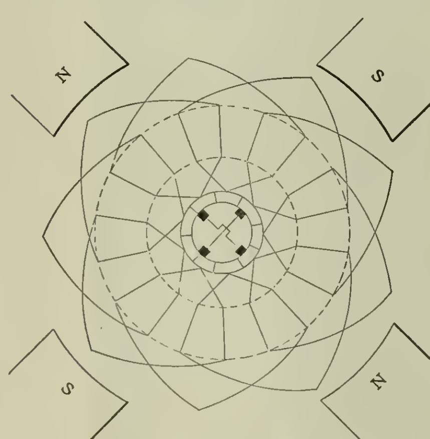


FIG. 2. WAVE-CONNECTED WINDING

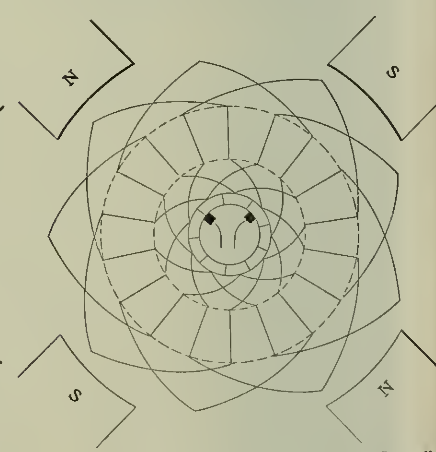


FIG. 3. WAVE-CONNECTED WINDING

The rewinding of a coil on a ring armature can be accomplished without disturbing its neighbors, but in drum windings in which the wire is wound directly in the slots it may be necessary to remove any number of coils up to the entire winding, depending on the manner in which the coils are arranged with reference to the damaged one.

Most modern armatures are of the general type shown in Fig. 4, in which the coils are wound on forms and insulated before being placed in the slots. Fig. 5 represents a coil for the armature shown in Fig. 4, and Fig. 6 shows a bar-wound coil of the type used in larger machines. These coils span several teeth of the armature core and each slot contains the bottom half of one coil and the top half of another coil some slots from it, the span or "throw" of the coil varying with the teeth per pole of the armature. Fig. 7 shows the core, and Fig. 8 a partly wound view of the armature in Fig. 4.

When it becomes necessary to replace a formed coil the binding wires must first be cut, or the fiber wedges holding the coils removed, and the connections to the commutator unsoldered. The top half of the injured coil should then be raised by slipping two pieces of ¾-inch linen tape under the extended ends of the coil and gently raising it from the slot. In order to remove the lower half of the coil it will be necessary to lift the top halves of as many coils as the injured coil spans. When the damaged coil has been removed it should be repaired if possible by re-insulating the burned spot, but if this is impossible a new coil should be put in. As a general rule it does not pay to make coils except in a shop having special facilities, and even then the coils can be purchased cheaper in many cases from the manufacturer of the motor, and the machine is not kept idle while coils are wound and dried.

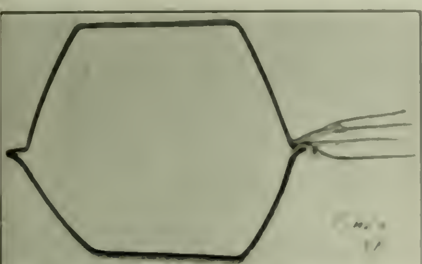


FIG. 5. A COIL WIRE

FIG. 3. CROSS CONNECTIONS

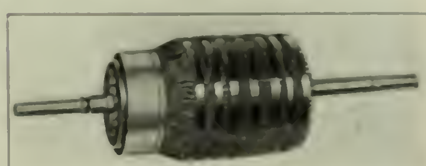


FIG. 4. A COMPLETE ARMATURE

FIG. 6. A BAR OR STRAP COIL

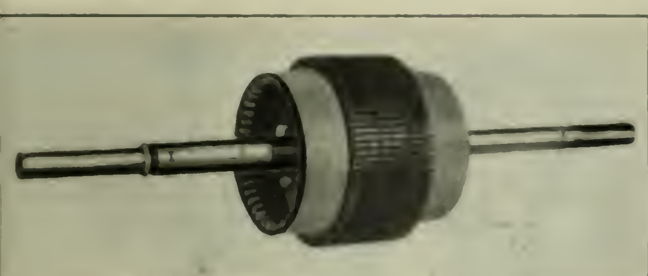


FIG. 7. ARMATURE CORE

FIG. 8. PARTLY WOUND

To Make Coils in the Shop

Spare coils for every size of armature should be kept on hand, but in case it is necessary to make coils in the shop the following procedure will give satisfactory results. Obtain two pieces of hardwood about 1 inch longer and wider than the coil desired and about ½ inch thicker, and lay out half the coil on each, as shown in Fig. 9. Then cut out to shape and bolt the two together with a distance piece between equal to the offset of the coil. The completed form is shown in Fig. 10. Start the coil in one of the holes E or F, depending on whether a right- or left-hand coil is desired, and wind on the surfaces X Y of the form, being careful to keep the wire tight until the required number of turns are wound. Most coils have two layers, but these layers should be separately wound and afterward rested together and connected.

When a layer is completed it should be held by wire loops at the points A B C D on the form to keep it in shape, after which the form should be taken apart and the coil removed. As soon as all the coils are made they should be dipped in an insulating varnish which will hold them in shape while being taped, as well as improving the insulation. After dipping, the coils should be baked, but if no oven is available an air-drying varnish should be applied. Common shellac will serve the purpose if no other varnish is on hand.

When the coils are perfectly dry the layers may be taped together, with paper between and a layer of "Empire" cloth or [illegible] tape applied. This should be followed by a layer of plain white tape to prevent abrasion of the cloth layer and the coil bent to the exact shape required, after which it should be dipped again and the layers connected in series or parallel as required. Before the final taping is applied, sleeving should be slipped over the terminals of the coil and if the winding is at all intricate it is advisable to place different colors of sleeving on the two terminals in order that they may be readily identified.

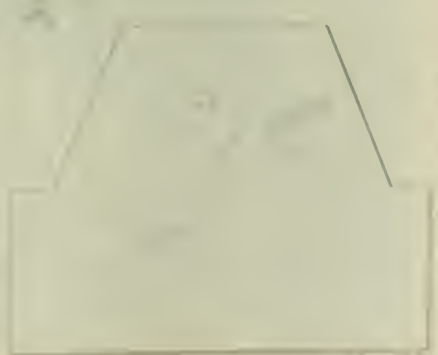


FIG. 9

While it is not claimed that the form described will make perfect coils, they will be accurate enough for practical use, and the form can be made by anyone of [illegible] [illegible], whereas the [illegible] accurate forms would take much longer and would be more expensive.

Before the coils are placed in the slots, the insulating troughs should be examined and renewed if damaged, and the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] of the [illegible].

[illegible] will [illegible] it into place.

[illegible] coils are [illegible] they should be wedged into place [illegible] [illegible] [illegible] vibration will [illegible] which may damage the insulation.

[illegible] all the coils are in place the [illegible] minals should be separated and each coil tested for continuity grounds or crosses with other coils, after which the bottom terminals may be carried to the commutator and soldered in.

The top connections should now be arranged in the proper order and the first lead tested and soldered to the proper bar, after which the other top leads are connected one at a time in proper sequence until all are in place.

Great care must be used in soldering the top leads that they are connected in the proper order, because in some types of windings two short-circuits and four open-circuits can result from the interchange of two adjacent leads.

After all the coils are connected the winding should again be tried with the testing set and if found all right the armature should be placed on knife edges and balanced with lead strips placed in the

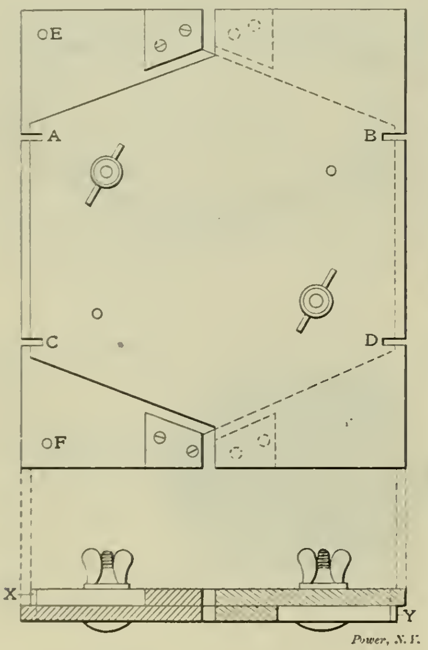


FIG. 10. COIL FORMER

slots over the coils on the light side. The binding wires may then be replaced and the armature put into service again.

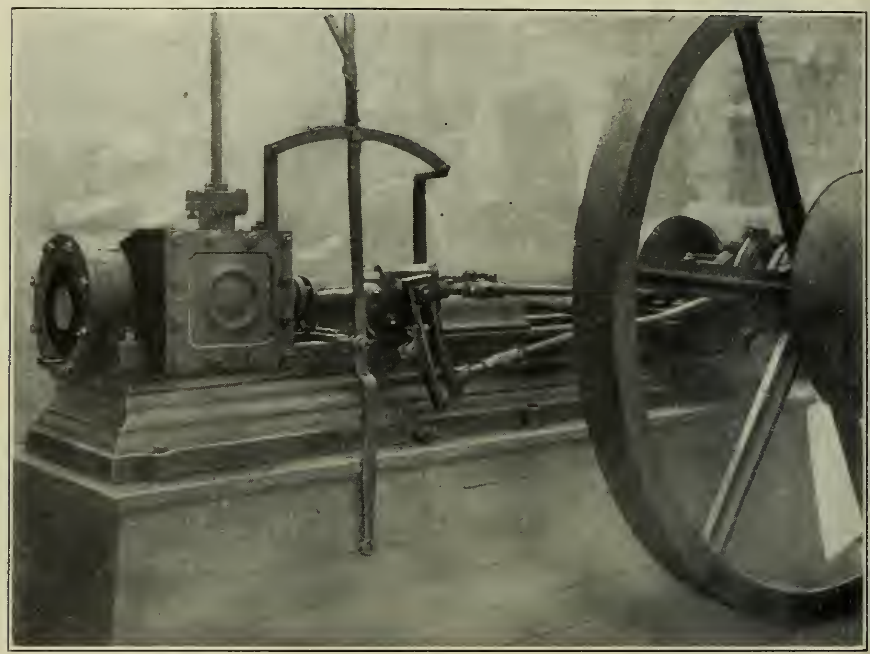
In a paper read by Prof. J. A. Smith before the Victorian Institute of Engineers it was shown that with a condenser temperature of 120 degrees Fahrenheit the amount of heat transmitted through each square foot of condenser surface was diminished 50 per cent., when air corresponding to 0.63 of an inch of mercury was introduced into the condenser. In other words, to obtain the same vacuum as when no air was present would require a condenser twice as large, or else a great deal more or colder circulating water.

At least 10,000,000 tons of peat is made and used to advantage in foreign countries every year.

An Historic Engine

Herewith are shown photographs of the engine used in the original packing plant of Armour & Co., which was located at a point that is now the very center of the immense union stockyards at Chicago. Built in 1866 by the old Columbian Iron Works, the engine practically had been in constant use until about one year ago. It was first installed on a high brick foundation behind three horizontal return-tubular boilers, and furnished the power for all the operations in the plant as then conducted. Due to the growth of the industry the engine was replaced by a larger one and was successively employed in hoisting ice, running the canned-meat department and the machine and pipe shop.

Finally, in 1901, when its 35, or so, effective horsepower could no longer be used to advantage elsewhere, it was exiled to Round lake, Ill., where it was put to a peculiar service. The company here harvests natural ice, and there is much trouble with a variety of long stiff grass or weed growing up from the bottom and interfering with the quality of the ice. Mounted on a flatboat, it was the duty of the engine to operate a device of special design for cutting this grass. During its sojourn here it was fitted with the link motion shown in the photograph.



TWO VIEWS OF AN HISTORIC ENGINE IN THE ARMOUR PLANT, CHICAGO STOCKYARDS

Recently the engine was replaced by a motor, shipped back to the stockyards and erected in the engine room of the company's power house, alongside a 600-ton ice machine, the latest piece of power machinery to be installed, representing the first and the last in power development of the company.

As shown in the photographs, the engine has the old box type of engine bed, locomotive guides and slide valve. The cylinder is about 12x16. Key adjustments are provided at the connecting-rod ends, but there is no gib-and-key arrangement as commonly understood; the key alone being used, held by a set screw.

The flywheel is cast in one piece, with the spokes loose at the inner end and fitting on a bushing keyed to the shaft. The whole is fastened securely by two rings of square iron shrunk on each end of the hub. This construction enables the flywheel to be used with any reasonable size of shaft, by varying the bushing, which doubtless was a desirable feature in the old days.

Electrolysis and Corrosion

By F. L. Johnson

While sitting at my desk one day, idly wondering why nearly everyone who had any work to do felt drawn to some kind of a city in order to do it, I was pleasantly surprised by the entrance of my young friend Sawyer. As he seated himself and looked around with his usual keen glance, I noted, in a subconscious way, that his appearance had improved. His trousers were freshly creased and several conventional touches in his dress showed that even in his strap-hanging moments he had kept up his habit of noticing things and profiting by what he saw.

After a few general remarks had been exchanged, he said:

"You probably have not forgot about that case of troublesome electrolysis I told of not long ago? Well, last week I had to go to the city where that happened and I took time to visit the plant to see if I could learn anything new about electrolysis of pump parts. I met the engineer, who at once told me of some things that had happened.

"This particular plant is operated differently from any other that I ever saw. No one man is responsible for its operation, successful or otherwise. On the part of the engineer, it is expected that he will keep the motive power in first-class running order all the time and have any unit that may be called for ready for immediate service.

"Of the electrician, it is expected that he will see that such units as will generate the required current in the most economical manner will be used. Coöperation between the steam and electrical departments is expected, but there is no provision for the preventing of friction between the two branches of the service. That friction did occur at times is evident from the fact that the engineer was never able to arouse any interest on the part of the electrician in the destruction of pump cylinders by what was believed to be electrolysis.

"New pump cylinders and parts were charged up to the steam plant and were no part of the operating expense of the electrical department.

"One day the engineer thought that perhaps the current that was destroying the pump came from the generator itself, and determined to try to find out if his guess was a fair one. At once the pump was overhauled and every part that showed any signs of electrolysis was replaced by a new part. The electrician was then notified that the engine was out of repair and could not be run.

"Then, while imaginary repair parts for the engine were being waited for, the pump was run night and day for a week, at the end of which time the pump was opened and found to be in first-class condition. The electrician was called in and shown the condition of the pump and informed of what had taken place. He was skeptical and wanted another week's run of the pump under the same conditions. It was given, and at the end of the second week, during which things were carefully watched by the electrical department, the pump was again examined and found in perfect condition.

"All imaginary repairs on the engine having been completed, it was started and run for four days, when it was necessary to shut down because the studs, nuts, valve seats and springs left their proper places in the pump and went floating away with the overflow, in company with the electric current which came from somewhere and took away with it all the metal it could carry.

"During the second week of running the pump independently a connection was made from the rail of a street-car line, half a mile away, to the pump. A flow of current of from 7 to 10 amperes was measured at the pump. But the engineer could not learn whether the flow was to or from the pump, nor the voltage of the current. Connections were also made to other pumps where no wasting away had taken place, with the result of a still larger amount of current flowing, and one of these pumps had been in use for years and never showed any signs of wasting by electrolysis nor anything else except wear where wear would be expected.

"Now, this matter has interested me considerably because I cannot understand why one particular pump in a system having common suction and discharge mains should be affected by electrolysis unless there is a leak from the generator of the engine which this particular pump serves. Now, as I understand the several periods of the story, [illegible] a problem of this kind expends his energy in trying to prove that certain factors do not enter into the problem, instead of seeking to find all of the factors.

"However, I did not start in here to moralize over the tendency of the man who takes no interest in finding leaks or removing their cause, simply because the cost will not be charged up to his department, but to have a little talk with you and ask if you could suggest any way of solving this particular problem."

I said that I had heard engineers say that before the introduction of the electric light little or no trouble had been experienced from the wasting of condenser tubes, even at sea, where nothing but salt water was used for condensing. He replied:

"I have heard the same story, but it is so hard to prove it that I have given up. Before the introduction of electricity, condensing plants were few and far apart, while now they are everywhere, but the practical engineer who operated condensing plants at that time has almost disappeared. I have met only one of the old school and all that he would say on the subject was, 'Young man, you will have to get your information just as I did, by experience.'

"I had heard about a man who had made electrolysis and corrosion a study, and I went to see him, asking about the destruction of pumps and condensers, and for a possible remedy. He went to the bottom of the subject for me. He said that while he would not say that wandering currents did not contribute in a measure to corrosion, he emphatically claimed that corrosion is going on where no extraneous currents can be held responsible for the damage. Then he talked about solution-tension, osmotic pressure, porosity of metals, molecular oxygen, ferrous ions, ferric condition and polarization by hydrogen.

"I left him with my head in a whirl and dizzy from the effects of the close-to-date use of the appalling depths of my ignorance of the subject.

"Some day a man who does not know enough to know that these things are beyond his reach will come along and, because he does not know, he will find out, and everything will be so plain that the engineer who does not even know the difference between passive resistance and depolarized hydrogen can touch a button or close a switch and read as easy as a chart the exact condition of his condenser tubes and the quality of the water passing through them, and running a condensing plant will seem like going on a vacation.

"I've been there, assisted a [illegible] who had designed a boiler which takes so much of the heat out of the furnace gases [illegible] the boiler, and [illegible]

Use Cylindrical Flywheels for Safety

Widening Rim and Shortening Radius of Flywheel Will Obviate Explosions without Sacrificing Convenience, Cost or Efficiency

BY A. L. HODGES

As the flywheel is one of the most important subjects in the mechanical world just now, it is the duty of every engineer to investigate all its properties and endeavor to conceive a way to change its makeup, in order to eliminate the big element of danger always lurking therein. The purpose of this article is to prove by mathematics and experiment how this can be done, the final product having very few disadvantages compared to the present-day affair, and a great many advantages over it.

The determining factor in the worth of a flywheel is its moment of inertia. This is a peculiar property of a rotating body and can be defined as the resistance offered to rotational motion, or, if already in motion, the resistance encountered in stopping it. It is both of these that makes the flywheel of use in machinery, by making the machine run smoothly, no matter how the load varies. Now the moment of inertia depends on several things. It is expressed by the formula,

$$I = M K^2,$$

where

I = Moment,
M = Mass of the body,
K = Radius of gyration.

This radius of gyration is found for different bodies by calculus. For a uniform and homogeneous disk it is ½ R, or one-half of the radius. For a ring with the mass concentrated in the circumference, it is R, or the radius. Now the flywheel is of this latter type, its mass being mostly on the periphery. In the ensuing argument the mass will be considered as being concentrated on the circle half way between the outside and inside diameters of the rim, and while this will be in error slightly it does not vitiate the argument at all, as will be presently seen.

Why Flywheels Explode

As the moment of inertia, then, depends directly on the mass and as the square of the radius, if we have two flywheels weighing the same, and one having a radius equal to twice the other, it will have a moment of inertia four times as great. This has caused the tendency in manufacturing flywheels to get greater efficiency by making the radius longer, and oftentimes with disastrous results. To see why flywheels disintegrate the forces acting to pull them apart and to hold them together must be investigated. The centrifugal force is the disintegrating force. It is expressed by the formula,

$$F = \frac{M V}{R},$$

where

F = Force,
M = Mass of each rotating particle,
V = Velocity,
R = Radius.

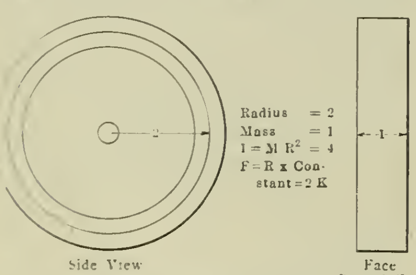


FIG. 1. PRESENT FLYWHEEL

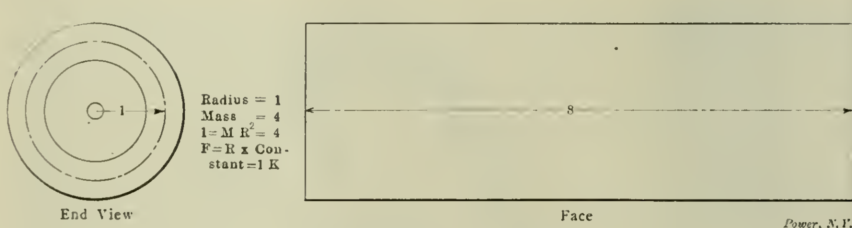


FIG. 2. PROPOSED FLYWHEEL

Now the velocity of a particle on the rim of each of two flywheels going the same number of revolutions per minute varies directly as the radius. But suppose the expression is reduced to terms of the radius. The velocity is certainly the number of revolutions in a given time multiplied by the circumference of the circle, which is, of course, $2 \pi R$. Let N stand for the number of revolutions per unit time. Then

$$F = \frac{M (N 2 \pi R)^2}{R} =$$

$$\frac{4 M N^2 \pi^2 R^2}{R} = 4 M N^2 \pi^2 R.$$

Now the proposition was to let all these terms be constant for the two flywheels except R. The number 4 is a constant, so is π^2, it is given that the N^2 is constant and the M, or mass, also. So that for two flywheels having the same mass and the same number of revolutions per unit time, it is seen that the disintegrating force varies directly as the radius. It must be remembered that the moment of inertia, the property desired, varies as the square of the radius.

Widen Rim and Shorten Radius

What is the force, then, preventing disruption of the wheel? It is that of cohesion only, or the attraction of the molecules for one another. This force acts only through small distances, yet it is sufficient in the case of steel wire to hold up 150,000 pounds per square inch. To return, then, to the original proposition. The idea is to increase the mass of the wheel's periphery considerably by widening its rim and necessarily the hub, but to shorten the radius, so that although the amount of inertia will be the same as before, the force tending to disintegrate will be very much less, so much less in fact that it would be practically impossible for the wheel to explode. The appearance of such a wheel would be that of a cylinder more than a wheel, but right here comes the practical side of it. For such a wheel no pit would have to be dug and no ceilings cut through to give it room. It would take up slightly more floor space, but as its hight would not be great, a frame could be built around it and steps over it.

Another item is that of friction. On account of the increase in mass, the friction would be somewhat greater, but as it would allow of greater speed it is at once seen that the difference would not be very great in the long run. As to the element of danger, that would be absolutely eliminated, as the periphery of the wheel could stand as great a speed as the big one, being made from the same material, but it is smaller and would allow a greater number of revolutions per minute. So in case the machinery, through accident or carelessness, attains a speed above normal, there would be absolutely nothing to fear from the improved flywheel.

In the accompanying sketches are given comparative drawings of two wheels having the same moment of inertia, but the element of risk very different, as shown by the ratio of velocities for the same number of revolutions per minute. The velocities vary as the radius, so the unit radius would have only one-half the velocity of the other, and consequently one-half of the disintegrating force as the other. The mass, however, must be four times as great. This would merely make the rim eight times as wide, using the same thickness of rim in both cases.

It must be remembered that as the rim of the wheel gets thicker, the wheel itself more nearly approaches a disk, and the gyration radius would be ½ *R* instead of *R*. Therefore it is necessary to keep the rim as thin as possible. The figures following are only true on the assumption that the mass is concentrated in the middle circle. Of course, for any desired flywheel all these can be easily worked out. The purpose of this article is simply to show that exploding flywheels are not necessary and can be rendered impossible without sacrificing in the least any convenience, cost or efficiency.

It is possible that the above reasoning is not quite clear to those students who have used Kent's handbook entirely, for here it is claimed that the tensile stress per unit cross-section of the rim is expressed by the formula

$$S = C\ R^2\ r^2,$$

where

C = Constant,
R = Radius of wheel,
r = Number of revolutions per minute.

But it must be noticed that this is derived from the previous formula

$$S = C_1\ W\ R\ r^2,$$

where

C_1 = Another constant,
W = Weight or mass of the rim,
R = Radius of wheel,
r = Revolutions per minute.

How, then, is the variable W omitted from the formula which contains only R? Because W is considered a variable which, as it is the weight of ring of unit cross-section, will vary as R. Consequently, the constant is changed and the form varying as R^2 in the final formula is obtained. Right here comes in the agreement in reasoning with the first part of this article. One of the conditions was that the mass being constant the force varied as R alone. This is at once clear, for if M is constant, form of the cross-section can vary. The rim would merely become thinner. Also that the M is not the mass of a unit cross-section, but of the whole rim or one particle in the rim. The crux of the whole thing is that the mass can be increased without increasing the radius by merely widening the rim.

THE BALL BEARINGS TO REDUCE FRICTION

As to the friction of the cylindrical flywheel, it is known that friction does not depend on area, but merely on the weight and a constant for any two given surfaces. So the shaft or axle of the new flywheel could be made of as large a diameter as desired, and it could be supported in as many places as desired to prevent vibration of the shaft, without increasing the friction. Now as this is so, the more area in contact the less would be the pressure per unit area. This would allow for the use of any bearing metal now used for that purpose. Referring to Fig. 2, in that particular case four supports of the same dimensions would be needed as for Fig. 1, or two supports of twice the dimensions. Either would give the same pressure per unit area on the bearings. To have more than two supports, the cylinder could be made into separate wheels on a rigid shaft, which would not lessen its efficiency and would only lengthen the shaft by a distance equal to the width of the extra bearings.

As the number of supports, then, does not increase the friction and lessens the pressure per unit area, ball bearings ought to find an immediate application. A great improvement in ball bearings has been made in recent years. Their sphericity and accuracy in size have been improved and their ability to resist crushing has been more than doubled by the use of special alloys of crucible high-carbon steel. Consequently, smaller balls can now be used to do the work of larger ones, which would have been used before had the space been available.

Another improvement is the recent introduction of the annular ball bearing, where the balls are placed in a groove between two rings, which thus give a larger bearing surface and consequently allow for a greater pressure on the balls. The pressure on a sphere is a rather interesting problem. If it were possible to have two spheres each of an absolutely incompressible material, the place of contact would be a geometrical point and no matter what the weight, the pressure exerted would be infinite. But as this is impossible the hardness of both the ball and the shaft allow of such flattening out according to the pressure, and thus a considerable area is subjected to pressure.

As a result, [illegible] has been found, possible to decrease the friction to [illegible] over the former bearings. Thus it can be seen that by the use of ball bearings the new flywheel can be brought down to almost as low a friction as the old type, although it does contain several times the amount of [illegible].

The Turbine and Reciprocating Engine for Naval Purposes*

By LOUIS W. [illegible]†

It has been fairly well proven that for land purposes and for merchant vessels of high power and speed the turbine has given satisfactory results from an economical standpoint. A turbine under these conditions runs at maximum speed and maximum power. A passenger ship leaving port starts out under full-power conditions and remains under the same conditions until the arrival at the next port, time of passage meaning money to the owners.

For naval purposes the installation of turbine machinery is an entirely different proposition. A ship is built to fight, and should be able to maintain the greatest speed possible if called upon under the best conditions. A ship built may never be called into a naval fight, but no one can tell when the day will come when the machinery may be called upon to perform its greatest power. It may be only for an hour or two, but this hour may mean victory or defeat.

If run at maximum speed the turbine may be the best available. The question, however, arises, which would be the better for all-round work, both at low and high speeds and give as good results in cases of emergency? It may be admitted that for maximum speeds the turbine has a little the better of the argument, but for all-round cruising, and taking into consideration the installation of machinery, I think the reciprocating engine up to the present time is the better installation.

If two shafts are installed in the ship and on each shaft one turbine of a large unit, the economy is sure to drop when the speed drops, and at low power the economy will be greatly decreased because a large unit cannot be satisfactorily designed to give economical results at all speeds. The maximum peripheral speed at the buckets is neither week in some vessels, much less than usually [illegible] of a turbine employed for electric lighting, and if the most general design were followed in the two-shaft [illegible] turbine should be at least [illegible] as long if equal economy were to be obtained. In order to give a low peripheral speed at a satisfactory number of revolutions, the diameter of the turbine has to be increased, which means a material increase in the weight of the machinery. If two turbines are placed on each shaft, with a high-pressure and a low-pressure on each shaft, the economy [illegible] will be much, but it is sure to fall [illegible] at the lower speeds and greatly exceeds that of a correctly designed reciprocating [illegible]

*Abstract of paper read before the American Society of Naval Engineers. [illegible]
†Assistant [illegible]

engine at low powers. If three or four shafts are installed, or even with two shafts, combinations may be made whereby cruising turbines are installed, and the economy may be obtained at the lower speeds which will correspond closely to that of the reciprocating engine. As these economical results are obtained, what is done to obtain them? More turbines of smaller units have to be installed, more shafting, more piping, with joints, and increase of valves, and the whole equipment has to be increased and complicated. It becomes a question whether, to obtain this economy at the lower speeds equal to that of a reciprocating engine (it is doubtful whether it is obtained), this increase of machinery and complications will offset any gain which is claimed by the turbine. The less the amount of machinery on board and the less complicated it is, the easier will it be to handle and care for. The machinery on board a man-of-war at the present time is complicated enough without adding any more complications to it.

For naval purposes under ordinary conditions a ship rarely cruises at maximum speed. The ordinary cruising is around 10 or 12 knots, which is, say, 15 per cent. to 20 per cent. of full power. At this speed the cruising turbines would be practically the only ones in use and the others would run idly. With the reciprocating engine the economy can be regulated by using the cutoffs so that no change is necessary by making any change in the combination of the motive power. For these lower powers the economy of the reciprocating engine is decreased but slightly. For maximum speed the reciprocating engine could be built to make the speed required and at the same time be economical. If all possible refinements in design that tend to economy are made, the reciprocating engine could be nearly, if not quite, as economical as the turbine. These refinements consist in the reduction of clearances, proper proportioning of the sizes of the cylinders, care in providing smooth exits through ports and passages, longer stroke, if possible, better condensing apparatus and the use of superheated steam. With high-class land engines, owing to the use of Corliss and drop types of steam valves, the clearance spaces have been much reduced. I do not see why Corliss valves, or something on that style, could not be used for marine engines. They might be placed in the tops of the cylinders. If as many experiments as are being made at the present time on the turbine were made on the reciprocating engine, I think an increase in the economy would be shown with the reciprocating engine.

Working out the water rates of about ten ships in the United States Navy, the average gives about 17.2 pounds of water per indicated horsepower for main engines only. This is at maximum power under service conditions. Assuming that the water consumption was greater than this, say 19 pounds (which is quite high and perhaps ought to be about 17.5 to 18 pounds), this would give for a 20,000-indicated horsepower engine a water consumption per hour of 380,000 pounds. Assuming that the boilers evaporated 9.5 pounds of water per pound of coal, then the amount of coal burnt per hour for the main engines would be 17.8 tons. Now assume that the turbine installation of 20,000 gives a water consumption *under service conditions* of 15 pounds, this will mean a water consumption per hour of 300,000 pounds, which, assuming as before the same evaporation per pound of coal, would mean a consumption of 14.1 tons of coal per hour. With the increase in auxiliaries required for the turbine this would be brought a little higher. This will show an increase in economy on the side of the turbine at the high speeds, but how long is either going to run at those top speeds? The reports of the economy of the turbine show the gain at the maximum speeds, but reliable information is not obtained, as a general rule, for the lower speed, and it does not appear that the turbine has beaten the reciprocating engine in *overall efficiency*—that is, taking into consideration the engine and screw together. The degree of economy of the turbine in marine practice must compete on the largest scale with that of a quadruple-expansion engine expanding saturated steam with 210 pounds fifteen times into a vacuum of 25½ inches, with an economy of 13.6 pounds of water per indicated horsepower per hour.

Another question to enter into the installation of a turbine or reciprocating engine is that of the relative propeller efficiencies. It is claimed by some that the high-speed turbine will give a smaller screw and thereby get deeper immersion of the blades and less draft to the ship. This may be well enough for torpedo boats and vessels with shallow draft, but for larger vessels larger screws are needed. With propellers for turbines running at high speeds it is just a question how fast the water will flow to the screw. In a small turbine the revolutions have to be high in order to get the peripheral-blade speed. As soon as the revolutions increase above that designed the efficiency of the screw decreases and cavitation losses may also enter. It is a difficult question to design a screw that will meet all the demands of a naval vessel. The thrust may be divided among three screws, but this will increase the machinery installation and complicate matters. The larger the screw, the greater the efficiency. If a blade of standard width gives insufficient surface, to prevent cavitation then either the blades have got to be made wider, other things remaining the same, or a larger pitch ratio must be chosen, which will mean an increase in the diameter of the screw and reduction in the revolutions, which means an increase in the diameter of the turbine and an increase in the weight. For marine turbines the vane speed can hardly exceed 200 feet without great sacrifice to the propeller efficiency, and is generally from 140 feet to 100 feet. If the revolutions are, say, 250 per minute, then the corresponding turbine diameter would be 10 feet 7 inches, and if the revolutions were decreased to 200, then the diameter of the turbine would be 13 feet 4 inches. A screw may be designed for a turbine with a certain speed, but as the speed decreases the economy is lost in the turbine, and the screw will also lose its efficiency when the revolutions for which it is designed vary to any great extent. At high speeds of revolution the propeller efficiency drops very materially and, as a general rule, the gain in economy is counterbalanced by the loss in propeller efficiency.

In land service an arrangement is now being tried with a low-pressure turbine working in conjunction with a reciprocating engine, the low-pressure turbine being placed so as to use the exhaust from the reciprocating engine. This is giving satisfactory results and has secured great gains in the economy of steam. With the reciprocating engines as now used in the naval service, at high speeds, the vacuum does not have a great deal of effect in the power of the engine. This is due to the small size of the ports and the quick opening and closing of the valves. To get the full effect of the vacuum it would mean increasing the size of the valves to such an extent that it would be impracticable. If a low-pressure turbine was placed so as to take the exhaust from the main engines the vacuum would have its full effect in the turbine, which would mean more work being done and more economy. By using this low-pressure turbine in conjunction with the main engines some complications would arise, and it is a question whether for the increased economy the installation of the low-pressure turbine would be worth while. This combination is spoken of in Lieutenant Dinger's article in the *Journal* of the American Society of Naval Engineers, November, 1908.

A good many foreign navies, in fact, nearly all, have tried, and are still trying, the installation of the turbine, but the results have been kept a secret and their economical and practical results are still a question of doubt. All reports, as a general rule, of the ships having turbine installation show a better economy at the maximum speed than the ships fitted with the reciprocating engine, but the results at lower speeds are not so well reported, and the average result is not very satisfactory for any authentic information.

Many things are claimed for the turbine, among them being a saving in weight and a saving in space. The saving in weight *seldom* shows an advantage of 5 per cent. over that of the reciprocating engine. The tendency now is to increase the weight without any gain in economy. The turbines installed in the first battleship in the British navy averaged about 40.4 pounds per indicated horsepower, now the average is about 43.2 pounds. When one takes into consideration that a turbine installation requires high vacuum, which means an increase in the cooling surface at the condensers and a more complete condensing apparatus, the weight of the turbine will not be so very much under that of a reciprocating engine for the same power. In order to get the greatest efficiency out of the propeller for general work, and at varying revolutions, the propeller must be increased in size. When this is done the speed of rotation of the shaft must be reduced. The general tendency is to decrease the revolutions, which, as a general rule, means increasing the diameter of the turbine rotor in order to obtain the proper vane speed. Any increase in the diameter of the rotor means, of course, an increase in weight and space. The average weight, including main-engine cylinders, shafting, main-engine framing and bearings, reciprocating parts of main engines, main-engine valve gear, main condensers, main air and circulating pumps and propellers arranged for the "Louisiana," "South Carolina," "Michigan," "Washington," "Tennessee," "West Virginia" and "Maryland" is 68.5 pounds per designed indicated horsepower. If we take out the main condensers, main air and circulating pumps and propellers, the average weight per designed indicated horsepower will be 52.35 pounds. Should we take out the weight of the shafting aft from the engine this would bring the weight per indicated horsepower still less. When one takes into consideration the turbine combinations that are being made to increase the economy and the increased diameter in the turbine it will not be astonishing to note that the weights will not differ much. There is not so much space saved in the turbine installation, and the space used by the turbine and condensers will not be much less than the space used for the installation of a reciprocating engine. The head room may be less in the turbine, but if proper facilities are made for removing the turbine casing and removing the exhaust pipes the head room will not be reduced much. When the combinations of turbines are installed for economical purposes the space saved is very small, if any, over that occupied by the installation of a reciprocating engine.

Another one of the claims of the turbine might be added here, and that is the reduction in the engine-room staff. This is true, but if forced lubrication were used on the reciprocating engine (it is being installed on some at the present time), this engine-room staff might be reduced somewhat.

The adjustment of the rotor in a fore-and-aft direction should be very exact. When it is taken into consideration that the clearance is from 1/16 inch to [illegible] inch between the stationary blades and the rotor, it will be readily understood that there is not very much chance for a longitudinal movement of the shaft. When the turbine is going ahead and is suddenly thrown to full astern, there is bound to be a great strain set up in the thrust, which would, if there was the slightest give to the thrust, allow a play in a fore-and-aft direction. After running for a time the shaft collars are bound to wear the shoes in the thrust, and any slight play in the thrust will have to be closely watched. In case the shaft does change an amount equal to the clearance, it would mean that the shrouding of the blades would be badly cut, and in case the blades were not shrouded it might mean the destruction of the blades and the motive power of the ship. Cases have occurred where the shrouding has been cut, and in some cases where the blades have gone.

Nearly every ordinary case of breakdown in a reciprocating engine at sea can, with a little ingenuity on the part of the engineering personnel, be repaired and the ship be able to get to port. The parts of the reciprocating engine are easily accessible and can be temporarily repaired in some way or another. Spare parts can also be carried to cover any ordinary breakdown. It is different with a turbine; if any of the moving rotors are disabled there is no easy way to repair the defects unless the casing is taken off and proper facilities given to do the work, and if the blades are gone there is no way to repair the defects. Ordinarily, most of the merchant ships now fitted with turbines run between two ports, and are at one time of the run close to the works where they were built or may be within easy reach of the works. With a man-of-war this is entirely different. She may be ordered at any time to any part of the world, and if easy and feasible methods of repairs are not given for the work then the ship should not be ordered to any place outside of close communication with the shops where she was built. No spares can easily be carried for the rotor of the turbine, and if this rotor should be disabled there is no easy method to repair it. A turbine ship might be on a foreign station for years at a time or might be on blockade duty or performing special duty in time of war. If anything should go wrong in the interior of the turbine it is a much more difficult operation to repair than with a reciprocating engine.

In accepting the turbine for naval purposes all the above points must be carefully considered to cover all conditions of speed and general work. The specifications for turbine ships should [illegible] ing service conditions than at full power, and any tests made with the turbine should be made with the installation on board and under service conditions. The comparison should then be made with the reciprocating engine. When the grand average shows a decided advantage in favor of the turbine for all-round work for naval purposes over that of the reciprocating engine then, but not until then, should the turbine installation supersede the reciprocating engine in the ships which are to be built in the future, whose speed is not much above about 21 knots.

In writing this article I am not at all against the use of the turbine, but I think up to the present time it has not shown, taking everything into consideration, a great enough advantage in all-round work to warrant its taking the place of a reciprocating engine. I think that if some refinements were made in the reciprocating engine, this form of motive power would, for naval purposes, keep at equal pace with the turbine installation.

Government Bulletin on Smokeless Combustion of Coal

A bulletin on the smokeless combustion of coal in boiler plants, with a chapter on central heating plants, will soon be issued by the technologic branch of the United States Geological Survey, giving in detail a study of the conditions found in industrial establishments in thirteen of the largest cities of Indiana, Illinois, Kentucky, Maryland, Michigan, Missouri, New York, Ohio and Pennsylvania, between 400 and 500 plants having been inspected. Sufficient information was collected to make the data from 284 plants of value for this report.

The bulletin, prepared by D. T. Randall and H. W. Weeks, not only shows that bituminous coals high in volatile matter can be burned without smoke, but that large plants carrying loads that fluctuate widely, where boilers with banked fires must be put into service quickly and then forced to the capacity of their units, can be operated without producing smoke that is objectionable. Proper equipment, efficient labor and intelligent supervision are the essential factors.

The burning of coal without smoke is a problem which concerns the Government directly because of the advantages of smokeless combustion both in public buildings and on naval vessels. To publish [illegible] experiments as a factor in [illegible] the fuel economy of the United States, therefore, is a part of its general investigation of the best methods of utilizing the [illegible] of this country. The United States Geological Survey has made a careful study to determine the conditions necessary for the smokeless combustion of [illegible] coal in boiler plants.

The general conclusions of Messrs. Randall and Weeks are as follows:

Smoke prevention is possible. There are many types of furnace and stoker that are operated smokelessly.

Credit is to be given to any one kind of apparatus only insofar as the manufacturers require that it shall be so set under boilers that the principles of combustion are respected. The value of this requirement to the average purchaser lies in the fact that he is thus reasonably certain of good installation. A good stoker or furnace poorly set is of less value than a poor stoker or furnace well set. Good installation of furnace equipment is necessary for smoke prevention.

Stokers or furnaces must be set so that combustion will be complete before the gases strike the heating surface of the boiler. When partly burned gases at a temperature of, say, 2500 degrees Fahrenheit, strike the tubes of a boiler at, say, 350 degrees Fahrenheit, combustion is necessarily hindered and may be entirely arrested. The length of time required for the gases to pass from the coal to the heating surface probably averages considerably less than one second, a fact which shows that the gases and air must be intimately mixed when large volumes of gas are distilled, as at times of hand firing, or the gas must be distilled uniformly, as in a mechanical stoker. By adding mixing structures to a mechanical-stoker equipment both the amount of air required for combustion and the distance from the grates to the heating surface may be reduced for the same capacity developed. The necessary air supply can also be reduced by increasing the rate of combustion.

No one type of stoker is equally valuable for burning all kinds of coal. The plant which has an equipment properly designed to burn the cheapest coal available will evaporate water at the least cost.

Although hand-fired furnaces can be operated without objectionable smoke, the fireman is so variable a factor that the ultimate solution of the problem depends on the mechanical stoker—in other words, the personal element must be eliminated. There is no hand-fired furnace from which, under average conditions, as good results can be obtained as from many different patterns of mechanical stoker; and of two equipments the one which will require the less attention from the fireman gives the better results. The most economical hand fired plants are those that approach most nearly to the continuous feed of the mechanical stoker.

The small plant is no longer dependent on hand-fired furnaces, as certain types of mechanical stoker can be installed under a guaranty of high economy, with reduction of labor for the fireman.

In short, smoke prevention is both possible and economical.

During 1904 to 1906 coals from all parts of the United States were burned at the Government fuel-testing plant at St. Louis, in furnaces which were in the main of the same design. Most of the tests were made on a hand-fired furnace under a Heine water-tube boiler. The lower row of tubes of the boiler supported a tile roof for the furnace, giving the gas from the coal a travel of about 12 feet before coming into contact with the boiler surface. This furnace is more favorable to complete combustion than those installed in the average plant. A number of coals were burned in this furnace with little or no smoke, but many coals could not be burned without making smoke that would violate a reasonable city ordinance when the boiler was run at or above its normal rated capacity.

In 1907, the steaming section of the St. Louis plant was moved to Norfolk, Va., where subsequent tests of this nature were made. The plant at Norfolk was equipped with two furnaces—one fired by hand and the other by a mechanical stoker.

In the course of the steaming tests some special smoke tests were made and the influence of various features in smoke production was noted. As the tests were made as far as possible under standard conditions with a minimum variation in boiler-room labor the results bring out the importance of other factors, such as character of fuel and furnace design.

A brief summary of the general conclusion is as follows:

A well-designed and operated furnace will burn many coals without smoke up to a certain number of pounds per hour, the rate varying with different coals, depending on their chemical composition. If more than this amount is burned, the efficiency will decrease and smoke will be made, owing to the lack of furnace capacity to supply air and mix gases.

High volatile matter in the coal gives low efficiency and *vice versa*. The highest efficiency was obtained when the furnace was run at low capacity. When the furnace was forced the efficiency decreased.

With a hand-fired furnace the best results were obtained when firing was done most frequently and with the smallest charge.

Small sizes of coal burned with less smoke than large sizes, but developed lower capacities.

Peat, lignite and subbituminous coal burned readily in the type of tile-roofed furnace used and developed the rated capacity with practically no smoke.

Coals which smoked badly gave efficiencies 3 to 5 per cent lower than the coals burning with little smoke.

Briquets were found to be an excellent form for using slack coal in a hand-fired plant. They can be burned at a fairly rapid rate of combustion with good efficiency and with practically no smoke. High-volatile coals are perhaps as valuable when briquetted as low-volatile coals.

A comparison of tests on the same coal washed and unwashed showed that under the same conditions the washed coal burned much more rapidly than the raw coal, thus developing high rated capacities. In the average hand-fired furnace washed coal burns with lower efficiency and makes more smoke than raw coal. Moreover, washed coal offers a means of running at high capacity, with good efficiency, in a well-designed furnace.

Forced draft did not burn coal any more efficiently than natural draft. It supplied enough air for high rates of combustion, but as the capacity of the boiler increased the efficiency decreased and the percentage of black smoke increased.

Most coals that do not clinker excessively can be burned with from 1 to 5 per cent. greater efficiency and with a smaller percentage of black smoke on a rocking grate than on a flat grate.

Air admitted freely at firing and for a short period thereafter increases efficiency and reduces smoke.

As the CO in the fuel increases the black smoke increases; the percentage of CO in the flue gas is therefore, in general, a good guide to efficient operation. However, owing to the difficulty of determining this factor, combustion cannot be regulated by it.

The simplest guide to good operation is pounds of coal burned per square foot of grate surface per hour.

None of the problems of combustion has received more experimental treatment than the burning of coal in hand-fired furnaces. Hundreds of devices for smokeless combustion have been patented, but almost without exception they have proved failures. This record may be explained by the fact that many of the patentees have been unfamiliar with all the difficulties to be overcome, or have begun at the wrong end. Numerous patents cover such processes as causing the waste gases to reënter the furnace, and schemes for collecting and burning the soot are legion. So many manufacturers who have been looking for some cheap addition to a poorly constructed furnace to make it smokeless have experienced inevitable failure that the work of educating the public to rid cities of the smoke nuisance has been hard, long and only partly successful.

The total number of steam plants having boilers fired by hand is far greater than the total of plants with mechanical stokers, but if the comparison is based on total horsepower developed the figures show less difference. Particularly is this true in sections of the central West, where mechanical stokers are generally used at large plants. As a rule, hand-fired plants do not have proper furnaces, and methods of operation are far from conducive to good combustion. Coal is usually fired in large quantities, and little opportunity is given for the air and gases to mix before the heating surface is reached and combustion is arrested. In all the hand-fired plants visited success in smoke prevention has been obtained chiefly by careful firing. The coal was thrown on often in small quantities, the fire was kept clean, enough ash to prevent the passage of air through the fire never being allowed to collect on the grate; and more air was supplied at firing than after the volatile matter had been distilled. Even with such precautions the plants might have made objectionable smoke at times but for the fact that usually some method was employed for mixing the gases and air before they reached the heating surface.

Some general conclusions from the facts set forth in the bulletin are as follows:

The flame and the distilled gases should not be allowed to come into contact with the boiler surfaces until combustion is complete.

Firebrick furnaces of sufficient length and a continuous or nearly continuous supply of coal and air to the fire make it possible to burn most coals efficiently and without smoke.

Coals containing a large percentage of tar and heavy hydrocarbons are difficult to burn without smoke and require special furnaces and more than ordinary care in firing.

Briquets are suitable for use under power-plant conditions when burned in a reasonably good furnace at the temperatures at which such furnaces are usually operated. In such furnaces briquets generally give better results than the same coal burned raw.

In ordinary boiler furnaces only coals high in fixed carbon can be burned without smoke, except by expert firemen using more than ordinary care in firing.

Combinations of boiler-room equipment suitable for nearly all power-plant conditions can be selected, and can be operated without objectionable smoke when reasonable care is exercised.

Of the existing plants some can be remodeled to advantage. Others cannot, but must continue to burn coals high in fixed carbon or to burn other coals with inefficient results, accompanied by more or less annoyance from smoke. In these cases a new, well designed plant is the only solution of the difficulty.

Large plants are for obvious reasons usually operated more economically than small ones, and the increasing growth of central plants offers a solution of the problem of procuring heat and power at a reasonable price and without annoyance from smoke.

The increasing use of coke from by-product coke plants in sections where soft coal was previously used, the use of gas for domestic purposes and the purchase of heat from a central plant in business and residence sections all have their influence in making possible a clean and comfortable city.

The Alberta (Can.) License Law

On May 9, 1906, the legislative assembly of the Province of Alberta, Canada, passed its first engineers' license and inspection law, entitled, "The Steam Boiler Act."

This act, with the amendments passed in 1907 and 1908, clearly defines the terms "boiler," "owner," "engineer," "inspector," etc., prescribes the duties of all persons connected with the operation and inspection of steam boilers, and provides for the enforcing of the act.

The act provides for obtaining a certificate of qualification as engineer in three ways:

First, any person who holds a certificate of qualification as an engineer from any incorporated body authorized to grant such certificates of qualification for operating steam boilers and engines, or from the Dominion or any provincial government, or from any competent authority in any other portion of the British Empire, or the United States of America, shall be entitled, upon making application to the minister accompanied by such evidence of his qualification as may be required by the minister and upon payment of a fee of $5, to obtain a certificate of qualification as an engineer in the class determined by the minister.

Second, those who have had over one year's experience in charge of and operating steam boilers and engines outside of this province, upon furnishing evidence of the fact and passing an oral examination before an inspector, can obtain provisional certificates which entitle them to act as engineers to operate steam boilers and engines of any capacity not exceeding 75 horsepower for one year, and at the expiration of such certificates, if the holders desire to continue to act as engineers, they have to undergo a written examination for first-, second- or third-class certificates, as may be determined by the inspector. The fee for a provisional or final certificate is $5.

Third, persons who have had no experience in operating steam boilers and engines, but who desire to become engineers, can do so by serving as apprentice for one year to an engineer or engineers who are registered as holders of first-, second- or third-class certificates for the province, and at the expiration of such time passing an examination before an inspector.

Examinations for final certificates are held from time to time at various points throughout the province by the inspectors, and persons desiring to undergo an examination should notify the inspectors or the deputy minister so that they may be informed of the next date of examination.

The names and addresses of the inspectors are: Joseph Bruton, Calgary; David Tyson, Strathcona; F. W. Dickens, Red Deer.

Persons undergoing a written examination are examined as to their knowledge of the construction, care and operation of steam boilers and engines; also a carefully [illegible] list of theoretical and practical questions. Any candidate through lack of education may be allowed to secure the services of a person who will write answers to questions, or interpret only as instructed by the candidate, but such person or interpreter must not be an engineer.

Candidates writing for a first-class certificate must obtain 70 per cent. of the total number of marks allotted, those writing for second- must obtain 60 per cent., and for a third- 50 per cent., in order to pass. Those who fail for first-, but make 60 per cent. of marks allotted, may be granted a second-class certificate, and those making only 50 per cent. on the second may be granted a third-class certificate. Candidates failing to pass may not again write for the same or a higher class of certificate until after the expiration of one year.

For the guidance of those who may desire to present themselves for examination for certificates as engineers, the following information is given regarding the subjects of examination:

(a) Questions relating to the origin of steam and its uses.

(b) Questions relating to the different kinds of boiler to generate steam, and manner of constructing them, including the strength of materials used in building boilers, and the proper proportions in size and thickness of material to be used to boilers with proper areas of grate, etc.

(c) Questions regarding the different kinds of safety valve for controlling the pressure in steam boilers and other necessary fittings.

(d) Questions regarding the proper methods of caring and maintaining steam in boilers and the care necessary to keep them in good order, and when repairs are necessary the method of making them.

(e) Questions regarding the kind, construction and operation of the different appliances used to feed and supply boilers with water during operation.

(f) Questions regarding the different kinds of engine used in developing steam, including their construction, and the methods of calculating their power and the proper methods of timing and operating such engines.

The questions are made as clear and concise as possible and every effort has been made to make the questions cover such theoretical and practical knowledge as should be possessed by every engineer charged with the care and operation of steam boilers and engines.

Candidates desiring to qualify for examination can obtain the necessary theoretical information to enable them to answer the questions by studying any recognized textbooks on the boiler and steam engine.

Forms of application and any additional information may be obtained by addressing John Stocks, Deputy Minister.

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Courtesy Due the Engineer

The engineer often enters into correspondence with different manufacturers in order to find out what is most suitable for his plant, considering the conditions under which he has to operate. He uses his firm's letterhead to show who he is; but many times the dealer will write the firm in reply, with the result that the letter promptly reaches the waste basket, causing at least delay and perhaps trouble for the engineer. It is the engineer's duty to find what is needed, then to advise his employer. Then when a manufacturer or dealer receives word from that employer it is time enough to write him and not before. This consideration is due the engineer.

The writer has within a short time sent orders to a firm to the amount of $10,000, yet it is possible that that firm does not know to whom to credit that business. This goes to show that while the employer pays the bills, the engineer may have to furnish the brains. In fact, that is what he is paid for. As a rule manufacturers and dealers are courteous to and assist the engineer in many ways, seeming to appreciate the fact that he is "the man behind their machines," yet there are others who persist in working against their own interests.

J. F. Miller.

St. Augustine, Fla.

Timing Gas Engine Valves and Ignition

Mr. Tilden in his letter on page 416 of the March 2 issue comes to conclusions which do not seem to "jibe" with my experience, and I should like to point out the reason why I am strongly of the opinion that it is better if the valves do not close and open on the dead-center points. I made several tests on vertical gas engines and I found that a proper adjustment for the valves is as follows:

For vertical engines (Fig. 1): Inlet valve to open 30 degrees ahead of the dead-center point; to close 6 degrees after the dead-center point. Exhaust valve to open 40 degrees ahead of the dead-center point; to close 30 degrees after the dead-center point.

For horizontal engines (Fig. 2): Inlet valve to open 20 degrees ahead of the dead-center point; to close 20 degrees after the dead-center point. Exhaust valve to open 40 degrees ahead of the dead-center point; to close 10 degrees after the dead-center point.

This adjustment will give better results than when the valves open and close at the dead-center point.

It is true that a gas engine acts during two strokes as a pump and that the valves of a pump should close at the end of the stroke. But it is a well known fact that in a gas engine it is important that the mixture is, as far as possible, free from exhaust gases, or else there will be slow combustion, which may cause backfiring if the cylinder head is not free from dead spaces. By adjusting the valves as mentioned herewith there will be a better clearing of the cylinder, if the engine is well constructed, which means a better mixture, and this is of more importance than the very small loss of mixture, if any, produced by opening and closing the valves a little earlier and later.

As mentioned by Mr. Tilden, it is important that the time of ignition may be changed while the engine is running. It should be possible to ignite the mixture from 50 degrees ahead to 20 degrees after the dead-center point, the latter adjustment being used for starting the engine.

Harry A. Meixner.

Brooklyn, N. Y.

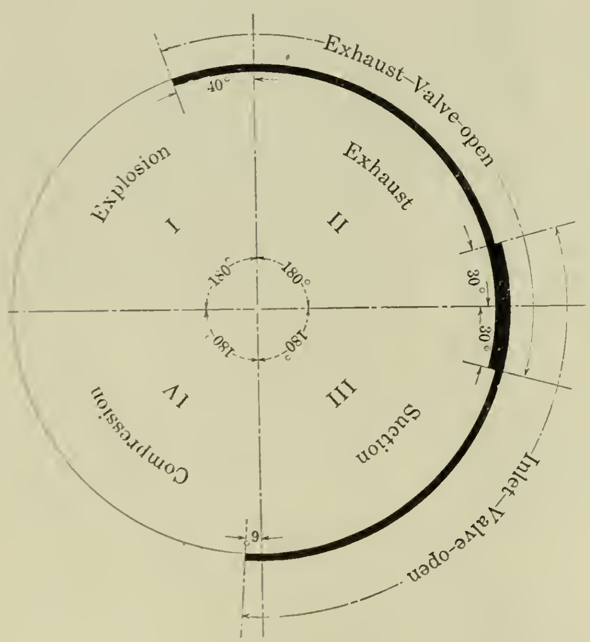


FIG. 1

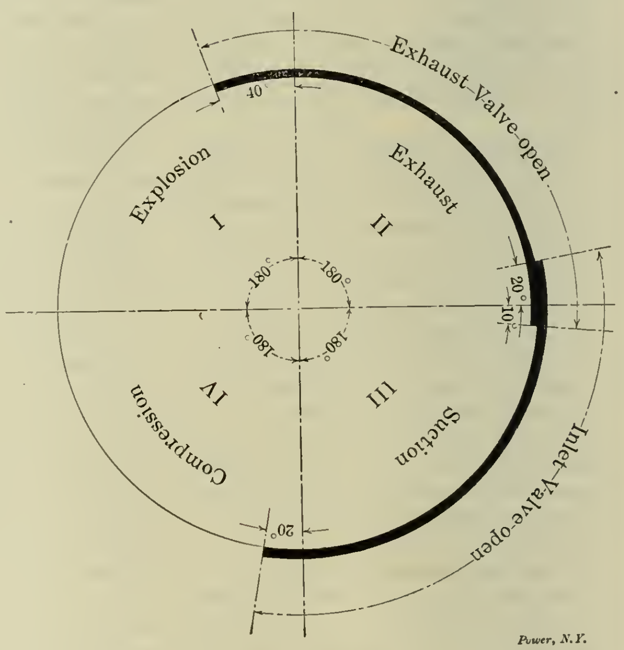


FIG. 2

Improvement on Low Water Alarm

The low water in the storage tanks located on the roof of the factory was rather difficult to account for when the insurance inspectors made their visit. After promises had been made to keep a closer check on the actual amount of water in reserve, a careful inspection of the low-water alarm was made, with the idea that the trouble came from this source.

A construction similar to Fig. 1 was in use. This consisted of a float connected to a stem, to which was secured a brass disk *A* which made contact with the two springs *B B*, when there was an absolute

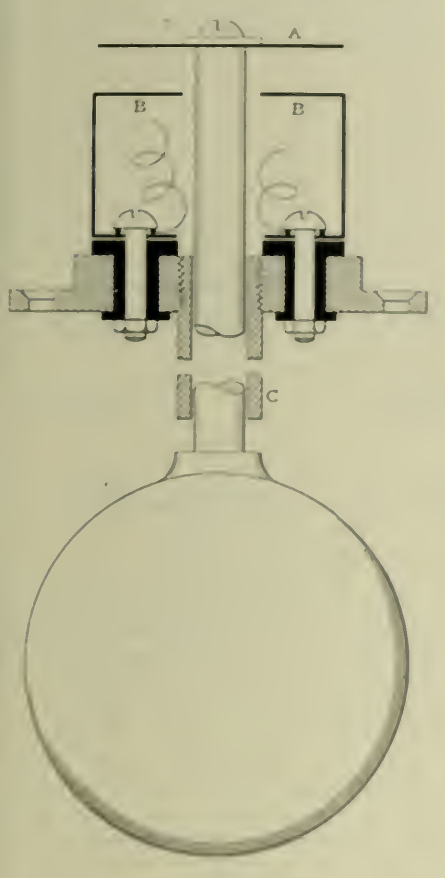


FIG. 1

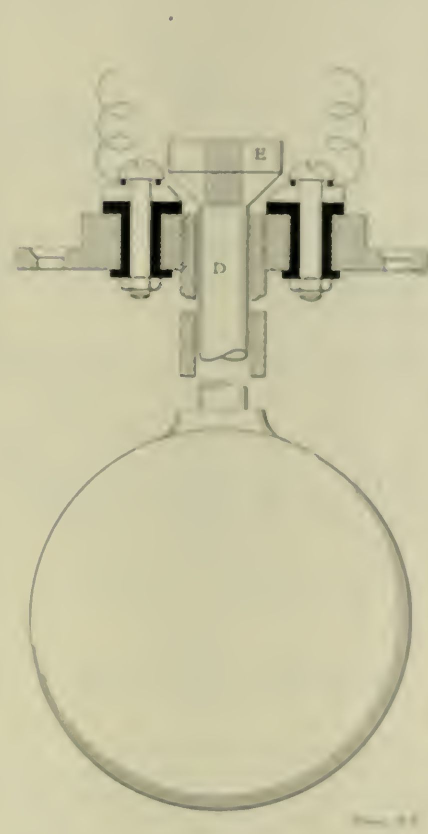


FIG. 2

alinement of the top of the springs. The guide pipe *C* was supposed to make contact probable and if one of the springs had not become bent the scheme would have worked intermittently, with fair results.

However, the design seemed so hopeless that a few changes were made, as shown in Fig. 2.

The rod *D* was threaded at the upper end and a brass cone *E* attached. The two springs *B B* were discarded and two segments of a circle were made of brass and attached to the fiber cross shown in the section in black. The action now became much more positive, as the cone *E* wedged into position and made contact with both of the segments, and there was no possibility of any of the parts getting out of order.

The scheme has given perfect satisfaction and the inspectors have since found a tank full of water on their rounds of inspection.

CURTIS C. MYERS.

Indianapolis, Ind.

Lubricants for Cylinders

In reference to John M. Sewell's article on the above subject, I should like to make a few remarks, partly as a friendly criticism and partly to enlighten his views.

A few years ago the chemist dominated the lubricating-oil trade, and oils were judged by certain physical tests made on them. The tests were usually made for gravity, flash, viscosity, acid, etc. Actual results on engines so constantly contradicted the chemists' ideas that Henry M. Wells and myself began an investigation and were fortunate in obtaining the assistance of scientifically trained men in the Manchester University engineering department, where a system of research work was carried. Some extremely interesting results were obtained.

One important factor was made clear in this research work, viz., the chemists' tests were useless in selecting a good oil or the best oil out of a number designed for any given purpose. Of course, gravity had no value at all, and when viscosity was found for high temperatures, practically all cylinder oils had the same viscosity at, say, 400 degrees Fahrenheit. At 600 degrees Fahrenheit they all became thinner than water.

The flash point also appeared a poor factor for classing oils as to quality. The flash is found under ordinary atmospheric conditions and pressure, but when an oil is placed under considerable pressure and in the presence of steam at a high temperature, conditions are changed and consequently the flash point becomes of exceedingly doubtful value. It was found, on examining oil and deposits taken from steam engines using high-pressure and superheated steam, that no cylinder oil decomposed, even at over 700 degrees Fahrenheit. This is not the place to go thoroughly into these or other factors, and they are merely mentioned to show that the chemists' ideals are not the engineers'.

In regard to Mr. Sewell's claim that pure mineral oils are best for cylinder lubrication, I believe I am correct in stating that practically all the best cylinder oils are mixed with oils that are not mineral. Pure hydrocarbon oils have had a fashion, in name at least, but I thought it had completely died out, for oil manufacturers enjoyed the joke too much. The acid bogey crops up now and then, but there are bad workmen in most trades. Further, I ventured to state that practically all mineral oils contain acid and no inconsiderable quantity of it, either. I have certainly seen more damage done by such acid than is done by badly compounded cylinder oils containing decomposed animal or vegetable fats.

In conclusion, I would point out a slight oversight on the part of Mr. Sewell, when he mentions that a gas-engine oil must have a high fire test and be a pure mineral oil. The temperatures in a gas engine are enormously higher than in a steam engine, and yet we use on the gas engine what is really only an engine-bearing oil with a flash point considerably lower than any steam-cylinder oil. A steam-cylinder oil with a high flash point would be useless on a gas engine, and the gas-engine oil with its low flash point, as compared to a steam-cylinder oil, would be useless on a steam engine. Flash point, therefore, has no influence. As regards gas-engine oil being pure mineral, it is quite possible that such oil is used, and probably successfully, in some cases, but the great majority of gas engines use a compounded oil containing other ingredients than mineral oil. Experience seems to point to the fact that such mixtures are a necessity for successful lubrication of a gas-engine cylinder.

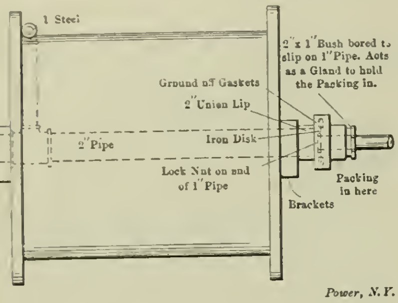
WILLIAM BARRY TAYLOR.

Boston, England.

A Hose Reel

The accompanying sketch shows the manner of constructing a hose reel. It is very convenient for keeping the hose in good shape and in running off or coiling the hose.

The reel turns on the 1-inch pipe which



HOW TO MAKE A HOSE REEL

has a stuffing-box joint between it and the union.

J. O. Benefiel.

Anderson, Ind.

Kerosene as a Scale Remover

Mr. Mellen set forth his views regarding the use of kerosene for removing scale from steam boilers. Evidently, Mr. Mellen did not go very deeply into the properties of kerosene, or he would not have assumed that the "150 degrees" on a barrel of illuminating oil implies that that is the point at which it will vaporize. If the barrel contained gasolene the "150 degrees" would mean the point at which it would vaporize, but for kerosene the vaporizing point is 338 degrees Fahrenheit and upward, so that Mr. Mellen's conclusion that kerosene in a boiler passes off in the form of vapor long before any steam is used from it is not true, unless the pressure in the boiler exceeds 100 pounds. As the pressure on the boilers in the case he had in mind was only 20 pounds, it is quite evident that the kerosene did not pass off in the form of vapor.

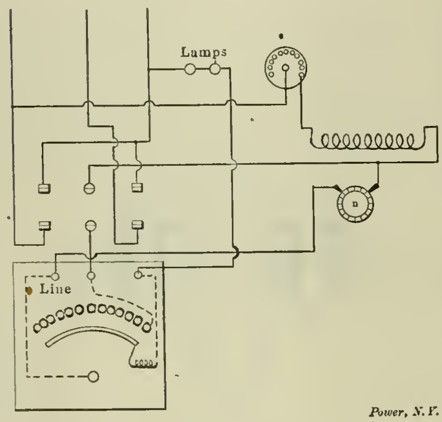
I also think that Mr. Mellen is inclined to condemn kerosene too strongly as a scale preventive. Where used with intelligence it seems to give excellent results. The first application of the oil should, if possible, be made while the boiler is idle, by inserting from 3 to 6 quarts of oil, then filling the boiler with water, heating it to the boiling point and allowing the water to stand in the boiler a week or two before removal. The oil should then be added in small quantities (2 to 4 quarts per week) when the boiler is in actual use.

W. S. Durand.

Brooklyn, N. Y.

Mr. Hull's Emergency Motor Connections

Referring to Fig. 1 of C. V. Hull's interesting article on page 763 of the April 27 number, I should like to suggest that the seriously objectionable feature of connecting his field winding directly to the line could easily be avoided by making the connections as shown in the accompanying diagram. This not only compels the operator to open the field circuit every time the armature is disconnected, but it causes the lamps to indicate which voltage the motor is running on, by burning dimly or brightly, and it eliminates one of the wires from the field winding to the main line, one terminal of



MR. MALCOLM'S DIAGRAM

the field winding being connected directly to one armature terminal on the motor, as usual.

George W. Malcolm.

Brooklyn, N. Y.

Gas Engine Back Firing

In making tests, in the works, of four-cylinder vertical gas engines considerable trouble was experienced with back-firing. This would occur at no load just the same as when the brake was on up to 100 horsepower. It did not occur on the compression stroke, as they often do, but on the suction stroke. If it had occurred on the compression stroke it would not have been heard in the air pipe; at least, not so loud, as all the valves are shut.

As the engines were only just erected, the trouble was not due to incandescent carbon deposit, but it was thought it might be due to burs on sharp corners getting red hot. Care was therefore taken to clean everything and round off the holes to the indicator cocks, etc. We started up again, but things were no better, the back-firing occurring with annoying regularity. Just then the producer was put out of commission owing to a damaged lining. We turned the town gas over to the engine and it ran as nicely as could be desired; no back-firing occurred at all.

By the time the end of the test was due the suction producer was all right, so we turned the gas on to the engine again. Back-firing occurred, however, as loud and as often as before. This showed that either the mixture or the gas was at fault. We twisted the air cocks to all positions and got a very slight improvement by more air. Next I turned off the steam a little at the producer and the improvement was considerable. I then turned it off by degrees still more, taking care that the generator did not heat up abnormally, and soon the back-firing ceased altogether.

Now, from what I have read of the theory of the production of gases, I remembered seeing it stated that there are some mixtures of oxygen with hydrogen that are explosive at comparatively low temperatures. So I think that when I turned off the steam the gas that was coming through before was modified so that these mixtures were not in it. I should, however, like to read another opinion about this. If it is so, then the hot gases remaining over from the exhaust stroke would easily light back the fresh gas when the inlet opened.

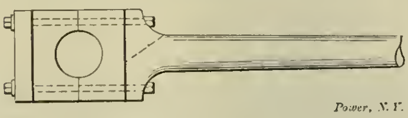
As this case cannot be unique the cure may be of use to others.

John S. Leese.

Manchester, Eng.

Cause of an Engine Wreck

One morning recently a 400-horsepower tandem compound engine, belted to a generator and running noncondensing, with full load and a gage pressure of 135 pounds, was running smoothly, when the top lug on the connecting rod next to the crank brasses broke as shown in the illustration, wrecking the engine. When the lug broke, the brasses pulled apart at the top when the engine was taking the pull, allowing the connecting rod to



CAUSE OF ENGINE WRECK

drop to the floor, after bending the lower bolt in a segment of a circle.

When the connecting rod dropped to the floor the piston hit the cylinder head of the low-pressure cylinder, cracking the low-pressure piston. The crosshead shoes were detached from the crosshead and shot out on the floor. After the load had been taken off, the flywheel and generator ran for about 25 minutes.

D. C. Chittenden.

Brantford, Ont.

Kerosene Oil in Boilers

I have taken charge of boilers which were badly coated with a hard-lime scale and have removed it very effectually by the use of kerosene. I would not, however, recommend the use of kerosene indiscriminately, for if the water to be treated carries a quantity of vegetable matter it is liable to be muddy. Other boiler solvents would be better, but a hard-lime scale that cannot be removed by other solvents can be moved by an intelligent use of kerosene. If a boiler is excessively scaled there is some danger from the use of kerosene, as it will undoubtedly find the weak places in the shell and tubes and is liable, in removing the scale, to start a leak. In order to obtain the best results it is necessary to put the kerosene into the boiler before filling it, as the oil will then float on the surface of the water, the entire surface of the shell and tubes will be covered and if there is any scale, the oil will work underneath and detach it from the iron. A practical demonstration of this can be obtained in the case of an old bolt, the nut of which, however rusty, can readily be removed after a liberal use of kerosene. The usual grade of kerosene oil will vaporize at approximately from 115 to 125 degrees, the difference being relative as to whether the vaporizing is carried on in an open or closed vessel. Taking the average point as 120 degrees, it is certain that feeding kerosene, drop by drop, into the feed water is useless, especially if a heater is placed between the feeder and the boiler, as it would be a very poor heater which would not heat the water to more than 120 degrees, and as steam at even 80 pounds pressure, absolute, would have a temperature of 292 degrees, there remains 172 degrees in excess of the vaporizing point of kerosene. So it appears that the only method of obtaining satisfactory results is by putting the oil into the empty boiler.

CHARLES H. TAYLOR.

Bridgeport, Conn.

Arranging a Water Column

A short time ago the writer had occasion to visit a fellow engineer and, while being shown through the plant, noticed a little feature that may be of interest. Everything was in order and the engines running nicely, but the water glasses on the boilers were in the wrong place, and it was necessary to keep a light hanging near them all the time. I suggested the remedy shown in the accompanying sketch.

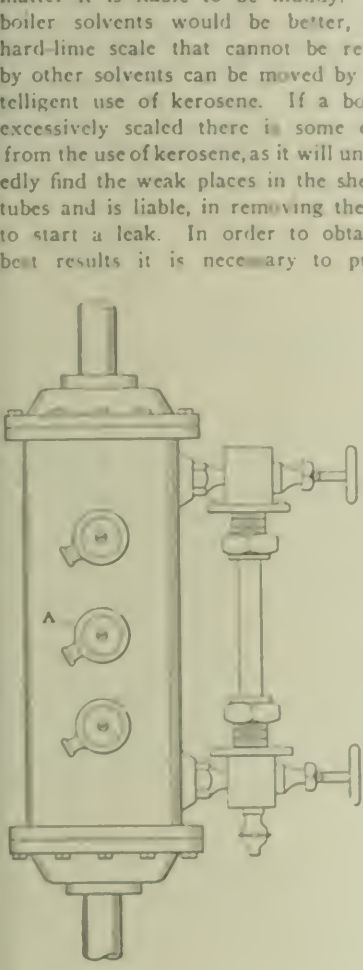


FIG. 1

FIG. 2

In Fig. 1, the water column is shown with the try cocks in front at A, also the water glass, which could not be seen at a short distance from the column to the left. Fig. 2 shows the same water column turned one-quarter around to the left, bringing the glass to the front, but putting the try cocks B too close to the breeching door of the boiler. By disconnecting the water column from the piping and turning it upside down, it changed the position of the try cocks shown at B to that shown by the dotted lines, at C. It will be noticed that they are in an inverted position. They were given one-half turn each, which put them in the correct position. In making this change it was necessary to transfer the water-glass shut-off valves so as to have the gage valve J at the bottom.

C. W. DUNLAP.

Depew, N. Y.

Increase of Salary

In answer to the question propounded by Mr. Mitchell, I should most certainly ask for an increase of salary, as the employer shows by his actions that he will not give it until asked. My way would be to show him where and how I had saved him money and then ask him if I was not entitled to at least part of the amount I had saved him. If he were the right sort of a man he would grant it; if not, there is only one way to do, and that is to look for another situation where your work will be better appreciated, and when secured, leave in a square and fair way. The only argument one can use with some employers is more pay or a new man, but I do not believe in the use of it until peaceful persuasion has failed.

It is a hard matter to decide this question when all the facts are not known, but it looks to me from those given, that if the company mentioned could pay its former engineer $15 per week the present one under the circumstances ought to get that amount, or more, without asking for it.

There are a large number of employers who know very little about a steam plant or what is going on there, and as long as the wheels keep turning and the bills for fuel, supplies and repairs are not too high, will never give it a thought. This class of employer will not give an increase of salary unless it is brought to his notice with good, strong arguments and facts. I take it from the information given that the engineer has kept a record of his plant and knows somewhere near the cost of operation, and if so he has one good, strong, convincing argument in his own hands.

Most employers, if approached in the right way and the matter is put up to them in a business-like manner, will meet you more than half way and will either grant your request or give good reasons for not doing so, in such a way that there will be no hard feelings. But walking into a man's office and informing him that "I have saved you so much money, or, the plant has cost you less money to run under my charge than under my predecessor, and I want the same or more salary than he got, or you can get another engineer tomorrow morning," is not the right way to go about it, and will lead to hard feelings and cost you your situation.

Present the facts of the case as you see them, give him to understand that you think it is right you should get an increase, and also that there will be no hard feelings, only disappointment, if you do not get it, and then you will know the road open for a second attack if needed. Use diplomacy, for it pays in the end.

W. E. Sargent.

Franklin, Mass.

I should say that the engineer referred to certainly had the right idea about "showing his employers by his work that he was worth all they could afford to pay," but unfortunately he was the right man in the wrong place, as he was receiving $200 per year less than a former man, while saving his employer $2400 per year in expenses.

Few employers are willing to increase a man's pay voluntarily, however good he may be, but let him hang on as long as he will, and when he tires of the conditions under which he is working, and desires to leave, he is told that he is a good fellow, along with a lot of other "gush," and perhaps if he can be persuaded to stay, a little "satisfier" is attached to the pay check, and he blushes when he gets it. He is a good fellow, though, and he stays. It seems to me that the man who really knows and does things is the man who gets the little plum, although we desire to believe the reverse.

Some time ago an engineer was told by the superintendent that since he had taken charge "things had been going 100 per cent. better;" but a short time afterward, when this same good engineer asked for an increase in salary, he was told that there was no chance for any raise. This engineer was making a good saving, but he didn't get any of it.

If a man can better conditions or save his employer dollars, I see no reason why he is not entitled to a portion of the saving, and if he cannot get it without the asking, he should ask. He will be turned down enough at that. My experience has been that I never get what I do not ask for.

Some large manufacturers give their employees a portion of what they save the concern. This is based on the premium system, but the giving of a portion saved could be carried to practically every department where capital and labor meet.

Yes, ask for more salary if you conscientiously think you deserve it, and know the reason why, even if you do not get it. Hold up for your just dues, for no one respects a weakling. The good man too oft gets the flowers after he is gone

L. Earle Brown.

Ensley, Ala.

The question of requesting an increase in salary seems to me to be one not rightly classified by the word "proper." An engineer, or anyone else, in fact, is employed on the basis of his being able to produce results. If he can do this, his employment may be considered "proper," if you please, but there is no real significance in such a designation.

In the case of the engineer who had shown an operating saving of $50 per week over his predecessor, there should not only be no hesitancy in his asserting his right to an increase of salary, or an amount at least equal to that of the other engineer, but rather he should receive an even better salary than the other engineer, in proportion to the increased savings. The employer who does not appreciate an engineer who can save $50 per week over the operating cost which obtained previous to his taking hold will never give an increase unless it be asked for, and probably then only when he sees that he cannot otherwise hold the engineer. Again, an operative who can show such saving does not have to work at a lower salary than one who cannot, and if his salary does not increase as a natural result, it will be increased by someone else. Wide-awake employers are on the lookout for efficient engineers.

It is a modest principle not to ask for an increase of salary, but a dollar is a dollar, and the man who does not sell his labor at its highest market value, but conscientiously keeps quiet and wonders why his employer does not raise his salary, may be a long time waiting. The employer who wants real live men is not hunting cheap ones.

F. E. Lister.

Brooklyn, N. Y.

As a rule, a man will always work for the same wages he started out at, if he does not ask for more. I have always made it a point to earn more for the employer than I was receiving in wages, and I have gained my point, as I have never been refused a raise when I asked for it. I think before a man asks for an increase in salary he should consider very closely whether he is worth enough to his employer to warrant the raise. No man with ordinary intelligence can work at the same business any length of time without being worth more to his employer.

Employers will hire just as cheaply as possible, no matter what you are worth to them. I think it every man's duty to himself and family to ask for a salary to the extent of their actual worth to their employer, and if the employer does not then concede to what the employee asks, the employee should be prepared to quit his job and go where he can get what he is worth. Most employers know pretty nearly what you are worth to them after you have worked for them awhile.

The most important point is, to be sure that you are fully worth to your employer what you are asking for, and if you get the raise, bend every energy to make good and prove to him that it is a good thing for him that he conceded to your wishes.

Monroe Johnson.

Emmetsburg, Iowa.

I should say that the engineer has good grounds to ask and expect to receive pay even greater than the former engineer had been getting. I think it is a mean business to pay less to a good engineer who does better work than the former engineer.

Edward Anderson.

Stevensville, Mont.

By all means ask for an increase in salary. The average engineer piles up fortunes for men who never toil at productive labor, and yet imagines he is in duty bound to work for just what salary his boss may choose to give him. Try to get an increase in salary, and lay it aside, for the day will surely come when the "boss" will say: "I don't need you any more, you are too old."

J. F. Carman.

Astoria, L. I.

Exhaust Release Valves

Is there a Corliss valve gear which releases the exhaust valves from the control of the eccentric? If not, would there be any gain, instead of connecting the exhaust-valve rods directly to the crank, by connecting them to the dashpots by a bell crank and rod, similar to the way the admission valves are connected, with a fixed trip that will detach the hook after the valve has come to the end of its travel, and immediately upon the release of the exhaust valve, the dashpot would bring the valve back to its open position, thereby getting quicker release later in the stroke than is practicable without the release?

Would the small gain in efficiency be offset by the increased first cost and maintenance? I should think that in a large slow-speed Corliss engine these few extra complications would be offset by the increased efficiency.

W. A. Fullgraf.

Ottumwa, Ia.

What Knocked the Cylinder Head Out?

Under the heading "What Knocked the Cylinder Head Out?" W. A. Hamlin reports in the January 19 number, page 168, an accident to an Atlas automatic engine and gives as the probable cause the catching of the "outer" piston ring in the head-end counterbore of the cylinder.

I wish to take exception to this diagnosis of the case, as the design of the piston and cylinder make it untenable, as I will show.

Mr. Hamlin says that the packing rings consisted of three sections, and according to that the piston must be 11 inches or less in diameter, as larger piston rings have four sections. These small pistons f the Atlas make have only one packing ng, ¾ inch wide, and Mr. Hamlin's eference to the "outer rings" must therefore be taken as the outside, that is, head nd lap or tongue of a ring section.

The sections of the ring are arranged s shown in Figs. 1 and 2. There are no rass bushings, but radial holes are drilled to the piston head to receive the spiral rings and brass keepers. To hold the ston ring below the surface of the pisn head, while the piston is being entered to the cylinder, ¼-inch holes are drilled r retaining pins, going through the head d flange, the center of the ring section, d ending in the crank end flange of the

FIG. 1

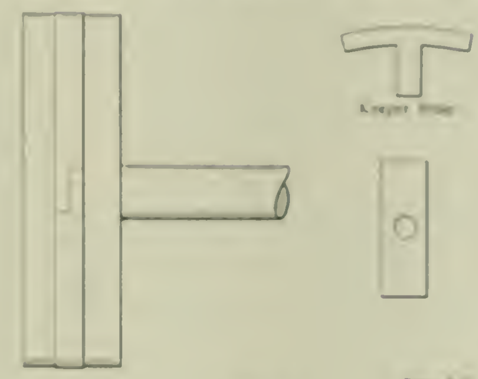


FIG. 2

ston head. These pins are removed hen the piston is in place to allow the g to bear against the cylinder bore. he ring is kept from turning by small ns, which are driven into the inside face the ring sections and engage the epers.

Suppose the ring is placed so that the epers are in the centers of the sections, Mr. Hamlin states, then the length of e keepers, viz., 2 inches, and their being ld in a radial position would prevent e sections from rocking. The distance tween the inside edges of the two counterbores is ⅛ inch more than the stroke the engine, and a ¼-inch ring can avel only 3/16 inch over the edge of the unterbore on each end, making it impossible for the ⅛-inch tongues of the ng sections to catch, however the ring ight have been placed.

Mr. Hamlin says that the velocity of the wheel pulled the wrist strap apart, rrying the crank and connecting rod ound, the connecting rod striking the osshead, knocking it through the crankd cylinder head and piston through the ad-end cylinder head.

I think the steam sent the disconnected osshead and piston much faster and with ore force through the cylinder than the nnecting rod could. The inertia governor certainly gave full steam as soon as e disconnected shaft slowed down, but e connecting rod, besides being too short ithout a strap, was much too slow to do

There must have been another cause of the accident. A liberal dose of water is the nearest I can think of.

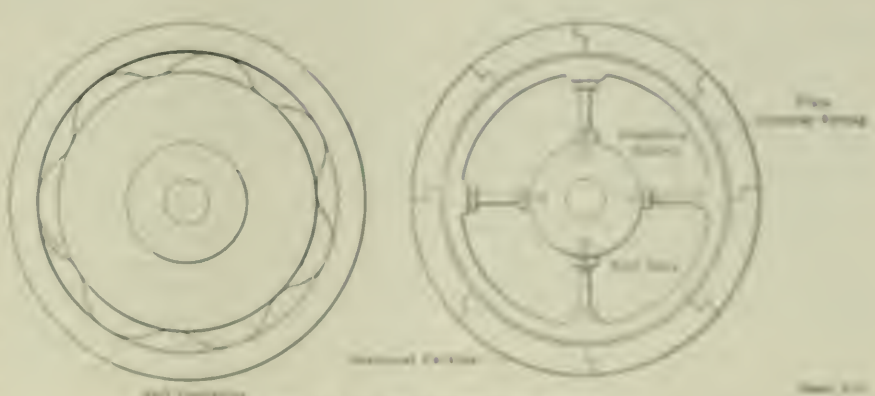
H. Wiebaker.

Indianapolis, Ind.

Self Centering Pistons

I recently had an experience with a salesman who was introducing what was claimed to be a self-centering piston, for which great claims were made regarding the economical use of steam; in some particular cases as high as 10 per cent. was guaranteed.

This piston appeared to be nothing more or less than one of the old types with the packing rings somewhat revised, the idea being that the piston was centered and the rings held to the walls of the cylinder by means of a crimped spring extending around the bull ring and underneath the packing rings, as shown.



DETAILS OF SELF-CENTERING PISTON

While this method may hold the packing rings out to the walls of the cylinder it appeared to be far from a self-centering piston, owing to the fact that the spring at the bottom was compelled to carry the entire weight of the piston. This weight undoubtedly compressed the spring, thereby allowing the piston to fall so that it was not exactly centered, and it also would allow the piston to lift up and down at each stroke, possibly not to any great extent at first, but pistons that are running in this condition very rapidly wear and conditions become worse.

A short time ago I had an experience with one of these so-called self-centering steam-expansion kind of pistons, in which the rings were let out by the steam pressure. While this method may work quite successfully when first installed, it very soon becomes otherwise. In this case the steam was admitted to the under side of the rings, thus forcing them to the under side of the cylinder.

If the load is always kept the same and the cutoff at one particular point, it might work, but suppose that after six months or a year of running the load should be decreased, this would make an earlier cutoff, and as the cylinder had become worn larger on each end, owing to the action of the steam, the result would be a serious leakage. When the cutoff was at one particular point the rings were subjected to the full pressure of the steam until this point of cutoff was reached. After this point had been passed the rings were simply held to the walls of the cylinder by the expansion of the steam which was rapidly becoming less as the end of the stroke was neared. This inequality of pressure resulted in the wear of each end of the cylinder becoming larger, and as no provision had been made for centering the piston it necessarily was down on the bottom all the time. Of course this wear in effects also allowed the piston rod to ride on the bottom side of the packing in the stuffing box, thus destroying it, causing frequent packing.

It also caused a poorly running crosshead, as when the piston is out of center, and in some cases I have known it to be as much as 3/16 inch low. In such a case it is impossible to insure a good running crosshead, owing to the fact that the rod is continually out of line, and any attempt at these adjustments must inevitably result disastrously to the crosshead or the guides.

A good sectional packing with facilities for adjustment, combined with a good intelligent engineer, are to my mind the best combination obtainable.

Charles H. Taylor.

Bridgeport, Conn.

Will the Load on the Bolts Change?

In the March 30 number, page 609, G. A. Glick submits a problem entitled: "Will the Load on the Bolts Change?" Mr. Glick's Figs. 1 and 2 are reproduced here. Fig. 1 represents a steam cylinder and cover having no gasket between them, the joint being ground and made up metal to metal. Fig. 2 represents the same cylinder and cover, the joint being made up with a gasket between the two faces, as shown.

The area of each cylinder is 120 square inches and each cylinder cover is fastened on by 12 stud bolts and nuts. Each nut is screwed down tight, until each of the 12 studs is under an initial tension of 1000 pounds.

The question asked is this: If steam is admitted to the cylinder under a pressure of 100 pounds per square inch, will the tension in the stud bolts in either case increase, decrease or remain the same? And in each case what is the total tension in pounds on each stud due both to screwing up the nuts and to the internal fluid pressure in the cylinder?

From the foregoing we get: Number of bolts times the tension in each bolt equals

$$12 \times 1000 = 12,000$$

pounds, which equals the total tension in the 12 bolts, or the pressure tending to close the joint.

In Fig. 1 this 12,000 pounds represents the total compression on the metal at both faces of the joint, and in Fig. 2 the compression on the gasket between the two faces.

The total internal fluid pressure in the cylinder tending to open the joint in each case will be the area of the cylinder times the pressure per square inch, which equals

$$120 \times 100 = 12,000$$

pounds.

Some engineers are of opinion that when the pressure is in the cylinder the bolts are stretched to an extent sufficient to relieve the compression in the gasket or packing, thus relieving the bolts of the initial tension caused by the elastic thrust of the gasket against the two faces of the joint when screwing down the nuts.

Where rubber or any elastic gasket or packing is used between the flanges to make a tight joint, the gasket is compressed or flattened to some extent and the bolts may or may not be elongated or stretched, depending on their rigidity and the tension in each bolt when tightening up.

Any farther extension or elongation of the bolts due to the internal fluid pressure may not affect the initial tension to any great extent, as the pressure within the cylinder may not be great enough to cause an extension or elongation in each bolt sufficient to relieve the compression in the gasket; or, in other words, if the extension of the bolts due to the internal fluid pressure is small compared with the compression of the gasket, the ultimate load on each bolt may approach the following value, namely: The initial tension due to screwing up plus the tension caused by the internal fluid pressure in the cylinder.

In Fig. 2 a tension of 1000 pounds is produced in each bolt by screwing up. When steam at 100 pounds pressure per square inch is turned into the cylinder an additional load of

$$\frac{120 \times 100}{12} = 1000$$

pounds is produced in each bolt (the area of the cylinder being 120 square inches and there being 12 bolts).

The total or ultimate tension in each bolt is, then, somewhere in the neighborhood of

$$2 \times 1000 = 2000$$

pounds, provided, of course, that each

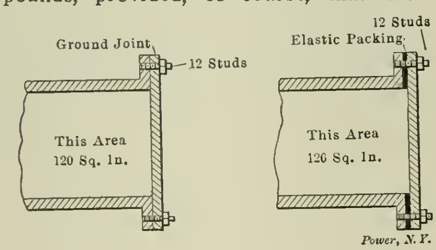


FIG. 1 FIG. 2
(Reproduced)

bolt does not stretch sufficiently under the pressure in the cylinder to relieve part or all of the outward elastic thrust of the gasket, or, as it is called, the compression of the gasket.

If, however, in the case cited the extension of each bolt diminishes in part the compression in the gasket, the exact ultimate load per bolt cannot be determined without first knowing the exact outward thrust in pounds exerted by the gasket at the time the pressure is in the cylinder.

This, it seems, would be a very hard matter to determine with any degree of accuracy. Then, again, it is reasonable to assume that most gaskets after having been subjected to high compression and heat for any length of time would attain a permanent set, thus necessitating the going over and tightening up of the nuts several times after renewing a gasket, in order to keep the joint tight against the internal pressure. This is absolutely necessary at times, until the gasket becomes permanently set, and at first thought may give rise to the idea that the pressure within the cylinder has caused a permanent set in the bolts or studs, when in reality the gasket is at fault.

Where rigid flanges are bolted together metal-to-metal, using no gasket, as in Fig. 1, the conditions are somewhat different.

In this case it is very probable that any slight extension of the bolts due to the pressure within the cylinder would relieve the initial tension due to screwing up, and the ultimate load per bolt would be either the tension due to screwing up, or the tension produced by the internal steam pressure, according as the former or the latter is greater. In Fig. 1 these forces are equal, therefore the ultimate load per bolt should be in the neighborhood of 1000 pounds, provided the internal fluid pressure causes a slight extension of the bolts relieving the initial tension.

Any additional pressure in the cylinder over and above 100 pounds per square inch would thus add to the tension in the bolts.

Where the connecting flanges are deflected by the bolts the case would be similar to Fig. 2, where a gasket is used between the faces of the parts to be connected, the deflection of the flanges acting in a manner similar to the compression in the gasket, exerting an outward thrust against the bolts.

In any case, to determine to just what extent the bolts are strained in each of the foregoing cases, the relative rigidity of the bolts and the parts they connect must be known, as well as the elasticity of the gasket or packing.

William F. Fischer.

New York City.

Worn Dashpot Repair

The dashpot on the low-pressure sid of one of our engines was badly wor and would pound when the receiver pres sure changed. I persuaded the chief t let me send it to a local machine shop along with Mr. Ferguson's sketch, whic was published in a recent number. H gave me permission, provided I paid th bill if it did not work. In a week i came back, with what looked to be a goo job. I connected it up and started th engine. The noise was bad before, but i was a hundred times worse with the ne ring. When the valve was opening th plunger would grind and chatter an when unhooked the plunger would nc drop until it was forced down by the clo ing shoulder.

I took out the ring and filed the shar edge off the top. That helped some, b letting down a little oil, but it would n close the valve, no matter how the a valve was regulated, and as it pounde so that I was afraid I might have to pa for a new jim-crank lever, I took it ou

The chief ordered a new plunger. came and we fitted it, and everything we nicely. The laugh is on me, as I had pay $2.80 more for the repair than t new plunger cost. I am a little poor but a whole lot wiser.

Thomas Sheehan.

Pittsfield, Mass.

Setting the Slide Valve

Every engineer believes he knows how set the simple slide valve, but few can ll at what point of the stroke the exhaust opens or closes. I have found many ide-valve engines using more steam than ey should, although in each case the lve was set by the stereotyped rule of: Place the engine on one of its dead cenrs with the eccentric rolled 90 degrees advance of the crank and enough rther to get the required lead. Then roll e engine over to the other center and if e lead is the same the valve is properly t." Easy, isn't it? We are often told at it is not practical to advance the centric to obtain a cutoff earlier than or ¾ stroke, on account of the excesve compression.

It is the writer's experience that the ily way to set the slide valve properly r highest economy is to remove the lve from the steam chest and, taking a nall try square, place one leg of the uare on the valve seat near the edge of ch port, in turn, and draw a mark forard on the bottom side of the steam est with a sharp scribe, so that the exact sition of the ports can be seen after the lve is back in position. Before putting e valve back in position, however, take e try square and, beginning with the ce of the valve, square around to the ck, making marks so that the position the edges of the hollow steam passage in be seen when the valve is in position.

Next give the valve, say, ⅛ inch lead, ith the engine on one center, and then rn to the other center, when if the lead the same the eccentric rod and valve em are of the proper length. After aking a mark on the crosshead, roll the igine in the direction it is to run and by oking at the marks in the steam chest id on the back of the valve it is easy to ll the exact point of exhaust closing id opening. By marking the slide where ie mark on the crosshead stands when ie exhaust is just closed, and turning the igine over on the return stroke, and aking another mark on the slide when ie exhaust is just shut, one can tell by easurement if the compression is equal.

The eccentric should be set with as uch regard to the exhaust opening and osing as to the outside lead. The writer as greatly improved the economy of veral slide-valve engines by cutting out me of the excessive inside lap. It is not hard thing to do and can be done best a milling machine or planer, although can be done with a common chipping hisel. Care should be taken not to take ut too much at a time if the engine is to e run condensing, as a condensing enine should have an earlier exhaust closre than a noncondensing engine.

C. E. Barrow

Readsboro, Vt.

Cost of Treating Boiler Feed Water

I wish to make a tardy correction of an error of mine in connection with an article that appeared in the number of March 23 on "Proper Treatment of Boiler Feed Water," page 555, column 1. The cost of treatment for 70,000 gallons, instead of 1000 gallons, at the present market price of lime and soda ash is 66.5 cents. This would make the cost per 1000 gallons 0.95 cent, which is more reasonable. Our tanks are of 70,000 gallons capacity and I neglected to reduce the cost to the 1000-gallon unit in spite of the fact that I was reminded that the cost of treatment was excessive.

A. J. Boardman

Indianapolis, Ind.

Boiler Efficiency

The letter of A. Bement, in the issue of March 16, shows that he uses the term "boiler efficiency" in a different sense than it has been used by all the authorities on steam boilers for the past forty years, and in a sense that is not in harmony with the meaning of the word "efficiency" as applied to other things than boilers. The general meaning of the word is a fraction denoting "output divided by input," and generally it is not so much a function of a machine itself as of the conditions under which it is used. It is therefore not a constant quantity for any particular machine, but a variable quantity. Thus in a centrifugal pump working under different heads, it ranges from zero, when the head is too great for the pump to overcome the static resistance, up to possibly 75 per cent., when the head is something less, and down to zero again when the head is zero, the variation of efficiency being represented by a curve. In an electric generator the efficiency also varies with the load.

In a steam boiler the efficiency is zero when the rate of combustion of coal is sufficient to provide only for the loss by radiation; it rises to a maximum when the rate of driving is in the neighborhood of three pounds of water evaporated per square foot of heating surface per hour, and usually falls off rapidly when the rate is above four pounds.

Mr. Bement says "the efficiency of a boiler as a heat absorber cannot be altered without changing the design of the apparatus." If he will consult the records of the tests of 13 boilers at the Centennial exhibition in 1876 he will see that a change in the rate of driving changed the efficiency in every case. In Donkin and Kennedy's book on boiler tests he will find vast differences in the efficiency of one shape of boiler, viz., the Lancashire. The efficiency of a boiler is not a constant depending on the design, but a variable depending on the quality of the coal, on the method of firing, on the rate of driving, on the air supply per pound of carbon and on the loss by radiation. The Geological Survey is, therefore, perfectly right in its use of the term "efficiency."

W. Kent

Sandusky, Ohio.

Bridgewalls in Theory and Practice

In the March 9 number, W. H. Wakeman has an article about bridgewalls in theory and practice. In my opinion the bridgewall, no matter how constructed, cannot prevent smoke or hot gases from going up the stack. As to smoke formation, much depends on how coal is fired and how it is worked after it has started to coke.

The way I fire my boilers produces the least work, very little smoke at any time and an even steam pressure, simply because I never put on green coal with low steam. If the steam gets down I use the bar or a three-pronged hoe and break the fire up, which will soon bring up the steam. Then I lightly cover the fire with green coal. I never use the hoe or slice bar on a green-coal fire.

If a fireman or an engineer wants to make as little smoke as possible, he should not disturb a thick fire of green coal.

William Murray

Philadelphia, Penn.

State Supervision of Boilers

The editorial in the March 2 number on State supervision of boilers treats both sides of the question in a very impartial manner, but one in my place would have leaned just a little toward the manufacturer's contention.

We got a new boiler, and it was needed the "worst way." After it was set up and connected to the main, as per law, that is, with a gate and a globe valve between the main steam pipe and the boiler, we were all ready to start it, when along came the State inspector and condemned one of the valves, because it was not of the outside-screw-and-yoke pattern.

We have the same valve on all the other boilers. It is an automatic stop valve and has always given satisfaction. The company that made this valve did not make one with the outside screw and yoke, but it is making them now, and our new boiler had to lay cold until it got one made.

Now the point is: was the original valve detrimental to the boiler's safety? If so, why don't the inspector make us change all the rest?

Perhaps there is something against the outside-screw valve that I know nothing about, but any information on the subject will be gladly received.

Thomas Griffin

Pittsfield, Mass.

Some Useful Lessons of Limewater

Chemistry of Lime Further Studied by Experiments with Shavings, the Flame of a Candle and with Gasolene, and by Making Acetylene

BY CHARLES S. PALMER

In the last lesson we laid out some work on the chemistry of carbon, and now we will get busy and put some life and meaning into the dead bones of the table, by the simple device of making a few tests that we can see and handle. You remember that the table began with the hydrogen compounds of carbon, on the left and "reduced" extreme, going from the various hydrocarbons through carbon itself; and so on to carbon one-oxide ("monoxide") and, finally, to carbon two-oxide (dioxide), carbonic-acid gas or carbonic anhydride, at the extreme right or "oxidized" end of the table. The typical hydrocarbon to study is methane or "marsh gas," CH_4, and it is a pity that there is no simple and handy method of making this thing in the pure form; but you can get so near it that the difference need cause little worry.

The name "marsh gas" means just what it says. Now that you stop to think of it, you will recall that you have often seen much queer bubbling on the surface of ponds where last year's vegetation is rotting at the bottom. If you should take the trouble to go to such a pond armed with a common fruit jar and a few matches, you could easily stir up some of this gas from the bottom of the pond with a stick; and, if you should collect some of the bubbles in your jar, by the simple trick of displacement in the jar full of water and mouth downward, using the pond as a large pneumatic trough, just as you collected the oxygen and hydrogen as shown in the earlier lessons, if you should do this, you would undoubtedly get a gas which would burn with a faint and almost colorless flame, but with much heat. The gas so collected, and so burnt, is mostly methane or marsh gas, CH_4; and, if you should happen to take along with you a small bottle of filtered limewater, you could pour some of it into the jar, after burning some of the marsh gas, and you would note the white precipitation of your old friend, plain carbonate of calcium, which would tell you that the burnable gas from the pond is something that contains some carbon, just as the formula says, CH_4; that is, the gas is not pure hydrogen, but also contains some carbon, because it gives, on burning, carbon two-oxide (dioxide), the oxidized extreme of carbon. Now, it is interesting to know that when you find a gas that burns with an almost colorless flame, it probably contains some hydrogen, just as marsh gas does, and, just as its formula (CH_4, i.e., C-H-4) says that it does, four atoms of hydrogen. Incidentally, it is interesting to note that this marsh gas or methane contains in each molecule, or in a definite volume, say a pint, more hydrogen than pure hydrogen, H_2 (H-2), does itself.

We have already noted that the carbon-hydrogen compounds, or the "hydrocarbons," are so many that their systematic study is almost beyond the grasp of the beginner; but we can get this one fine clue and guide to them, that is, that in their first acquaintance they are all very much alike in being able to burn. Furthermore, they all tend to burn to carbon dioxide (two-oxide), and this last gas can always be tested by limewater, giving the plain white carbonate of lime. So we will turn at once to several ways of getting and studying these hydrocarbons.

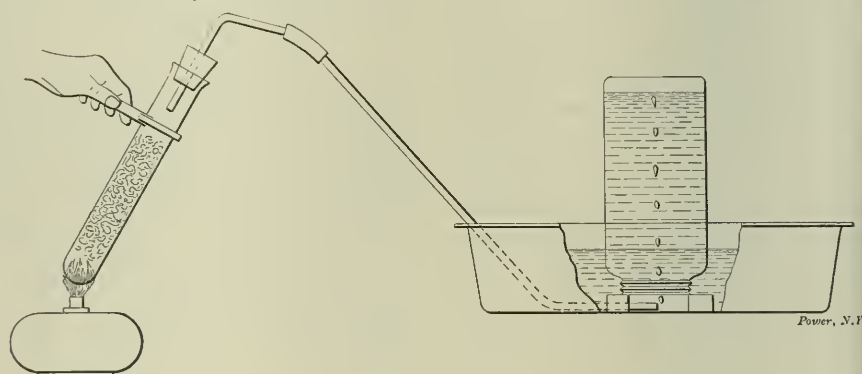


FIG. I

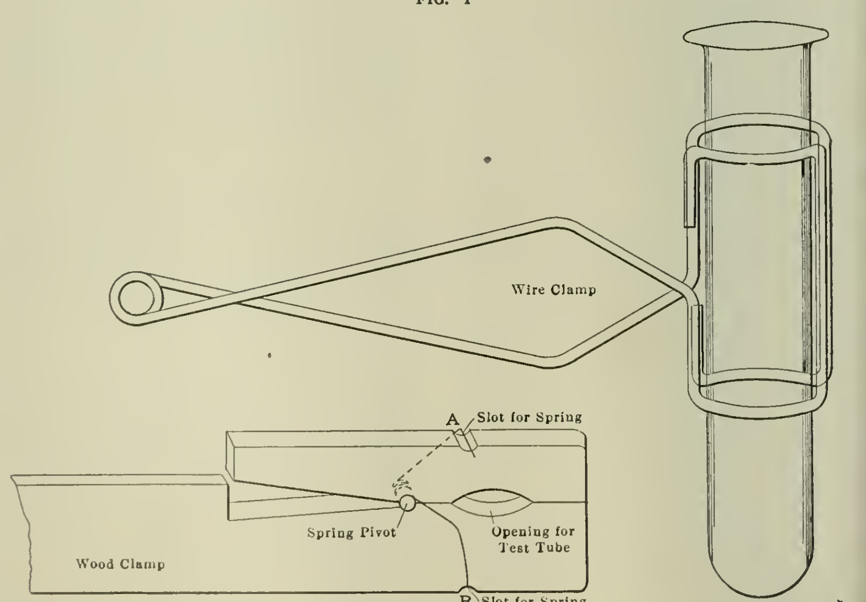


FIG. 2

Getting Gas from Shavings

Suppose that we start with some common wood shavings. Prepare the apparatus shown in Fig. 1. This consists of a common test tube fitted with a cork and a delivery tube leading over to the bottom of your pneumatic trough, with its jar filled with water and inverted, to catch the gas that will come over. Fill the lower three-fourths of the test tube with soft-wood shavings, packed moderately tight. Heat the test tube over any handy source of heat, such as an alcohol lamp, or even over a common lamp—for in this rather dirty experiment, you will not worry if the outside of the bottom of the test tube should get sooty. You can hold the test tube, while heating it, by simple wire or wood clamps, Fig. 2, or you can hold it by a strip of paper, as shown in Fig. 1. If you use the paper clamp or holder, you will naturally grip the test tube at the upper end, for you are going to heat the tube hot enough to get off some wood gas, and the bottom of the tube will naturally get quite hot. Some of this heat will come to the top of the test tube, of course, for it has to pass over, through the delivery tube, to the pneumatic trough.

In this experiment, you do not have to throw away any gas at the start, as you did in making hydrogen, because in this case the amount of air in the whole test tube is so small in comparison with what is to be given off by heating the wood that you can collect every bit of what comes over. But be sure and remember, in this and in every similar experiment where you lead gas off from a hot tube, to *take the delivery tube out of the water before you take the flame from the hot test tube, or before you take the hot test tube away from the flame*, so that the water will not be sucked back to the hot tube by the natural cooling of the hot gas inside. Natural gumption will tell you how to work the experiment, always noting that time is an important factor, and that some things will work in 10 or 15 minutes that might not work in the same number of seconds.

As you heat the tube of shavings, as shown in Fig. 1, about the first thing that you will note is the collection of water from the charring of the shavings. Some of this water will go over through the delivery tube and if it makes the common "water hammer" of condensing steam, you will not be frightened at that, it could not very well do anything else. You will also note the gradual charring of the wood, and pretty soon some gas will begin to collect in the inverted jar in the pneumatic trough. Now, all of this gas is not marsh gas, but enough of it is, and the rest of it is so closely related by birth to marsh gas, that you can think of all of it as being a mixture of several things much like marsh gas. You will also want to note the considerable quantity of water which collects at various parts of the apparatus, testing for it by a test that I will note later. You will also want to save the test tube of charred shavings, to examine it later for the strong acid reaction that it will probably show.

By this time you will have collected quite a jar of the gas from the heated shavings. If the wood is all charred before the jar gets full, remove the delivery tube from the water, take another test tube of shavings, and go on as with the first until you do get a full jar of gas. This gas you will remove from the pneumatic trough, with a card covering the jar and holding it mouth downward, just as you did in the case of the hydrogen. You will burn the gas, noting that it burns in the air, but that the splinter itself is put out in the jar of gas. You will also note the test for limewater at the end of the burning of the gas. The gas will probably not work the "cannon" test, with the small pursuy jar, as in the case of hydrogen, very well, because it is not all hydrogen, nor even all marsh gas, but contains some heavier gases, like ethane, and other things heavier than hydrogen, and perhaps heavier than the air. But collect enough of this wood gas to get at some of its main points. Of course, you

FIGS. 3 AND 4

could make some gas from coal, the yellow bituminous or cannel coal, and there you will have your trials and your surprises, too, so you cannot help learning something. In all these cases you will get some tar, some creosote, and perhaps some acid, as in the case of the wood (acetic acid, or "wood vinegar"). You may also get the odor, at least, of wood alcohol.

THE WONDERS IN A CANDLE FLAME

The next step is to study the candle and here I wish that every reader of POWER could get that matchless sound, clear and sensible book of Faraday's, "The Chemistry of a Candle," and read it. Indeed, it would be worth your while to buy a copy for yourself and put it in your own private library of chemistry. That little book tells you how to study the candle flame; how to examine the different parts of a flame; how to dissect the flame; and how to test the different parts separately. But you can do these things even without the book. First, you want to look at the flame of a common candle. You want to draw the flame, noting its several parts, as shown in Fig. 3.

You will soon see that a candle is a miniature gas factory; that the wick is the retort, where the candle stuff is distilled into gas by the heat of the flame. You will note the elegant and simple way in which the wick melts a little pool of oil about the lower part of itself to furnish itself with a continuous supply. You will also note the neat way in which the candle wick is braided so that, as it burns away, the top curls over to one side, perhaps so well that it does not have to be "snuffed," but burns off its own top. You will note that the top and sides of the wick are surrounded by a small reservoir of unburnt gas, which passes upward and outward to the air to be burnt.

You will also note the strong contrast between the colors of the different parts of the flame. At the bottom and sides of the flame you will see a bluish tint, where the gas, carbon monoxide (one-oxide), is burning, with the hydrogen. You will also note that the excess of carbon (and in such flames there is a great excess of carbon, compared with the available amount of oxygen at hand in the surrounding air) gets left in the first grab for the oxygen, and it has to wait until it gets to the top and outside parts of the flame before it can find its supply to go over to its destiny, carbon monoxide, and then carbon dioxide.

You can show that there is this central part of cool and unburnt gas about the wick of the candle, by holding a piece of common white paper right down flat onto the flame for a moment, when you will get a black ring of charred paper, where the hot outside ring of the flame attacked the paper. The untouched and still white center inside of the black ring on the paper is proof that this cool central reservoir of unburnt gas is there. But, more than this, you can take a short bit of fine glass tubing, as shown in Fig. 4, and actually pipe off some of it, burning it at the top of the glass tube by lighting it with a match or splinter. This gas in the core of the candle flame is worth some time and study, for it holds some secrets of flame that you want to know about.

If you get some of the old-fashioned candles, those that are made from tallow, the kind that smell dreadfully when put out and which smolder for some minutes after the flame is extinguished, you can perform some "stunts" worth doing. For instance, you can not only pipe off this central gas from the core of the flame, and burn it, but you can also see the core of gas and burn it in the open. To do this, let the tallow candle get to burning well and blow it out, noting the stream of unburnt gas which persists in coming off long after the flame has gone out. Now, if you do this in a room where the air is still, so that this current of unburnt gas from the tallow candle is not thrown about but ascends in a quiet, even column of gas, smoky gas that you can see, you can light this column of gas at the top with a burning splinter and the flame will run down the ascending column of gas to the wick, actually re-igniting the extinguished candle. If you have a real tough sample of the genuine old-fashioned candle, so that the ascending column of unburnt gas is so thick that it can be almost cut with a knife, you can make the flame run down as far as several inches from the wick. I have seen the flame run down 4 or 5 inches, and once or twice I have seen candles with such heavy tallow that in a quiet room the flame will run down to the wick as far as 10 or 12 inches. This statement looks like a fish story; but try it and give the tallow candle a chance to see what it can do. The books may try to decry the reality and genuineness of the experiment, and they may say that the column of ascending gas is not pure gas, that it contains much liquid and solid matter in "suspension" in the current of unburnt gas. All that may be; but at the same time, the "fat" column of unburnt gas from the tallow candle may represent very well some of the conditions found in actual experience, where flames seem to travel vast distances, i.e., relatively vast, along gases which are only waiting to be lighted to get in their work.

But there is another side to the study of the candle flame which we must note: The inside of the flame is full of unburnt gas, waiting to seize hold of any oxygen that may be available; hence this part, the inside and the lower parts of the flame, is called the "reducing" flame, because it wants oxygen, and will have it if it is given half a chance. But, the upper and outside parts of the flame have taken on all the oxygen that they want, and still they have the greatest amount of heat, and hence these parts of the flame are called the "oxidizing" parts. I will return to this subject later when we take up some of the points of simple blowpipe analysis. But keep your memory eye fixed on the inside reducing part and the outside oxidizing part of the candle flame. You can catch some of the unburnt carbon in the middle of the flame, or at the top, by holding a cold saucer in it for a few moments.

The Power of Gasolene

There are several, indeed many, other sides to this study of combustible gases, and the subject of gasolene is one of them. If you have not studied this, you will be surprised to learn what a chance for dreadful mistake and accident lies in this simple question of the amount of air that it takes to burn gasolene. Now gasolene is only a mixture of several hydrocarbons, all close cousins to methane and ethane. But in the molecules of the volatile liquids that make up what is sold as gasolene there is so much carbon and so much hydrogen snugly packed away that it is no simple matter to select the

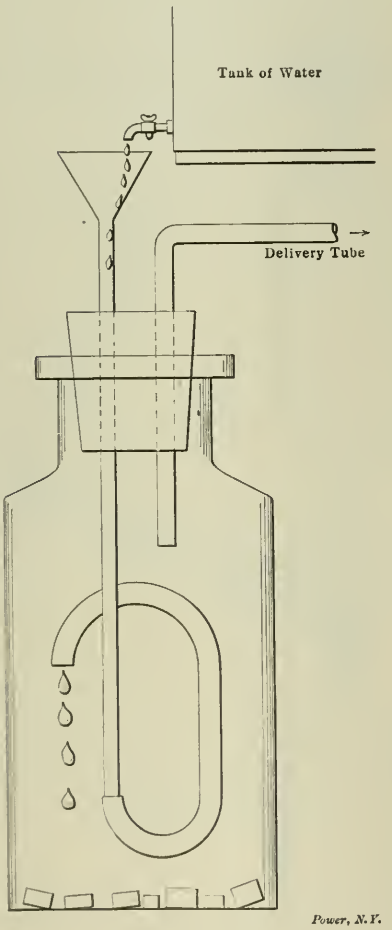


FIG. 5

right amount of air wherewith to burn them and then to mix them well.

Thus, you can pour out a teaspoonful of gasolene in any safe place and light it. when it burns quietly, if lighted at once. But take a common empty tin can, holding about a pint, and pour in the can some five to ten drops of gasolene. Try five drops at first, and gradually feel your way along. Put the cover back on the can, and let it stand for some few minutes, so that the slight amount of gasolene can well evaporate and get well mixed with the air in the can. Now, you want to have a small hole in the side of the can for a "touch hole," to which you will apply the flame when business is ready to commence. You will be surprised to see how much force you will get in this simple explosion. Then, you will go over to the corner, light your pipe of reflection and do some good thinking.

You will begin to have a great respect for those simple formulas that told you all about this sort of thing; only we did not realize what we were tampering with when we read that gasolene, for instance, is made up of C_7H_{16} (C-seven-H-sixteen). Seven atoms of carbon and sixteen atoms of hydrogen tucked away in one molecular handful, no bigger, though much heavier, than H_2 or O_2. You will see that one has got to stop and digest some of these things. You ask: How does it happen that so much carbon and hydrogen can be put in such a small space? How does it happen that such small molecular parcels of gasolene can take care of the oxygen in so much air? For you will find that a very few drops of gasolene will make all the air in the can frightfully explosive; and, still, the teaspoonful of pure gasolene which is unmixed with air will burn quietly. The point to note is, not why it all happens, but what it is that happens. That is what we all need to keep our eyes fixed on, the actual fact. When gases burn with each other, it is not only actual *weights* which unite with each other, but it is also definite proportions by *volume* which control the reaction.

Making Acetylene

Among the many other possible illustrations of hydrocarbons there is one which you really ought to study, both for the fact that it shows the nature of a class of hydrocarbons which are called "unsaturated" and also for the fact that it is made in the rather unusual method of treating a certain substance with water. I refer to the making of acetylene by treating what is called calcium carbide with water. As mentioned in the last lesson, this is used in making the brilliant gas for the powerful searchlights on automobiles and the like. You can easily get some of this substance, but you will have to study a bit to devise and construct a simple form of apparatus in which to make the gas. You cannot use large quantities of water recklessly; nor can you let the whole process take place in the open air; for we want to collect the acetylene as fast as it comes off, and yet add the water in *small* and continuous quantities.

A simple form of apparatus is shown in Fig. 5. This is merely a pickle bottle, with a funnel, and with the lower end of the funnel bent so that it is water-sealed from the outer air. The delivery tube is of the common make. You can get the water seal by putting a short piece of rubber tubing on the stem of the funnel in the bottle, long enough to make a complete bend (Fig. 5). Then you will put several pieces of the calcium carbide, which is a grayish, earthy-like substance, in the bottle, closing the bottle with the cork and setting over the funnel a can of water so arranged that water will drip into the funnel in a set of drops, not a stream, for that would be too much. You can easily control the dropping by making a small hole in the lower side of the can and plugging it with a match, which can be drawn out or pushed in as desired. The gas is collected in the jar in the pneumatic trough in the usual way. But be sure and drive out the air from the bottle, first, as you did with hydrogen. You will test the burning of this acetylene, C_2H_2, by burning, and the residual gas in the jar after burning with limewater.

But the most interesting thing about this gas is that it is made from water acting on calcium carbide. This substance is one of the later additions to our supply of interesting chemicals, and is usually made in an electric furnace. Just why water should be such an active agent in making this gas, acetylene, is more than we can fully explain at this time, but an inkling can be imparted. This substance, water, is a kind of "bank of chemical exchange." Look at the formula of water. It is H_2O. It contains both hydrogen and oxygen. Now if we pay into this "bank" hydrogen, we get back reducing action, but if we pay into this "bank" oxygen we get back an oxidizing action. Farther, if we pay into this "bank" of water both hydrogen and oxygen, we can back both reducing and oxidizing actions. Note the following equation for the reaction of water on calcium carbide:

H_2O Water	+	CaC_2 Calcium Carbide	=	CaO Calcium Oxide Lime	+	C_2H_2 Acetylene

Really, the calcium carbide is a kind of chemical "salt," and a kind which is decomposed by water. So, when the water acts on the "salt," calcium carbide, we get the base anhydride, lime, CaO, and the weak "acid," acetylene, C_2H_2. No one would ever guess that acetylene is an acid, unless he had the advantage of comparison with many other reactions; for acetylene does not act on litmus as the common strong acids do when they turn litmus red. But you can begin to see by comparison that the more one goes from the reducing or hydrogen end of a series of compounds toward the oxygen end, the nearer he gets toward acid properties.

And so as we go from the extreme reduced end of the carbon table, and long before real active acid properties are shown, as we go toward the oxygen end of the table, we begin to get some indications of acid properties. We will consider this strange chemistry more in the next lesson, but this is only a sample of what the chemistry of carbon has to teach us.

One thing that you must do, to clinch some of this, is to test the residue in the acetylene-making bottle with litmus, and you will find that lime is there and can be used just as was the lime in the barrel that you were using several weeks ago. You have got well started on the chemical study of lime, but we shall find that it holds up continually. Make some limewater from this residual lime from the calcium carbide in the pickle bottle, and test it every way you can, for it is the same old friend, to pilot you a bit farther.

The Ambiguous Term "Gallon"

As the liquid measures of the United States unfortunately bear no direct relation to those of England, much confusion is occasioned by the careless use of the term "gallon." Only recently in these columns confusion arose in regard to the amount of circulating water used in a certain plant by a failure to distinguish between the imperial gallon used in Great Britain and the United States standard gallon. For this reason it may be of interest to define the two standard gallons and trace their origin and variations from the early days of English history.

From as far back as the thirteenth century the gallon has been variable. Originally it was intended to be a measure of weight and not of bulk. To carry out this intention to its full extent would have required that every commodity measurable in bulk should have its own gallon, each holding the same weight, with the bulk varying inversely as the specific gravity. This would, of course, have caused endless confusion and early usage led to the adoption of two standard gallons related to each other in capacity as the inverse ratio of the specific gravity of wheat and wine, the latter standard being the wine of Gascony, which at that time, 1225, was a British province. These two standards were supposed to represent the average of the two classes of exchangeable commodities, wet and dry, the ratio referred to being assumed as [illegible].

In 1266 Henry III declared by statute that "an English silver penny, called a sterling, round and without any clipping, shall weigh 32 wheat corns in the midst of the ear, and 20 pence do make an ounce, 12 ounces one pound, 8 pounds a gallon of wine, and 8 gallons of wine a London bushel." In [illegible] a statute of Henry VI gave the gallon a different value, which was based on the weight of water. A ton was the weight of 32 cubic feet of water and the eighth part of a cubic foot, or 216 cubic inches, was taken as a gallon of water. Hence the wine gallon, being enlarged to hold the same weight of wine, became [illegible] cubic inches, and the wheat gallon [illegible] cubic inches.

In the latter part of the fifteenth century (1496), Henry VII provided that a new standard gallon measure be constructed to hold 8 pounds of wheat of 12 Troy ounces each, and in [illegible] the wine gallon was declared by law to contain 231 cubic inches. This is the present United States standard gallon for liquids.

In 1700 the old trouble with the excise officers broke out and led to two legal acts. First, the statute of William III, [illegible], establishing the Winchester bushel and vaguely defining its capacity as 2150.4252 cubic inches, and, second, a statute of the [illegible] Anne, [illegible], which in like manner established the Winchester gallon, specifying it to contain 268.8 cubic inches. Elizabeth constructed the standard gallon of 282 cubic inches, or nearly 8 pounds avoirdupois of wheat, which became the old ale gallon. The Irish gallon, which from 1430 to [illegible], had contained eight pounds Troy of wine, was at the latter date settled at [illegible] cubic inches, but in 1735 was again changed to 217.1 cubic inches for all purposes. The Scotch gallon was no less than 830 cubic inches.

Finally, in 1818, a royal commission was appointed to recommend standard measures, and as a result a bill was introduced in parliament and passed June 17, 1824. This bill was put into operation January 1, 1826, and fixed the capacity of the gallon by requiring that it should contain 10 pounds avoirdupois, or 70,000 grains Troy, of distilled water at a temperature of 62 degrees Fahrenheit and with the barometer reading 30 inches of mercury, stating at the same time the capacity thus determined to be 277.274 cubic inches. This is the value of the imperial gallon now in use in Great Britain, and is the only legal gallon in that country for both wet and dry measure.

In the United States no standard of measure was ever established, the gallon being inherited from Great Britain. Instead of using the British temperature of comparison of 62 degrees Fahrenheit, a temperature of 39.83 degrees Fahrenheit (taken as temperature of maximum density) was proposed by F. R. Hassler of the Coast Survey. The stated legal capacity of the gallon was to be 231 cubic inches and of the Winchester bushel 2150.42 cubic inches. On account of the change in temperature a further adjustment of these capacities was proposed, making the gallon contain [illegible] grains of distilled water at its maximum density at 39.83 degrees Fahrenheit, and the Winchester bushel [illegible] grains. This adjustment made the Winchester bushel of the United States and Great Britain slightly different, and on June 14, 1836, Congress gave legal sanction to these values and passed a joint resolution directing a complete set of all weights and measures adopted as standards to be delivered to the governor of each State.

If this were all and there were only one standard gallon in the United States, as in Great Britain, it would be an easy matter to distinguish between the two, but in this country there are not only the wine gallon containing 231 cubic inches, but also the ale, beer or milk gallon containing 282 cubic inches, and the dry gallon, besides the proof gallon for internal-revenue taxation. The proof gallon is a wine gallon of spirits containing half its volume of nearly pure alcohol at 60 degrees Fahrenheit and is the basis for computing the United States internal-revenue tax. For example, a gallon of spirits containing 40 per cent. alcohol would be 80 per cent. proof, and the number of proof gallons is computed by multiplying the per cent. of proof by the number of wine gallons.

New Hampshire and Minnesota definitely retain the ale, beer or milk gallon of 282 cubic inches; Wisconsin and Connecticut the dry gallon of 282 cubic inches as the legal standard, and Maine definitely mentions the milk gallon as among its list of State standards. The milk gallon is 51 cubic inches larger than the standard gallon used more generally throughout the country. There are thus three standard gallons: the dry gallon derived from the Winchester bushel; the liquid gallon derived from the wine gallon, and the liquid gallon derived from the beer or milk gallon.

In addition to the capacity measurement by volume the legal weight of a gallon of certain commodities has been fixed by statute in some States and in several cases by Congress for certain purposes. Thus in Nebraska 12 pounds of strained honey is a legal gallon. In Kansas 6½ pounds of kerosene and 8 pounds of castor oil, in Ohio 7½ pounds of kerosene and in Indiana 11 pounds of sorghum molasses are all legal gallons of the products named. These legal weights differ among themselves and do not accord with the true volume of one gallon of 231 cubic inches.

In dry measure the standards used have no direct relation to the liquid measures of this country or Great Britain. The fundamental unit is the Winchester bushel, a unit abandoned by England in 1824, but still retained in general use in this country. As previously stated, it contains 2150.42 cubic inches and is about 69 cubic inches, or 3 per cent. smaller than the imperial bushel of Great Britain. The United States dry gallon contains 268.8025 cubic inches, or 1.16365 liquid gallons. Here again conflicting State laws render an adequate statement of the standard of the bushel difficult. Although the standard Winchester bushel contains 2150.42 cubic inches, Nebraska has established 2150 cubic inches as the volume of a legal bushel for that State, and other States have made similar changes. Also several States have adopted the old ale or milk gallon as the capacity of the dry gallon, this being about 5 per cent. larger than the corresponding unit derived from the Winchester bushel, and special bushels have been established in the various States for different products.

In brief, this is the history of the gallon with its various legal values, but as far as engineering data are concerned, it will be safe to distinguish only between the United States gallon containing 231 cubic inches and representing the volume of 8.33 pounds avoirdupois of pure water at a temperature of 39.83 degrees Fahrenheit and the British imperial gallon containing 277.274 cubic inches and representing the volume of 10 pounds avoirdupois of distilled water at 62 degrees Fahrenheit weighed in air of the same temperature with the barometer reading 30 inches of mercury.

Recent Ice Jam at Niagara Caused Serious Damage

By James J. Jenkins

The power interests at Niagara Falls have had the most astonishing experience in their history, all caused by the greatest ice jam that locality has seen in more than 50 years. On Wednesday, April 7, the Lake Erie and Niagara regions were swept by a fierce gale. The effect was a general breaking up of the lake ice field, which was driven into the entrance of the Niagara river channel at the foot of the lake. The discharge of ice from the lake to the river was tremendous, and from shore to shore, in both of its great channels, the river carried the ice night and day until the Niagara river, from Lake Ontario to the falls of Niagara, full 14 miles, was coated with the frozen mass, which had gathered to a thickness of from 25 to 50 feet or more.

FIG. 1. IN FRONT OF THE NIAGARA FALLS POWER COMPANY'S TUNNEL PORTAL AND THE HYDRAULIC COMPANY'S POWER HOUSE

FIG. 2. THE TRACKS OF THE GORGE ROAD ARE BURIED UNDER THE ICE ALL ALONG THE SHORE TO THE RIGHT

The spectacle thus created was astonishing, but the effect was more so, for the river rose to an unusual hight, breaking beyond all previous high-water marks, while the ice was carried to the greatest hight and was sent crushing, with the full force of the current, against everything within 40 feet of the normal level of the river. Up to the coming of this ice jam and high water, all available data indicated that the lower river had never risen higher than 28 feet, which in itself is a remarkable hight considering the rapidity and freedom with which the lower Niagara discharges into Lake Ontario.

Situated very close by the foot of the Horseshoe fall, at the water's edge on the Canadian side, is the power house of the Ontario Power Company, in which the development is made on horizontal shafts. When the site for this power house was selected, all available data then at hand were closely studied, and the conclusion of the engineers was that it would be safe to build the power house where now located. The conditions that developed during the April jam have demonstrated an error of judgment, considering the fact that the Niagara river and its possibilities are unknown factors. For although this great power house is situated a number of feet above the normal level of the river, and beyond the previous high-water mark, the ice and water burst into the station through windows and door, making it necessary to shut down the plant to dry out the machines. The full extent of the damage had not been announced at this writing, other than in the following statement issued by the company:

"During the night the unprecedented accumulation of ice below the falls, extending for nearly nine miles to Lewiston and beyond, caused the water to rise about 40 feet above normal. The maximum record for high water in the past, covering a period of 70 years, is about 28 feet above normal. The power house is designed with its windows about 7 feet above the highest previous known hight of water. Last night, however, the water exceeded this previous record by about 12 feet, and the water and ice poured through the windows and south door of the power house, at once causing a stoppage of the machinery. Temporary connection is being made, through the courtesy of the Electrical Development Company, with that company's works, and the steam-reserve plants at Rochester, Syracuse, West Seneca and elsewhere are being used to supply a portion of the load in this State of New York. The intention is to supply the public-service corporations first, such as railroads and lighting companies, and, afterward, the manufacturers and private users.

"No permanent damage is done to the power house or its machinery. As soon as the water is pumped out of the power house, it will be necessary only to clean and dry the machinery before resuming full operation. The money loss is extremely small, but the inconvenience to customers is, of course, serious.

"A recurrence of the accident is impossible, as the windows will be built up solid to a hight above any possible rise of water in the future, and the south door, which is not necessary to the operation of the works, will be closed with masonry."

FIG. 3. ONTARIO POWER COMPANY'S POWER HOUSE ALMOST BURIED UNDER THE ICE

FIG. 4. [illegible]

The enormous hight to which the ice advanced in front of the power house is well portrayed in one of the accompanying illustrations, in which the broken edge of the ice jam will give a pretty fair idea of the thickness of the mass of ice in the river in front of the station. It should be borne in mind, too, that there is more ice below the water line than above it. From this point in front of the Ontario Power Company's station the ice field extended in an unbroken mass to the whirlpool rapids. Usually, the giant stream that bursts from the portal of the tunnel of the Niagara Falls Power Company, close by the New York abutment of the upper steel-arch bridge, has strength enough to open a wide channel in any ice field that may gather there, but it was different with this April jam, for the tunnel torrent had little or no effect on the gathered ice, simply losing its identity under the broad white surface that stretched for miles down the gorge.

Out in front of the power houses of the Niagara Falls Hydraulic Power and Manufacturing Company the mighty ice was unbroken and rough. The night the Ontario Power Company's station was flooded, the water entered the basement of one of the power houses of the Niagara Falls Hydraulic Power and Manufacturing Company to a depth of a foot, but this point was about 8 feet below the turbine installation. Taking into consideration the known drop of the river between the base of the Horseshoe and the foot of this station, it would appear that there must have been a backing-up of the water to effect the damage to the Canadian station. Between the two points there was a great mass of ice, and it is not strange if all the water and ice that plunged over the Horseshoe fall was unable to pass down the gorge without backing up.

So great was the jam that the whirlpool was bridged from shore to shore, while the river from the outlet to Lake Ontario was a whitened pathway. So high was the water that the ice was lifted over the tracks of the Niagara Gorge Railway, the roadbed of which was buried for miles under from 10 to 20 feet of icy cakes, and the poles and wires were torn down. Until the ice is off the roadbed, it will be impossible accurately to judge the extent of the damage. However, it is generally felt that it will be very heavy, quite sufficient to delay the early spring operation of the scenic line.

On the Canadian side of the river, below the Devil's hole, great damage was done to the steel towers of the aluminum power-transmission line over which the Ontario Power Company supplies current to the Niagara, Lockport & Ontario Power Company for transmission to Rochester, Syracuse and other places in the interior of New York State. This transmission system was interrupted, not only by the damage at the power house, but also by the damage to the towers, the center one of three towers being tipped over to the north onto one of the others. All about their bases there was ice, notwithstanding that they had been placed so high that it was felt they were above the danger line. Boathouses, fish traps, docks, private pumping stations and other structures near the water's edge were swept away for miles, and at Lewiston two fair-sized hotels, normally far removed from the river, were guarded for fear they would be crushed by the ice, which there reached an elevation of about 50 feet and touched the rear verandas.

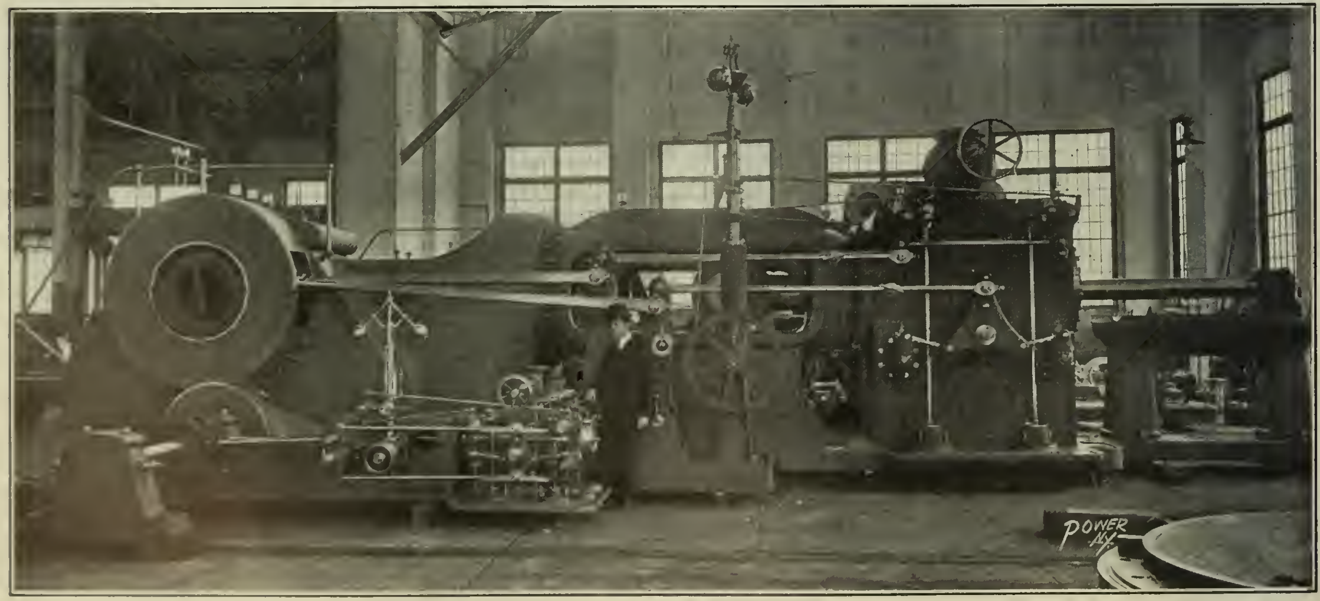
On April 20 it was possible to touch the floor of the Lewiston suspension bridge while standing on the ice. The belief prevailed that the ice was resting on the river bed between Lewiston and the mouth of the river, causing the water to back up.

Previous to April 20 estimates placed the damage at more that a million dollars. Now it is believed that it will be weeks before accurate figures are obtainable by any of the main interests affected. Generally speaking, it may be accepted as fact that it was the unexpected that happened, and all engineers who have to do with great works know what this means. The flooding of the station of the Ontario Power Company may cause a notable change in extensions of that plant, while the ice-jam effects will go down in history as making new records for the mysterious-acting, uncontrollable Niagara when it is under the terrific influence of a wind storm, particularly in winter, when any hour a million tons of ice may be swept into the gorge from the higher level above the falls. The use of dynamite and the warm weather broke the jam on April 25.

FIG. 5. SHOWING THE ICE JAM IN THE LOWER NIAGARA

Large Engine for Tennessee Coal, Iron and Railroad Company

The accompanying photograph shows the high-pressure side of a 42 and 78 by 54-inch cross-compound, condensing Cooper-Corliss engine on the erecting floor of the C. & G. Cooper Company, Mount Vernon, O. It was built for the Tennessee Coal, Iron and Railroad Company's plant at Ensley, Ala., and fifteen heavy steel cars were required for its transportation. The shipment was made forty days before the expiration of the four months stipulated.



LARGE ENGINE FOR THE TENNESSEE COAL, IRON AND RAILROAD COMPANY

This engine is practically a duplicate of the unit placed in operation at the Carnegie Steel Company's Duquesne works a year ago. It will drive a 2500-kilowatt Crocker-Wheeler alternator and is designed to carry heavy overloads. Alongside it is shown, for purpose of comparison, a 50-horsepower simple engine built for the Franklin Foundation, of Boston, Mass. A similar engine to that shipped to Alabama is being built for the Packard Motor Car Company, Detroit, Mich., to drive a 2500-kilowatt Western Electric Company direct-current generator.

Rate of Timber Consumption

It has been estimated that the amount of wood annually consumed in the United States at present is 23,000,000,000 cubic feet, while the growth of the forest is only 7,000,000,000 feet. In other words, Americans all over the country are using more than three times as much wood as the forests are producing. The figures are based upon a large number of State and local reports collected by the Government, and upon actual measurements.

The State forester of Connecticut, in a recent report, has given figures on growth and use for New Haven county, which give many more valuable details than are generally to be obtained, and well illustrate how the forest is being reduced by over-cutting. In this county a very careful study was made on each township of the amount of forest, the rate of growth, and the amount of timber used. For 1907 the timber used was 120,000 cords, in the form of cordwood, lumber, ties, poles and piles. The annual growth on all types of forest land, including the trees standing on abandoned fields, for the year, reached a total of 70,000 cords. Thus the amount cut yearly exceeds the growth by 50,000 cords.

The amount of standing timber considered as merchantable and available for cutting within the next few years was found to be 1,200,000 cords. Each year the annual growth increases the supply on hand by 70,000 cords, while the use decreases it by 120,000. The net reduction is therefore 50,000 cords a year. If the cut and the growth remain at the present figures, the supply of merchantable timber will be exhausted in about twenty years. At the end of that time there will be a large amount of forest standing in the county, but it will be in tracts under forty years of age, containing wood below the most profitable size for cutting. Cordwood could still be cut, but supplies of the most profitable products, like ties and lumber, would be practically exhausted.

Connecticut's case illustrates what is meant when the exhaustion of the timber supply is spoken of. It does not mean that every tree will be cut and that the ground will be bare. It means, on the other hand, that year by year the people of the country are cutting more timber than the forest grows, and that within a comparatively short time the continued loss will have so reduced the forest that it will be difficult and expensive to obtain timber of useful size in sufficient quantity.

Testing Coal at an Electric Railway Power House

There is a growing inclination on the part of electric-railway companies to determine accurately the value of fuel used in power stations. G. H. Kelsay, superintendent of power of the Indiana Union Traction Company, is making frequent tests of fuel used at the company's Anderson power station, to determine the evaporation of water with various kinds of coal. Adjoining one of the boilers in the station he has erected apparatus to weigh the coal and take the temperature of the water as fed to the boiler, the temperature of the steam and the quality of steam as delivered by the boiler during a 12-hour run. In making the test the supply water to the boiler from every connection is shut off, except the water as fed through an independent pump at the base of the testing tank. The water for feeding the boiler is obtained from the feed line header, and from this feed line header is passed to a carefully calibrated tank with tapered top and reduced neck, so as to hold a definite and exact quantity of water when full. The tank has been carefully calibrated for various temperatures of water, and a thermometer is inserted in the tank at midway to get the temperature, and from curves plotted from temperatures and weights the weight of each individual tank of water is determined. Water is then discharged to a lower tank and pumped into the boiler. Coal is discharged from the bunkers over the boiler into a portable hopper mounted on a set of calibrated scales. From each hopper of coal a small sample is taken and at the end of the day's run these samples are carefully mixed and quartered so as to obtain a sample sufficient to fill a quart fruit jar, giving the nearest possible average coal used during the day's test. From this sample of coal B.t.u. determinations are made by means of a Parr calorimeter. During the test of 12 hours the men conducting the test endeavor to keep the fires in a uniform condition, so that the results of all coal tests will represent the merits of coal for each test.—*Electric Traction Weekly.*

The joint annual convention of the Southern Supply and Machinery Dealers' Association and the American Supply and Machinery Manufacturers' Association will be held at Chattanooga, Tenn., May 5, 6 and 7.

Canadian General Electric Company

The annual meeting of shareholders of the Canadian General Electric Company, Ltd., was held at Toronto on March 29. The report of the directors for past year of a highly satisfactory character, showing profits to the amount of $[illegible], leaving $[illegible] after providing for depreciation and interest on borrowed capital. Of this, $[illegible] was paid in dividends and $[illegible] carried to the credit of profit and loss account, bringing it up to $[illegible]. The reserve fund stands at $[illegible], making a total surplus of $[illegible]. The report states that notwithstanding the continued industrial depression, the company had been fortunate in securing several important contracts, which will ensure their works would keep them fairly busy during the current year. As an indication of the improvement in conditions it was noted that during the past three months more orders had been secured than during the previous six months, leading the directors to look forward to the future with more confidence than at any time during the preceding year.

The Gas Engine in Blast-Furnace Practice

On Tuesday evening, April 20, George A. Orrok, secretary of the Gas Power Section of the American Society of Mechanical Engineers, delivered an illustrated lecture before the members and guests of the [illegible] Science Club of Brooklyn, on "The Gas Engine in Blast Furnace Practice." There were 70 lantern slides showing several types of gas engines in section, both vertical and horizontal, in all stages of assembly in the shop and power plant. The lecture was of a popular rather than scientific nature.

As applied to blast-furnace practice, several views were shown of the two-stroke-cycle gas engines used at the Lackawanna Steel Company's works in Buffalo and the four-stroke-cycle engines at Gary, Ind.

Discussion lasted for nearly an hour after the close of the lecture and was of an interesting character.

In 1887 an engine built to the design of [illegible] by the [illegible] Manufacturing Company, of Scranton, Penn., was put into the Washington Mill at Lawrence, Mass. George H. [illegible], who has been in charge of the engine ever since, [illegible] that it is still running without a [illegible] of the cranks and [illegible], and in the same position that it was put in when it was erected.

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Contents PAGE

Philanthropists in Disguise

One of the most amusing collections of statements intended as serious which we have ever read is contained in an address recently delivered at Adelphi College, Brooklyn, by Glenn Marston, who is old enough and intelligent enough to know better. Two extracts will suffice to indicate the general tenor of the address. Speaking of public-utility corporations, Mr. Marston said: "The good they do reaches far beyond the donations to charity and other worthy movements which constitute the outward and visible sign of public beneficence." Also: "The public-service corporation has solved the problem of combining business and philanthropy."

We were not aware that any such problem as the combination of business and philanthropy existed, but conceding that there is such a recognized problem, the claim that it has been solved by any of the lighting and power companies strikes us as distinctly humorous. In order to be philanthropic a person or organization must do good intentionally and unselfishly. If there is a single central-station manager in the country who is operating his plant on that basis we should like very much to learn his name and address. Most of the central-station men we know are honorable and fair-minded in their business dealings as well as in private life, but we do not know any who would be foolish enough to pose as philanthropists merely because they light unsavory localities—for due consideration—and furnish power—also for a consideration—to run sewing machines formerly "treadled" by overworked men and women.

A Fuel Extravagance no Longer Necessary

In Great Britain there are probably a dozen or more centers of blast-furnace activity, and no large center of population is very far from some one of them. Consequently, it would seem to be merely a matter of ordinary engineering to utilize all of the surplus blast-furnace gas for driving electric generators and to transmit the energy from these to profitable markets. Yet the furnaces continue to waste their surplus gases while coal-burning power stations, operating within short distances from them, deliver electrical energy to transmission lines.

The chief reason for this extravagant procedure appears to be a lack of confidence in the reliability of the gas engine, notwithstanding the numerous examples of continuous and satisfactory operation in Germany. Probably the real secret is the proverbial conservatism of the British.

A somewhat similar, though not strictly analogous, condition has existed in this country until very recently, and it has not entirely disappeared yet and probably will not until the Gary plant has fully justified the confidence of its projectors. On this side of the Atlantic, however, the whole gas-power industry received a serious check by the failure of the few bituminous producers based on foreign designs which were built here before the difference between American and European coals was understood, and of a relatively small number of engines built chiefly from imported or pirated designs.

Now that the Steel Corporation has gone ahead so boldly in the utilization of furnace gases and a few courageous pioneer manufacturers are beginning to reap the reward of their persistent attempts to produce clean gas continuously from bitumionus coal, it is to be expected that great strides will be made in the application of gas power in this country. Never mind the facts that the Steel Corporation exacted heroic guarantees and that many of the persistent attempts alluded to were foolishly unscientific; it is sufficient that we are really about to "get there."

A Trust in Water Power

For some time rumors more or less indefinite and not at all specific in their charges have hinted of the existence of a water-power trust. These reports have gained credence from their very persistence and are apparently justified by some positive assertions by Judson C. Welliver in the May number of *McClure's Magazine.* A trust of modest means is not predicted, but rather a combination of interests of unlimited resources already actively engaged in the pursuance of systematic plans to secure control of all available water power in this country and Canada. A successful culmination of these plans would mean a corporation with more wealth than that represented by all the railroads of the nation, with Standard Oil, United States Steel and a dozen or so of the minor trusts thrown in for good measure. Be this as it may, it is of interest to note that some of the companies mentioned are of particular prominence in the power field, but whether they actually form a part of the trust combination or are merely endeavoring to secure a legitimate market for their product is a question which would require careful investigation to determine.

Manufactures and transportation, it is reported, use about 31,500,000 horsepower, of which 26,000,000 is supplied by steam and the rest water power. Carefully compiled data of the Hydrographic Bureau of the Geological Survey show that a minimum development, based on the natural condition of streams without the construction of reservoirs, would produce 37,000,000 horsepower. This is the low-flow figure, and the same streams will develop a minimum of 56,000,000 horsepower for the six high-water months of the year, so that for half the year a total of 37,000,000 to 56,000,000 horsepower would be developed, and for the remainder of the year over 56,000,000 horsepower. Without storage and at minimum flow it is thus possible to develop considerably more power than is utilized at present, and it is estimated that if reservoirs were erected of capacity large enough to equalize the annual flow, a total of 230,000,000 horsepower could be produced, or over seven times as much power as the whole country is now using.

With the available supply of natural fuels rapidly disappearing, conservation and before long necessity, will demand recourse to the waterfalls of the country for a much larger proportion of the total industrial power than they now contribute. Long before this condition actually developed, a trust controlling practically all of the power produced by water would be in an enviable position and to a great extent would undoubtedly be able to dictate the price of power. New fuels may perhaps come into use which would obviate such a disaster, but it would surely be wise to guard our water resources.

More Boiler Inspection Legislation Needed

Both in the editorial and correspondence columns of Power and The Engineer the necessity for the enactment of suitable boiler-inspection laws has been urged until it has at times seemed as though the readers would become surfeited with matter on this subject. But as scarcely a day of the year is marked off the calendar without the transpiring of news of a boiler failure that in all probability would have been prevented by intelligent inspection, it becomes nearly if not quite impossible for the man in close touch with steam-boiler operation to keep silent.

Last summer a boiler belonging to the town of Dartmouth, Mass., was examined by one of the State inspectors and the pressure allowed reduced to a point which rendered it useless to the municipality as a source of power. It was sold for junk for fifty dollars to a man who represented to the New Bedford Ice Company that the boiler was safe for a much higher pressure than was allowed by the inspector. Possession was transferred to the ice company and the boiler was sent to a place in New Hampshire and erected for the purpose of furnishing steam to operate ice-harvesting machinery.

What might reasonably have been expected happened. The boiler exploded, fatally injuring the man who purchased it from the town of Dartmouth and installed it for the New Bedford Ice Company. One of the State inspectors from Massachusetts visited the scene of the disaster and succeeded in obtaining possession of the spring-loaded safety valve which had been attached to the boiler. This valve, when tested at the Massachusetts Institute of Technology, was found to blow at one hundred and thirty-one pounds pressure. As the valve had been set by the State inspector to blow at eighty pounds a few weeks before, it would appear that the erecting engineer had attempted to set the release at one hundred and thirty pounds, or fifty pounds above the limit allowed by the State inspector.

Now, while no State inspection law can be perfect in conception or operation, the existence of a law in New Hampshire similar to the one operating in Massachusetts would have prevented the importation into the State of a piece of apparatus known to be dangerous as a menace to the life and property of its citizens. That there should be an organized movement on the part of all citizens looking to the enactment of suitable boiler-inspection laws in all States, or toward national legislation in this direction, is so plain that to mention it is a platitude.

"What is everybody's business is nobody's business" is palpably true in regard to boiler-inspection legislation, and recognizing this apathy on the part of the public, due, of course, to ignorance of the possible and probable danger arising from the operation of uninspected boilers, the engineer should make every effort in his power toward exciting public interest in a matter that is of vital interest to the public.

Coal Specifications

John Hall Rider, in a paper upon the "Electrical System of the London County Council Tramways," presented to the Institution of Electrical Engineers at a recent meeting, gives briefly the conditions under which the coal is purchased. The specified standards are:

Calorific value, 12,500 B.t.u. per pound.

Small coal allowance, 20 per cent. by volume (measured by the quantity which will pass through a wire mesh of ¼-inch square mesh).

Moisture, 10 per cent. by weight.

The calorific value and moisture are measured by the council's chemist on samples taken from every [illegible] brought into the pier front. The calorific value is determined by a Mahler bomb calorimeter on a sample previously dried at 100 degrees Centigrade, and the percent of moisture is determined on a weighed portion of the sample as taken from an airtight sample tin. The proportion of small coal is ascertained on the pier and a sample of about 20 pounds in weight taken at the option of the council either from the hold or from the quantity unloaded by the grabs.

If the quality of the coal in any cargo as ascertained by the samples tested is found different as regards calorific value, moisture or small coal, from the foregoing standards, the price paid to the contractor is varied as follows:

(a) If the calorific value exceeds 12,500 B.t.u. per pound, the price per ton is increased in the same percentage ratio as the increase in the calorific value.

(b) If the calorific value is less than 12,500 B.t.u. per pound, the price per ton is decreased in the same percentage ratio as the decrease in the calorific value.

(The council, however, has the right to reject the whole cargo if the calorific value is less than 11,000 B.t.u. per pound.)

(c) If the moisture is less than 10 per cent. by weight, the weight of coal to be paid for is increased beyond the quantity actually weighed out by a percentage equal to the percentage decrease of moisture.

(d) If the moisture exceeds 10 per cent. by weight, the weight of coal to be paid for is decreased below the quantity actually weighed out by a percentage equal to the percentage increase of moisture.

(The council, however, has the right to reject the whole cargo if the moisture exceeds 15 per cent. by weight.)

(e) If the proportion of small coal is less than 20 per cent. by weight, the weight of coal to be paid for is increased beyond the quantity actually weighed out by a percentage equal to one-quarter of the percentage decrease of small coal.

(f) If the proportion of small coal exceeds 20 per cent. by weight, the weight of coal to be paid for is decreased below the quantity actually weighed out by a percentage equal to one-quarter of the percentage increase of small coal.

(The council, however, has the right to reject the whole cargo if the proportion of small coal exceeds 25 per cent. by weight.)

The number of boiler explosions in the United States in 1908 was [illegible]. This compares with [illegible] in 1907, [illegible] in 1906, [illegible] in 1905 and [illegible] in 1904. The number of persons killed by boiler explosions in 1908 was [illegible], against [illegible] in 1907, [illegible] in 1906, [illegible] in 1905 and [illegible] in 1904. The number of persons injured [illegible] in 1908 was [illegible], against [illegible] in 1907, [illegible] in 1906, [illegible] in 1905 and [illegible] in 1904. The record of boiler explosions in the United States for [illegible] years and three months, to October 1, 1908, shows a total of [illegible], in which [illegible] persons were killed and [illegible] injured.

The annual meeting of the National Electric Light Association will be held at Atlantic City, N. J., June 1, 2, 3 and 4. On the first two days there will be two sessions each day; on the last two days there will be parallel sessions devoted to commercial, technical and accounting subjects. The [illegible] department [illegible] will be on Young's "Million Dollar Pier." The association's headquarters will be [illegible].

Improved Dexter Valve Reseating Machine

Thousands of good valves have been thrown away merely because there was no suitable reseating machine at hand and engineers, rather than bother, have ordered new and discarded the leaky valves. The accompanying illustrations

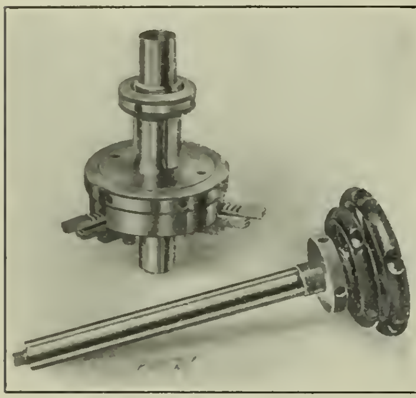

FIG. 1. DEXTER VALVE RESEATING MACHINE

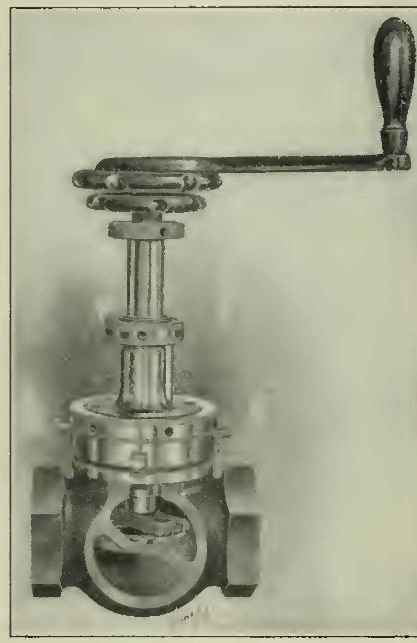

FIG. 2. APPLICATION OF DEXTER VALVE MACHINE TO GLOBE VALVES

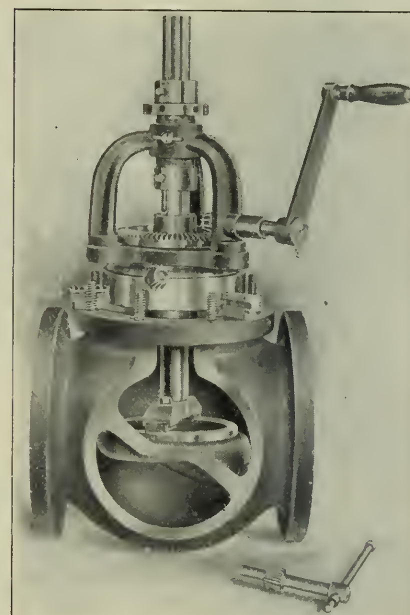

FIG. 4. DEXTER MACHINE FOR RESEATING VALVES UP TO 12 INCHES IN SIZE

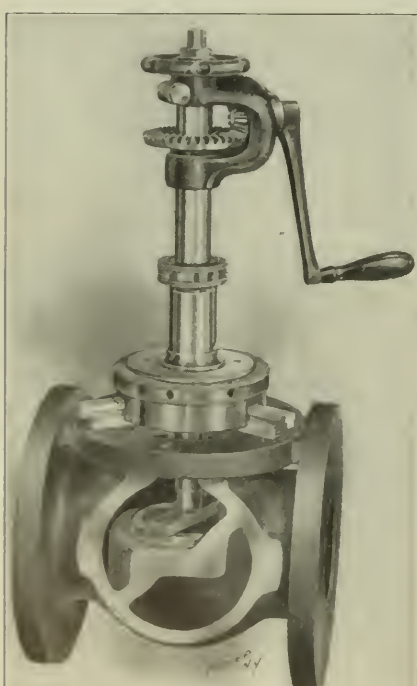

FIG. 3. APPLIED TO LARGER GLOBE VALVES

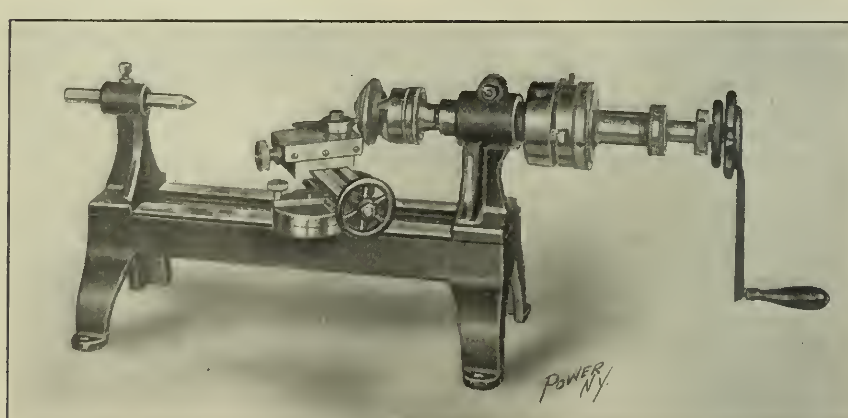

FIG. 5. TURRET-LATHE DISK CUTTER

show the application of the Dexter valve machine, manufactured by the Leavitt Machine Company, Orange, Mass.

Fig. 1 illustrates an improved valve-reseating machine with the tool spindle removed from its bearing sleeve in the body of the machine. This bearing sleeve extends through the chuck and is threaded on the inside of its upper end. These threads engage with the threads of the feed screw shown under the speed wheel of the tool spindle. The bearing sleeve and the tool spindle are slidable through the chuck, and instantly lowered to or raised from the valve seat and held in position by rotating the large nut shown on the body of the machine. This bearing sleeve supports the tool spindle for practically its entire length, which greatly strengthens the tool shaft and aids in keeping it in line.

Fig. 2 shows the application of this device for reseating globe valves from ¼ to 4 inches in size. The illustration shows a machine at work on a valve seat. The jaws of the machine are quickly and simultaneously adjusted to the valve casing by merely rotating the scroll of the chuck. This centers the machine, when the tool shaft is in alinement. Then a few turns of the handle and the seat is cut to a too flat surface.

Fig. 3 shows the machine as applied to valves from 3 to 6 inches in size. This machine carries a 6-inch cutter and is said to meet all requirements for this size of valve.

Fig. 4 illustrates the Dexter machine for reseating the larger size of valve up to 12 inches. The machine is geared 5 to 1, making a very powerful machine that carries the largest cutter easily, cutting the hardest metal smoothly without chattering, it is said. The jaws of the machine are quickly and simultaneously adjusted as in the case of the machines already described. The machine, being portable, is taken to the valve on the pipe line, the valve seat being trued without disconnecting the valve. This model is carried in three sizes for reseating all flat and taper-seated valves from 3 to 8 inches, 3 to 10 inches and 4 to 12 inches.

Fig. 5 shows a new turret-lathe disk cutter. Owing to the number of positions to which the turret head that holds the cutting tool can be adjusted, all kinds and shapes of valve disk can be easily and quickly recut. With one setting of the head, a crowning face can be cut on a valve disk; by feeding forward on the nurled nut, a 45-degree angle can be cut; or by feeding on the feed nut of the machine a true surface can be turned parallel with the machine; all without resetting the head. The turret head carrying the cutting tool can be quickly adjusted for turning up all kinds of work usually done in small lathes. This machine is portable, but can be attached to a bench.

Inquiries

Questions are not answered unless they are of general interest and are accompanied by the name and address of the inquirer

Horsepower to Turn Drum

Give a formula by which to obtain the horsepower necessary to drive a drum 8 feet in diameter by 16 feet long, resting on six 12-inch sheaves, with 12-inch faces, three of the sheaves being drivers and the other three mounted on an idler shaft. The drum when loaded will weigh about 27 tons and make 10 turns per minute. A

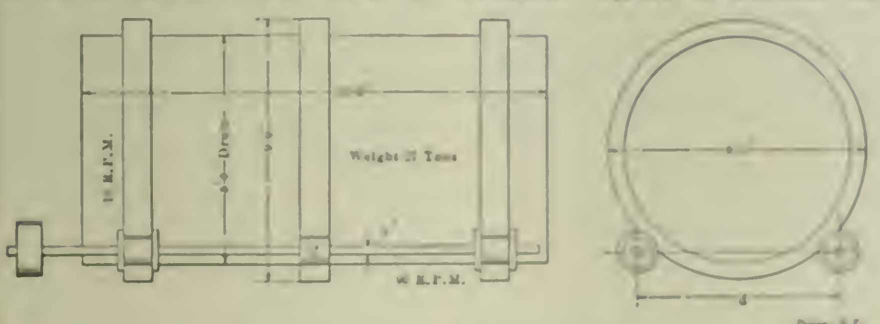

FIG. 1. ARRANGEMENT OF DRUM AND ROLLERS

FIG. 2. GRAPHICAL SOLUTION OF PROBLEM

sketch of the arrangement is shown in Fig. 1.

S. C. G.

Assuming the load to be distributed equally in the drum, the formula for horsepower at the periphery of the drum may be deduced graphically. In the accompanying sketch, Fig. 2, the large circle represents the drum, and the two smaller circles the rollers.

$$Sin\ \theta = \frac{c\,b}{a\,c} = \frac{\frac{d}{2}}{5} = \frac{d}{10}.$$

Make $f\,e$ parallel to $a\,g$ and $e\,g$ parallel to $a\,f$. Then the resultant $a\,e$ will represent the weight W of the drum.

$$a\,o = \frac{a\,e}{2} = \frac{W}{2}$$

and

$$a\,f = \frac{a\,o}{\cos\theta} = \frac{\frac{W}{2}}{\cos\theta}.$$

Therefore,

$$a\,f = P_1 = \frac{W}{2\cos\theta} = \frac{W}{2\cos\sin^{-1}\frac{d}{10}} =$$

$$\frac{W}{2\,\frac{\sqrt{10^2 - d^2}}{10}}.$$

Now as

$$P_1 = P_2 \text{ or } P_1 + P_2 = 2\,P_1,$$

the formula for friction would be

$$Friction = 2\,P_1\,f = F$$

and the formula for work would be

$$Work = F \times 9\,\pi \times 10 = 2\,P_1\,f\,90\,\pi =$$

$$\frac{180\,W\,f\,\pi}{2\,\frac{\sqrt{10^2 - d^2}}{10}}.$$

The horsepower at the periphery of the roller would be

$$H.P. = \frac{90\,\pi\,f\,W}{33{,}000 \times \frac{\sqrt{10^2 - d^2}}{10}}.$$

For cast iron rolling on cast iron the coefficient of friction is 0.004 and substituting in the previous formula for the horsepower required to overcome the rolling friction, the following result would be obtained:

$$H.P. = \frac{90 \times \pi \times 0.004 \times 54{,}000}{33{,}000 \times \frac{\sqrt{10^2 - d^2}}{10}} =$$

$$\frac{18.5}{\sqrt{10^2 - d^2}}.$$

To overcome the bearing friction on the roller shafts the horsepower would be calculated as follows: On the idler shaft the horsepower to overcome the bearing friction will be

$$H.P. = \frac{90 \times \pi \times \frac{1}{4} \times \frac{54{,}000}{2}}{33{,}000 \times \sqrt{10^2 - d^2}} \times 0.05$$

$$= \frac{90 \times \pi \times 54{,}000 \times 5}{33{,}000 \times 4 \times \sqrt{10^2 - d^2}} \times 0.05 =$$

$$\frac{28.9}{\sqrt{10^2 - d^2}}.$$

On the driving shaft let R equal the resultant of the belt pull and the pressure P_1. Then the following formula will give the horsepower required to overcome the bearing friction on this shaft:

$$H.P. = \frac{90 \times \pi \times R \times 0.05}{4 \times 33{,}000} = \frac{3.53\,R}{33{,}000}.$$

The total horsepower would simply be a summation of the values obtained for rolling friction, friction on the idler shaft, and friction on the driving shaft, and would read as follows:

$$Total\ H.P. = \frac{3.53\,R}{33{,}000} + \frac{47.4}{\sqrt{10^2 - d^2}}.$$

Then by inserting the value of R which can be ascertained in the plant, and the value of d, which is the distance between the idler shaft and driving shaft, the total horsepower required may be obtained.

Does Expanding Tubes Cause Leaks?

Do leaks usually occur when new tubes are expanded beside others which are badly incrusted with scale?

C. D.

It depends entirely on how much the old tubes are disturbed by the process of removing the tubes that are to be replaced. There is nothing in the tube itself or of expanding it properly that would cause a leak in another tube, no matter how badly scaled.

Location of Drip Pipe

The drip pipe from a header over a horizontal boiler extends through the shell into the water near the bottom of the boiler. Why was it not put in so that it would discharge into the steam space?

D. E.

Engineers and some others have prejudices against allowing water which, however hot it may be, is colder than the water from which it is condensed, to pass into the steam space of a boiler, as a water hammer of a more or less serious nature is liable to result.

Modern Science Club Program

In the program of lectures and discussions at the rooms of the Modern Science Club, of Brooklyn, the following features are announced for the balance of May: Saturday, May 8, general discussion on "The Rating and Reliability of House Heating Boilers;" Tuesday, May 11, a paper by Prof. John E. Sweet, illustrated by the stereopticon, on "The Growth of the High Speed Engine, or the Straight Line Engine in Particular," will be read by the secretary; Tuesday, May 18, H. J. Atticks will continue his discussion of "Steam Engine Governors;" Saturday, May 22, general discussion on "Turbine Governors," opened by Frank Martin; Tuesday, May 25, F. E. Town will read a paper on "Elevator Accidents and their Prevention." All lectures will start promptly at 8:15 p.m.

Business Items

Ira J. Owen, consulting engineer, of Chicago, has removed from the Marquette building to 855 First National Bank building and will continue to make a specialty of factory engineering.

The Pittsburg office of the Du Bois Iron Works, of Du Bois, Penn., manufacturer of gas engines, etc., has been removed from 1206 Park building to more commodious quarters at 1429 Park building.

The Parker Boiler Company has received an order for a 300-horsepower boiler from the Astoria Veneer Mills, Long Island City, N. Y. This company installed a 500-horsepower Parker boiler about a year ago.

The Carnegie Steel Company has added to the 1550 horsepower in Crocker-Wheeler form W motors in its Duquesne plant by the purchase of three more Crocker-Wheeler motors of the same type, especially designed for rolling-mill work, aggregating 225 horsepower.

The Union Electric Power Company, Union, Iowa, has ordered from the Minneapolis Steel and Machinery Company a 55-horsepower Muenzel producer gas engine and gas producer which will be installed in its new electric-light plant. The engine will be belted to two generators.

The Larson Lumber Company, Bellingham, Wash., has purchased a 20x36-inch Twin City Corliss engine with special Twin City frame from the Minneapolis Steel and Machinery Company. This is the second Twin City engine that they have purchased within the past three months.

The Buckeye Engine Company, of Salem, Ohio, announces the appointment of: Louis Bendit, associate, American Society of Mechanical Engineers, Kansas City sales manager, with offices at 501 New York Life building; also, J. R. Detweiler, district manager, at Wichita, Kan., with offices at 505 Barnes building.

In the March 23 issue, on page 543, in the article descriptive of the new power plant of the L. S. Starrett Company, Athol, Mass., it was stated that the chimney is of the Custodis type. We wish to correct this statement, as the chimney is constructed of radial bricks by the M. W. Kellogg Company 18 Church street, New York.

The Du Bois Iron Works advises us that it recently appointed James L. Kimball New England representative, with offices at 53 State street, Boston, Mass., also the James F. Marshall Company, 608 Chestnut street, Philadelphia, general sales manager for eastern Pennsylvania, Delaware and the southern half of New Jersey.

The Trill Indicator Company, Corry, Penn., is sending out a neat circular, recently issued, containing a list of a few of the concerns using the Trill "Triumph" indicator, among which are the William Todd Company, Cambria Steel Company, Jones & Laughlin Steel Company and a number of prominent universities.

C. A. Dunham & Co., of Marshalltown, Iowa, will shortly start operations on a new $50,000 office and factory building, as their present quarters are inadequate. The building will be used entirely for their heating and trap departments. They report a big improvement in business and recently opened branch offices in Fort Worth, Tex., Pittsburg and Denver.

The Ideal Automatic Pump Governor Company has been reincorporated under the laws of the State of New York, and has changed its corporate title to the Ideal Automatic Manufacturing Company, as its line of steam specialties now embraces pump governors, pressure-regulating and controlling valves and "Ideal" packing. The offices and works of the company are at 125 to 129 Watts street, New York.

"Belt Talks" is the title of a little cloth-bound book of about 100 pages which gives a lot of information about belting and will make good reading for any engineer who has anything to do with the belting about his establishment. There are a number of illustrations to help out the text. Of course the object of the book is also to tell about Bird's "Bulls-Eye" belting. It is sent free upon application to J. A. & W. Bird & Co., 34 India street, Boston, Mass.

We have been advised by the Keystone Lubricating Company, of Philadelphia, that the case which has been pending in the Denver courts for infringement upon its trademark by the Keystone Oil and Supply Company has been decided in its favor. There are several infringements upon the company's trademark throughout the United States by petty concerns, and action has not been taken against them on account of the pending decision.

The city of Bellevue, Ia., has placed an order for a Foos three-cylinder vertical gas engine, with gas producer complete, with the Foos Gas Engine Company, of Springfield, O., to replace a steam engine in the city electric-light plant. This will run in parallel with a steam engine, it being anticipated that the remaining steam engine will be displaced by another gas engine. The Foos company is doing a large business in gas-producer plants, both for electric work and pumping installations.

The Homestead Valve Manufacturing Company, of Pittsburg, Penn., reports several sales of Homestead valves for use on pressures of 5000 pounds hydraulic. These valves, they say, are meeting with great success and they have had several repeat orders from customers using them for this purpose. Many users of valves know the Homestead valve as a blowoff valve only, but they desire to call attention to the fact that it is successfully used on the highest known pressures.

The Willcox Engineering Company, of Saginaw, Mich., manufacturer of the Willcox automatic water weigher, has issued in pamphlet form, illustrated, "A Consulting Engineer's Report on the Willcox Automatic Water Weigher," it being a reproduction of part of an article, on "Recent Refinements in Boiler Testing," which was published in Power and The Engineer, February 23, 1909. The Willcox water weigher is highly endorsed in a letter accompanying the pamphlet, from the Michigan Sulphite Fibre Company, of Port Huron, Mich., which gives the weigher large credit for a saving of from 10 to 20 per cent. in the coal bill.

The Hewes & Phillips Iron Works, Newark, N. J., has under construction for the Windham Manufacturing Company, Willimantic, Conn., a cross-compound Corliss engine, 18x36x48, 100 revolutions, to develop 1000 horsepower. With this engine they are also installing a complete motive-power outfit consisting of a 750-kilowatt Crocker-Wheeler belt-driven generator, Stirling water-tube boilers, pumps, heaters, etc. The Oakville Company, Oakville, Conn., is installing a new Hewes & Phillip cross-compound condensing Corliss engine, equipped with the improved "Franklin" silent valve gear. This engine is 14x28x33 and will run at 300 revolutions, direct-connected to a 300-kilowatt generator. The engine is arranged to connect to a 12-inch barometric condenser; it will also have a primary heater and all the latest heat-saving apparatus.

The Hewes & Phillips Iron Works, Newark, N. J., is rebuilding one of the large Corliss engines operating the Wamsutta mills, New Bedford, Mass., furnishing two high-pressure 20-inch diameter by 72-inch stroke cylinders and new pistons and new valve gear for all four cylinders. The valve gear will be of the "Franklin" type. They are also building for this engine a wood-rim flywheel 26 feet in diameter by 102 inches face, with double arms. The engine will be speeded from 58 to about 70 revolutions per minute. The Downs-Plum Company, boxboard paper manufacturer, Blanchard and Ferry streets, Newark, N. J., is also having a 22x42, 400-horsepower Hewes & Phillips Corliss engine installed for the operation of its paper mill. The engine will work noncondensing, using steam in the dryers.

One of the oldest and largest printing establishments in Texas, that of Clarke & Courts, Galveston, has just completed the electrification of its drives. The order for 21 motors recently placed with the Birmingham office of the Crocker-Wheeler Company makes a total of 61 Crocker-Wheeler motors in this plant. The motors just ordered are for the following purposes: A 10-horsepower motor for driving the elevator; two 3-horsepower and a 2-horsepower for driving cutters; a 1-horsepower driving a group of numbering machines and a 1-horsepower driving a group of wire stitchers; a ½-horsepower driving a box machine and a similar motor driving a punch; eight ½-horsepower motors driving ruling machines and a ¼-horsepower driving a sewing machine. In the electrotype shop there are two 5-horsepower motors driving groups of machinery, a 1-horsepower motor driving a black-leading machine and a 3-horsepower driving a plating dynamo. This plant covers a whole block and is four stories high. It is considered the highest-class printing establishment west of the Mississippi river.

Help Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

Reversing Valve Gears in General Use

A Bird's Eye View of Link and Other Reversing Motions, Including Double- and Single-eccentric Motions; Direct, Bevel and Spur-wheel Drive

BY SIMPSON RICE

While volumes have been written on the subject of reversing valve gears, there does not seem to be any place in which all of the principal types now in use are illustrated and described, particularly with reference to noting the differences between them. That such a comparison has elements of value goes without saying, for, while the steam engine may, to quote the view expressed by many, be becoming a "back number" in the field of power generation, for any service which requires reversing, it is still the only dependable machine, and there is much which may yet be done to perfect the various types of gears by which reversing is accomplished. Therefore, a review of those which have thus far stood the test of continuous or intermittent operation, and the study of their essential characteristics, will be found helpful in a consideration of means for improving, or adapting to new service, the working parts of any individual type.

For the article following, which treats principally of the several methods employed for imparting the desired motion to the valves by means of eccentrics, cranks, bevel and spur wheels, rods, etc.—usually in combination with blocks and links—there has been prepared a group of diagrammatic sketches, uniformly conceived, which give what might be termed a bird's-eye view of all link and other reversing motions now in general use, and shows very clearly the differences between them. Supplementing these sketches are a number of other figures taken from drawings of engines now in operation, which show how the details of the leading types are applied in actual engineering practice. Such information of value as the article imparts will come chiefly from a close, analytical scrutiny of the several figures by which it is illustrated. Beyond what is said of the first motion described, no attempt will be made to follow out the movements of the various gears in detail further than is necessary to show radical differences in type; and for more complete information the reader is referred to standard works on the subject.

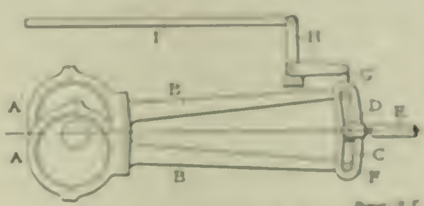

FIG. 1. STEPHENSON'S GEAR

In the lettering of the several figures similar parts have been uniformly indicated, as follows:

A = Eccentrics.
B = Eccentric rods.
C = Link.
D = Block working in connection with link.
E = Connection to valve.
F = Point of suspension of link.
G = Rods which support link and radius rod.
H I = Levers and connections by which reversing is effected.
J = Connecting rod.

In grouping the various gears for purposes of comparison, it seems desirable to separate them into three sections, viz., those having double-eccentric link motions, single eccentrics, and direct, bevel and spur-wheel drive. Were the mechanisms to be considered in their entirety as "reversing motions," it would of course be necessary to use an entirely different classification, as determined by the number, character and arrangement of the valves. [illegible] for our present purpose the following valve details affecting [illegible] of [illegible] lead, [illegible], etc., will be [illegible] only in passing [illegible] the particular [illegible].

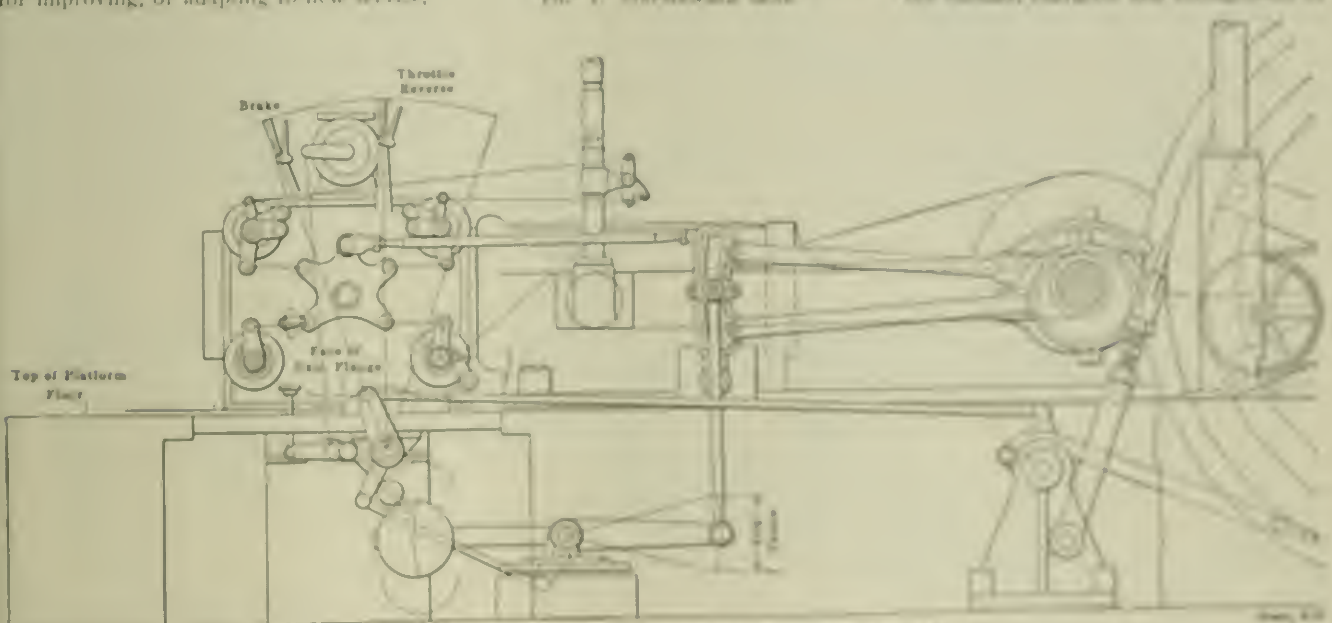

FIG. 2. STEPHENSON LINK ON [illegible] HOISTING ENGINE

Double-eccentric Link Motions

The Stephenson Link Motion—Link motions, [illegible] unquestionably belong to the most important [illegible] movements that occur in machinery." Among the earliest of arrangements for reversing engines and changing the ratio of expansion, and the one still most commonly used, is the Stephenson gear, illustrated in Fig. 1. The details and operation of this gear are as follows: The two eccentrics *A* and *A'* are keyed to the crank shaft, and to the link *C* are connected the two eccentric rods *B* and *B'*. The radius of the curvature of the link, suspended from the point *F* by the system of levers, is equal to the eccentric rod length. The block *D*, which fits the link, slides in it when the latter is raised or lowered, and is connected directly to the spindle *E* operating the valve. By moving a lever which actuates the rod *I*, the link is raised or lowered through the operation of the bell-crank lever *H* and the rod *C*.

When the eccentric rod *B'* is nearly in line with the valve spindle *E*, the action of the valve is the same as if there were but one eccentric, viz., *A'*. But, if the link is raised so that the block is near its lower end, the admission of steam is under the control of the eccentric *A*, since the eccentric rod *B* is nearly in line with the valve spindle; the eccentric *A'* will then cease to affect materially the action of the valve and the direction of the engine will be reversed. When the valve occupies a position at any point between the extremes of the link, it is under the influence of both eccentrics, but mainly controlled by the nearest one. If in the exact center of the link, it is subject to both eccentrics and the engine will not run in either direction, as each eccentric is working in direct and equal opposition to the other.

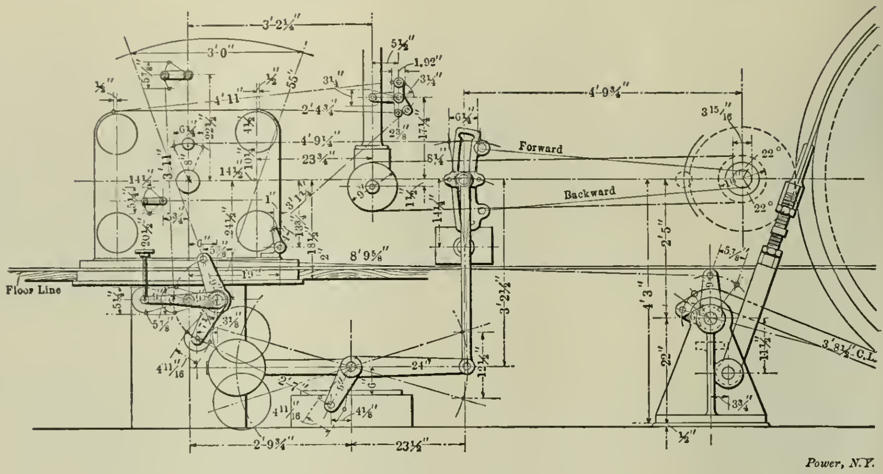

FIG. 3. DETAIL DESIGN OF STEPHENSON GEAR ON ENGINE OF FIG. 2

At such times as the block is not at the extreme of the link, the valve will not travel its full distance, or the eccentric throw, but only a distance which lessens as the block approaches the central point; but if the block is at either extreme of the link, the valve will travel a distance equal to the throw of the eccentric; at any other point the travel is less, being the same as if determined by another eccentric of smaller radius than either of those used.

The effect of decreasing the valve travel is customarily shown graphically by valve diagrams. Decreasing the valve travel results in cutoff at a point earlier in the stroke; the ratio of expansion is, therefore, increased; compression and release both occur earlier; the lead also is increased slightly. Hence it will be apparent that the combination of a pair of eccentrics with a link and sliding block allows both change in the direction of the engine and in the ratio of expansion. For those reasons, this gear has been extensively employed for locomotive, marine, rolling-mill and hoisting-engine service. The length of the link, which is curved

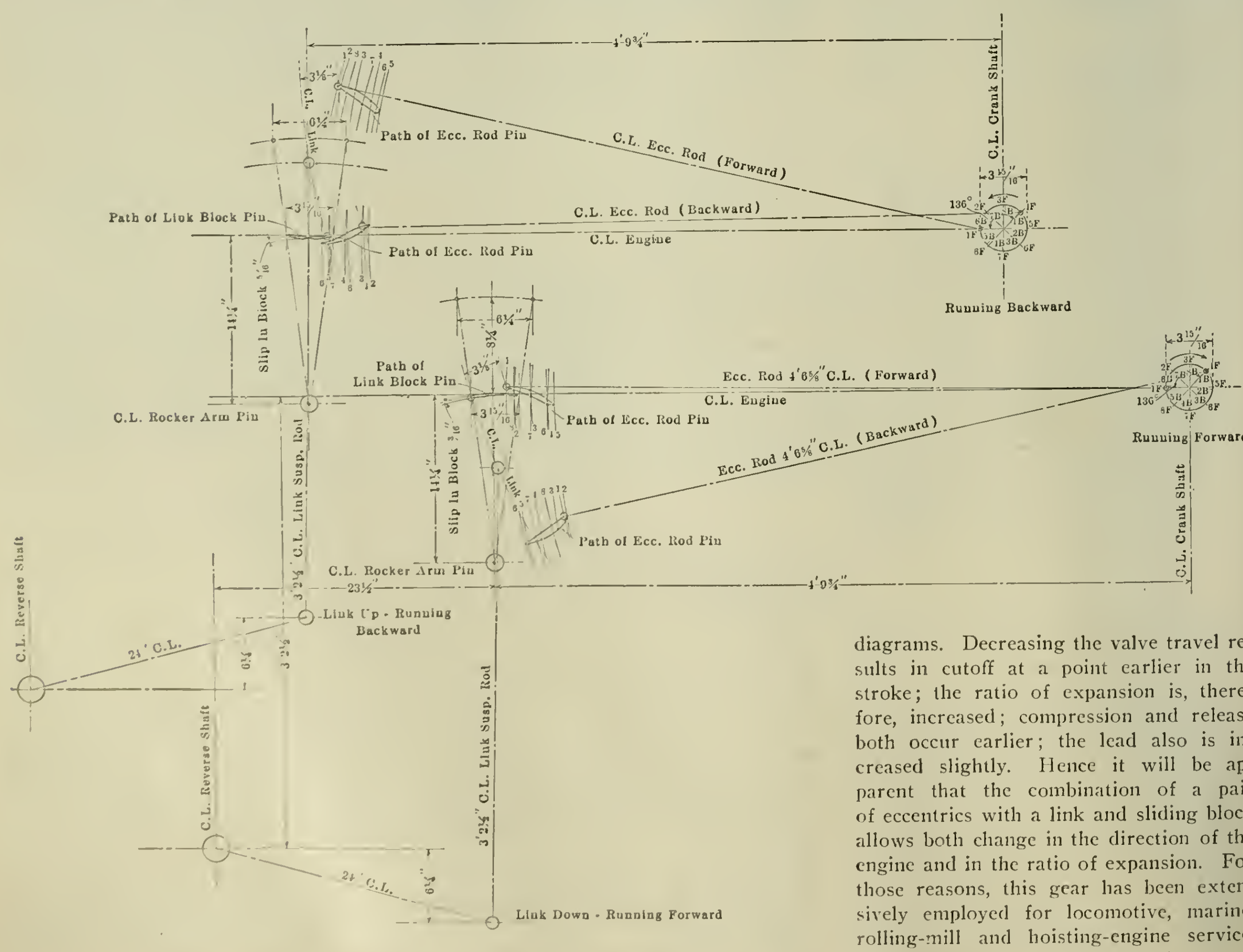

FIG. 4. GRAPHICAL METHOD OF LAYING OUT LINK MOTION

so that the lead will be equalized for all travels, should not be less than three times the full travel of the valve. It may be suspended from above or supported from beneath.

Figs. 2 and 3 show the Stephenson link gear applied to a geared hoisting engine, the details of which are plain. An arrangement such as this adapts itself readily to a gear where a variable cutoff

the pins, etc., each calculation being indicated by name. These are particulars which there is hardly space to dwell upon in a general comparison of this kind, but they are shown here for the reason that the same principle of laying out each part in exact mathematical relation to the whole and upon the lines of a single construction diagram, applies to the work of designing all types of reversing valve

[illegible] pins, so that the swinging of the upper [illegible] (backward eccentric) has very little effect on the valve travel. This link is supported on each side, so that the strains due to swinging, as the ordinary Stephenson link, are obviated.

Open and Crossed Rods.—According as to whether the angular advance of the two eccentrics is to be equal or unequal, the eccentric rods are either open or crossed.

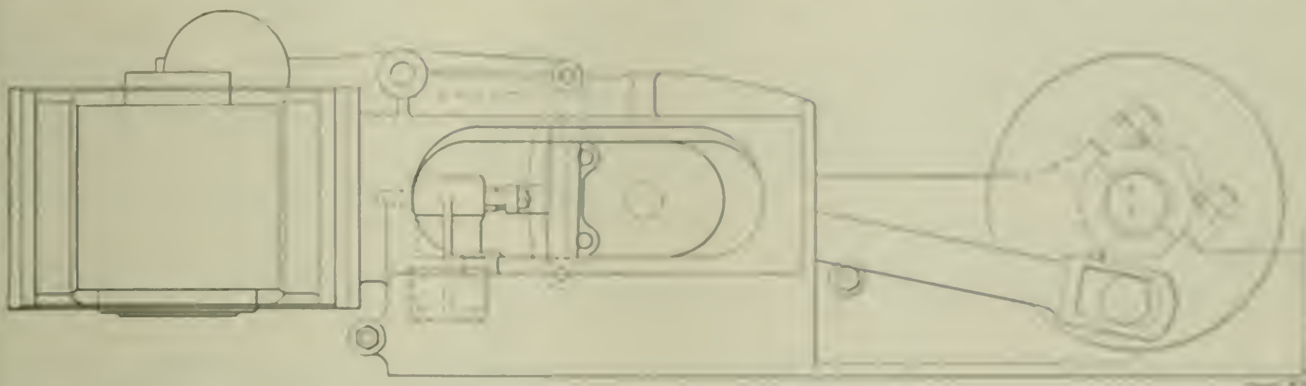

FIG. 5. MODIFICATION OF STEPHENSON LINK GEAR

is desired. This is accomplished, as above indicated, by moving the link block up or down, nearer to or away from the working eccentric-rod center. In the particular case illustrated, two engines were coupled on one crank shaft; consequently, a link was required for each, but they were both connected, through the medium of necessary levers and cross shaft, with the lever keyed in the center, so that each could be operated simultaneously with the other. The essential features of Figs. 2 and 3 are, of course, identical. The reason for giving both of them here is to illustrate, first, an outline of the side

FIG. 6. GOOCH LINK

The meaning of this term and what it implies, if not already understood by the reader, can be readily gathered from any reference book on link motions.

The Gooch Link.—Having considered the link motion principally in use, various other arrangements will be briefly described by which it has been sought, with

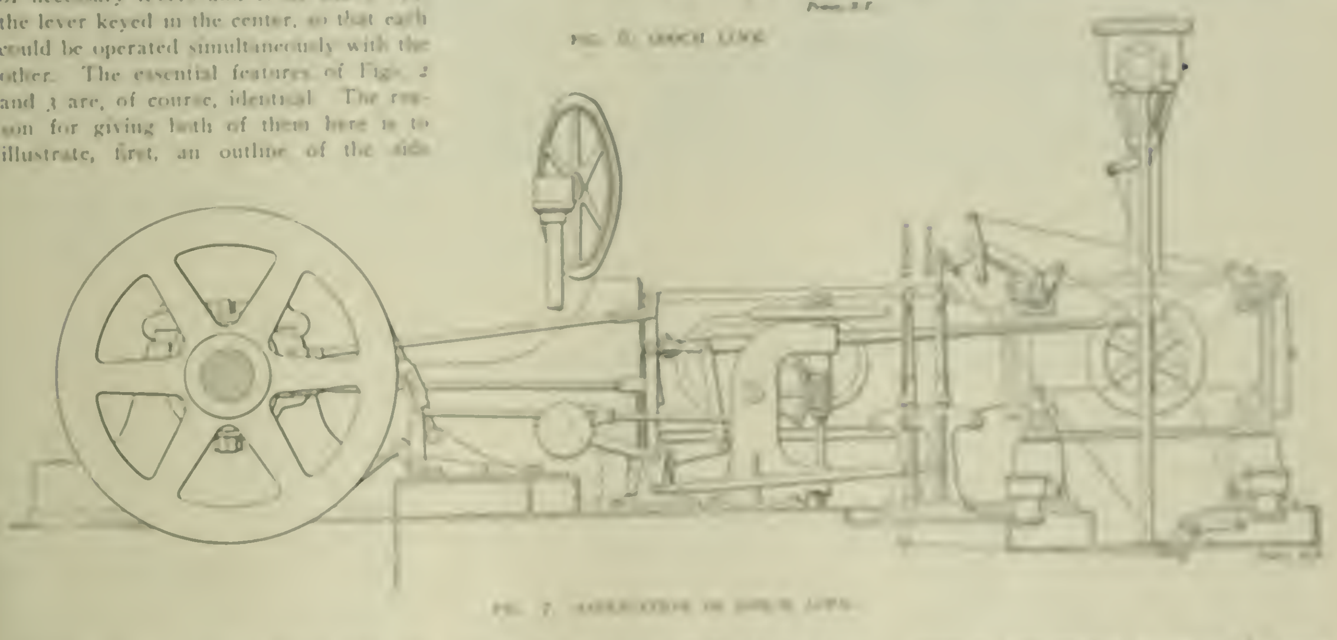

FIG. 7. APPLICATION OF GOOCH LINK

elevation of an engine fitted with the Stephenson gear, as it appears on the sketch of a proposed machine submitted by the builder to a prospective user, and, second, to show the design more in detail as worked out in the drafting room.

Proceeding still farther, Fig. 4 shows a graphical representation of the method of laying out the different points in the link motion, the slip of the link block, paths of

gear. The theory will be found in detail in Zeuner's treatise on the subject.

Fig. 5 shows an interesting modification of the Stephenson link gear for use on dredge engines or any engine which runs mostly in one direction [illegible] and the valve motion for backing and running on the [illegible] is not so important. As will be seen, the [illegible] connections to [illegible]

[illegible] so as to obtain the same [illegible] is the Gooch gear, the action of which is [illegible] to that of the Stephenson link. With this gear the link is not [illegible] The radius of the arc [illegible] that of the Stephenson link, is equal to the length of the radius rod [illegible] that the block may occupy different positions in the link, from one extremity to the other, without moving the valve. Therefore the lead is constant for all points of cutoff. The block, instead of being on the inside of the link, has its wearing surfaces on the outside of the link and is adjustable by means of wearing plates. The arrangement is shown in Figs. 6 and 7.

The Gooch link gives constant lead, but it has more joints to wear and cause lost motion and it requires more space than the Stephenson. In choosing the type of link motion the importance of a given feature must be well considered. Both gears may be designed to give an equalized cutoff. To illustrate by specific examples:

A hoist is a very slow-speed machine when starting and runs at higher speed when under way. A slow-speed engine requires but little lead, while for higher speeds considerable lead, early admission, exhaust and a larger amount of compression are necessary in order that the drum may run smoothly.

In starting, the link motion is thrown into full forward gear, which causes a late cutoff and slight lead. After the hoist is well started, the engine, like a high-speed power engine, requires more lead and considerable compression. An early admission and release are desirable in order that the steam may be admitted and exhausted freely. By raising the Stephenson link, these conditions are attained, as well as the advantage of using the steam expansively.

In marine engines the link motions are used more for reversing than for varying the expansion. Usually a marine engine runs at full speed and under full load. When the speed decreases, if the link is shifted toward mid-gear, there is excessive compression and early release. Engines of this type often use independent cutoff valves.

Allan Gear—Fig. 8 shows the Allan, or straight-link gear, and Fig. 9 a recent application of it. At the time the Stephenson gear was invented the means of slotting out had not been brought to the present-day perfection, and the construction of a curved link with large radius involved considerable difficulty; hence

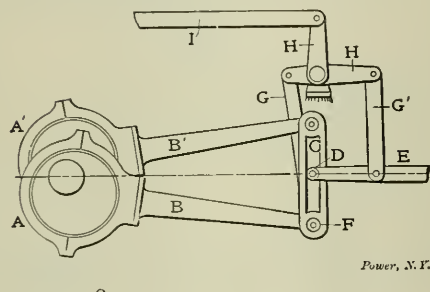

FIG. 8. ALLAN STRAIGHT-LINK GEAR

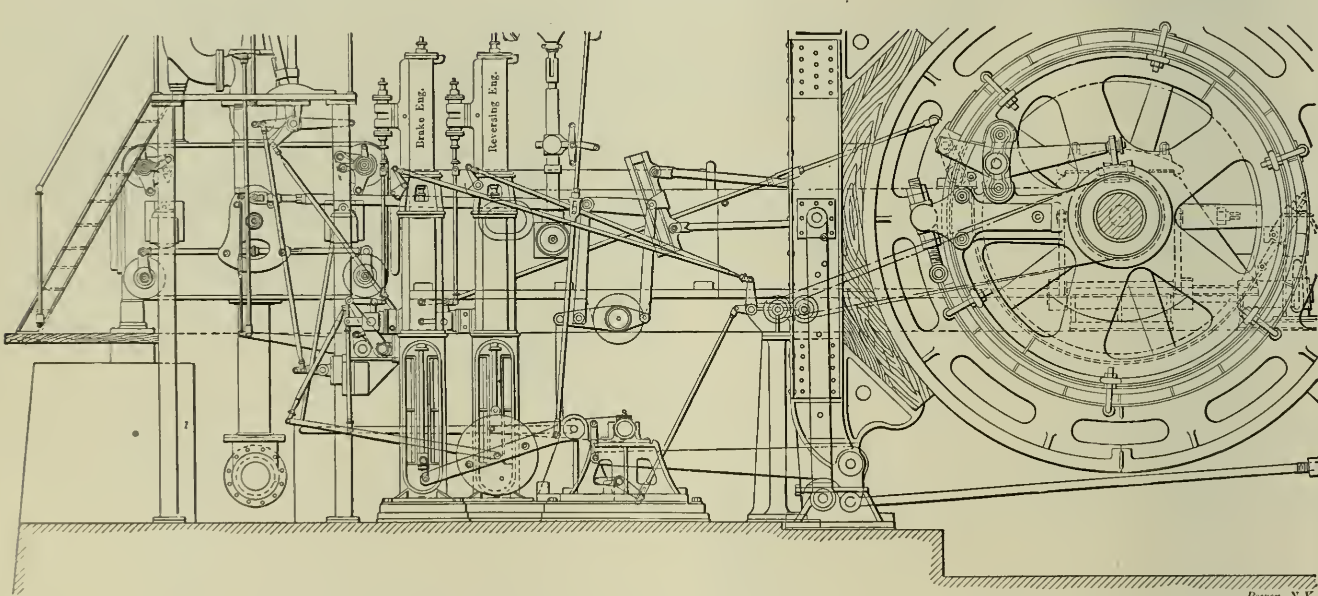

FIG. 9. RECENT APPLICATION OF ALLAN GEAR

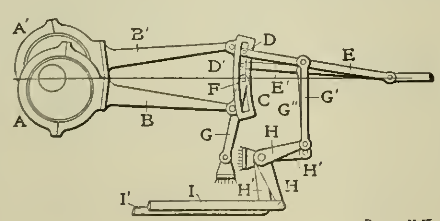

FIG. 10. POLENCEAU REVERSING AND CUT-OFF GEAR

Allan's straight link was designed as a substitute. In this gear the radius rod is moved upward as the link is moved downward and *vice versa*, causing the valve to travel evenly on each side of a fixed point; and, theoretically, the end sought can be completely attained, but in practice it has not worked as well. This motion is not now very extensively employed. It combines, however, the principal features of the Stephenson and Gooch links and is intermediate in relation to them. Fig. 9 is a modified form of the gear shown by Fig. 8 and has the link hanging down instead of being supported from below. In either case the motion is the same.

Trick Gear—A gear practically identical with the Allan link motion was independently brought out in Germany by the inventor whose name it bears, and mention is made of it here for the reason that the straight-link gear is sometimes referred to under that title.

Polenceau Gear—Very similar in its initial arrangement to the Gooch gear, and constituting practically a modification of it, is the Polenceau reversing and cut-off gear shown by Fig. 10; but, with this arrangement, a separate expansion valve is operated in connection with the main valve, necessitating two valve spindles E and E', as illustrated. It is plain to be seen from the sketch how this gear works. If the engineer wishes to throw the expansion valve out of action, so as to use the gear as a simple Gooch motion, he merely brings the levers in line and locks them together. The Polenceau gear is ingenious and has been extensively utilized, but it possesses a number of serious disadvantages, which will not be gone into here, that have made it unpopular in this country.

Meyer Gear—A modification of the Polenceau gear, which permits of all possible degrees of expansion from zero on, is the Meyer gear, largely used in rolling-mill engine service. This, however, affects principally the valve construction, which is not of interest here, and on the eccentrically operated link end a number of combinations, on the order of the foregoing, have been worked out, which have given the Meyer gear a wide range of adaptability. Among its good points is a minimum of valve friction.

Borsig, Breval, Gonzenbach, Napier and

Rankine, Farcot, and Georges gears, each of which embodies a separate expansion valve, are closely related to that of Polenceau's and have been used to a considerable extent in Europe, the last named being similar to the Meyer gear in that it fulfils most of the conditions of a perfect expansion gear. The arrangement of eccentrics, link and rods offers in each case, however, no essential difference from what has already been illustrated, and they are mentioned here only for the sake of completeness.

Guinotte Gear—A gear which can be actuated by Stephenson's, Gooch's, Allan's or a single-eccentric link motion, such as Waldegg's hereinafter described, is that of Guinotte. It differs, however, from Polenceau's and the other separate expansion-valve motions in the fact that, with this gear, the direction of an engine can be reversed without altering anything in the mechanism that controls the cutoff.

"It is an interesting fact," says a well known authority with reference to Stephenson's, Gooch's and Allan's gears, "that among the infinite number of possible cases, practice has picked out by trial just those three which have been found to be theoretically the simplest and most feasible." This remark applies with nearly equal force to the other link and valve motions referred to in the foregoing, but it seems hardly probable that inventive ability in this line has been so far exhausted as to preclude any material improvements in future. Of late, however, the efforts of engineers designing reversing engines appear to have been concentrated more upon motions of the several types described in the following sections, which have for convenience been classified under the headings of single-eccentric, direct-, bevel- and spur-driven gears.

SINGLE-ECCENTRIC MOTIONS

From the fact that a single-eccentric gear is much less expensive to construct than the double-eccentric link motion, a great deal of effort has been expended upon designing methods for reversing engines by the use of only one eccentric and a simple arrangement of rods with which to transmit the motion to the valve.

Hackworth Gear—Hackworth's reversing gear, which was the prototype of the Marshall gear shown in Fig. 11, works according to the principle that the motion of a point on a rod, one end of which moves in a circle and the other on a straight line passing through the center of that circle, is on an ellipse whose major axis coincides with the straight line; but that if the end of the rod slides on a line inclined to this center line, the major axis of the ellipse will be inclined. In Hackworth's gear, therefore, a single eccentric is keyed to the shaft exactly opposite to the crank; the eccentric rod has its end attached to a block which slides on a guide bar inclined to the line through the center of the shaft, and a rod from about the middle of the eccentric rod is connected to the valve rod, which works in a line at right angles to the line through the eccentric rod when in mid position. Now, if the guide bar on which the eccentric-rod block slides is moved so as to reverse its inclination, the inclination of the axis of the ellipse and, consequently, the motion of the engine are reversed.

Marshall Gear—The Marshall reversing gear is a modification of Hackworth's and differs from it only in the method of [illegible] at the ultimate motion of the rod end. In Fig. 11 it will be seen that the eccentric rod B is hung by means of a rod W from a point near the upper end of the lever V in such a way that the point W moves on the arc of a circle inclined to the center line. The motion is not quite as perfect as with the inclined sliding bar used for Hackworth's gear, and necessitates special designing of the lower end of the slide valve in order to get as much opening to steam there as at the top end, but there is less friction and, on the whole, it works most satisfactorily. The pins need to be of good size and require adjustable brasses to provide for the large amount of wear which necessarily comes upon them.

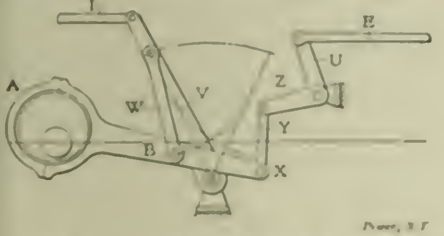

FIG. 11. MARSHALL REVERSING GEAR

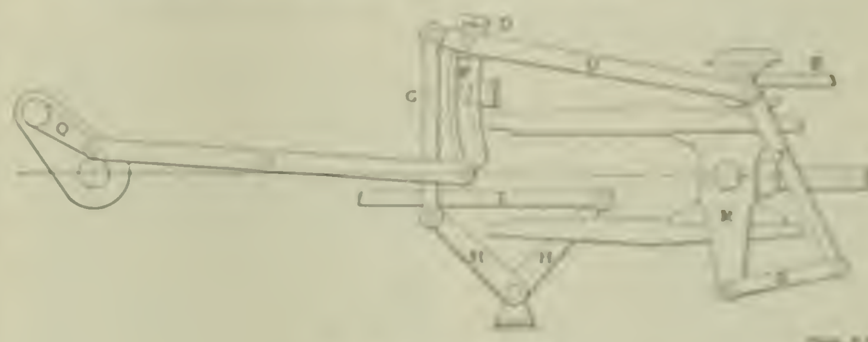

FIG. 13. WALSCHAERT GEAR

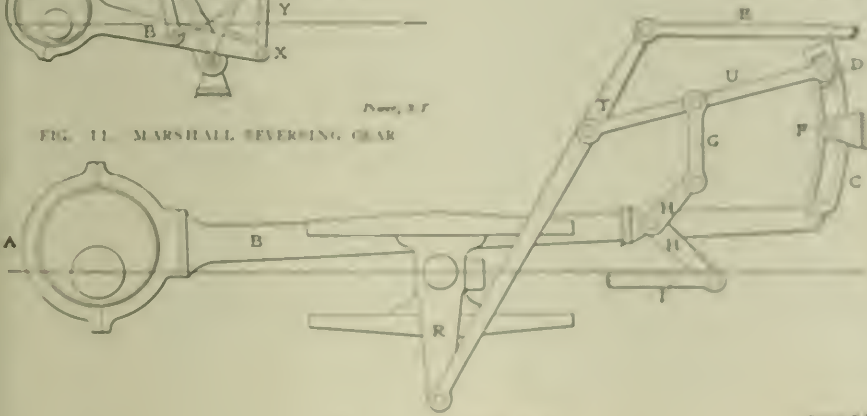

FIG. 12. WALSCHAERT GEAR

Among the great advantages of this gear, which were very clearly brought out in an article appearing on pages 660-661 of the April 21, 1908, number of POWER AND THE ENGINEER, is the excellent motion imparted to the valve, inasmuch as there are two quick and two slow motions in a revolution, the quick ones occurring at cutoff and the slow ones during exhaust and previous to opening. Constant lead and a large variation in the amount of cutoff are also possible with this arrangement without wiredrawing from small opening and slow closing of the port, as is the case with the ordinary link motion. The chief objections urged against the Hackworth gear were the excessive friction and consequent wear on the sliding blocks and the liability of so many pins to derangement. In Marshall's gear, however, these difficulties are largely overcome, making it particularly adaptable to marine and rolling-mill engine service.

Walschaert Gear—This valve gear, shown in Fig. 12, has fixed upon the crank of the driving axle an eccentric R whose center line forms a right angle with the center line of the crank. The eccentric rod B gives to the link C, which turns on the fixed pin F, an oscillating motion. The link has a curved slot in which the sliding block D can be moved up and down, so as to produce a variable expansion. The radius rod U is connected with a lever whose upper end is attached to the valve spindle E, while its lower end moves in a bracket H on the crosshead. The lever has a [illegible] pin attached to it [illegible] end moves back and forth with the piston rod, the point of connection with the radius rod *U* gets from the link another oscillating motion, and the upper end of the lever connecting with the valve spindle *E* is given a movement which, as experience has shown, is most suitable for producing the desired effect on the valve. In the gear for which this link motion is be called the link, to rise and fall, and the eccentric-rod motion is principally backward and forward. These two separate motions are combined at the point *X*, which moves in either a circular or an elliptical path, according to the relative proportions of the bell-crank lever arms *T* and *T′*.

The motion of the point *X* actuates the zontal travel of the valve rod similar to that produced by an ordinary link motion. The point *L* on the eccentric arm, however, has a somewhat complicated motion, being practically a distorted ellipse, the form of which is dependent on the motions of *X* and *Y*. The motion of *Y* is modified by the position of the supporting point *Z*, which is controlled from the cab

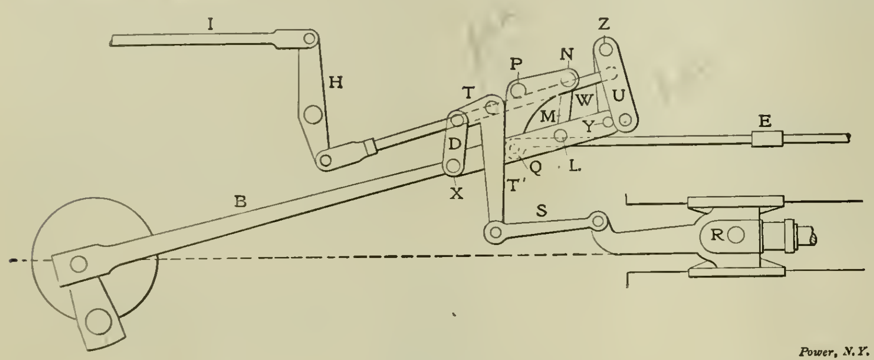

FIG. 14. BAKER-PILLIOD GEAR

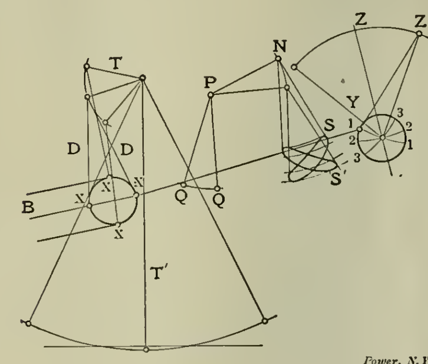

FIG. 15. DIAGRAM OF BAKER-PILLIOD GEAR

designed, the principal end sought is to secure a constant lead, and this object is completely attained; but the arrangement is generally considered too complicated, and constant lead is obtained at the expense of other qualities.

Walschaert Gear—The Walschaert gear, which has long been used on locomotives, is represented by Fig. 13, in which its essential features are clearly shown. As in the case of Waldegg's gear, the lower end of the lever *T* is connected to a bearing carried by the traveling crosshead, but it sustains a different relation to the radius rod *U*, the oscillating motion of which combines with the reciprocating movement of *T* to give a motion to the valve spindle *E* analagous to that obtained from a stationary link, as in the Gooch system. The eccentric is in the form of a return crank from the main crank pin. This arrangement is practically as complicated as that of the Waldegg gear, but constant lead is secured without many of the disadvantages attendant upon the latter.

Baker-Pilliod Gear—This gear, which has only recently been tried out on locomotives of the Chicago & Alton and Toledo, St. Louis & Western railways, is arousing a great deal of interest among operating men, and there is every indication that it will be largely adopted in this country. For that reason a somewhat extended description of it is given here. The mechanical construction of this gear, which has a constant lead, is similar to that of the Walschaert gear, but having considerably less throw. Referring to Fig. 14, the point *X* at the end of the eccentric rod is supported by an arm *D*, which takes the place of the link in the Walschaert gear and hangs from the short arm of a bell crank *T T′*. The lower end of *T′* receives its motion from the crosshead *R*. The pivot point of this bell crank is fixed. The crosshead motion causes *D*, which for convenience will eccentric arm *X Y*, and at the point *Y* this arm is supported by an arm *W* swinging about the point *Z*, which is held up by the reverse yoke *U* supported at a fixed point. The point *Z* is shifted by the movement of the reverse yoke *U*, controlled by the connection to the rod *I*, as shown in the figure. From this it will be seen that the operator can alter the position of the supporting point *Z* from which hangs the radius arm *W*, and so vary the curve made by the point *Y*. Now it will be seen that, as the eccentric arm *X Y* has a circular or elliptical motion at the end *X* and a radial motion at the end *Y*, all intermediate points along *X Y* will have motions compounded, so to speak, of the motion of *X* and the motion of *Y*.

Now for the method of actuating the valve rod. At a suitable point *L* on the eccentric arm *X Y* an upright arm *M* is placed. The upper end of this link is attached at *N* to one end of a bell crank which is pivoted at *P*. This point *P* is another fixed point on the motion. The

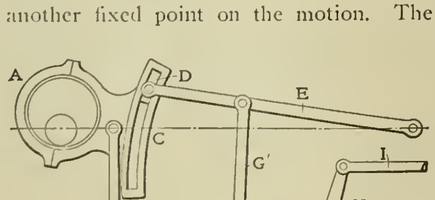

FIG. 16. FINK GEAR

point *Q* at the lower end of a vertical arm of this bell crank is where the valve rod is attached. The motion of the point *L* on the eccentric arm actuates the bell crank and the point *Q* swings on a curved path in obedience to the movement of the bell crank. The point *Q* has a radial motion about the pivot point *P*, and the movement is one of approximately hori- for forward or backward running and for all intermediate cutoff points.

The diagram, Fig. 15, shows the shape of the distorted elliptical path of the point *L*, and the portions of the ellipse passed over by the point *L* for the port openings and for lap and lead. The same letters that are used in Fig. 14 are used in Fig. 15. The ellipse marked *S* is the path followed by point *L* when in forward gear, and the ellipse *S′* is that followed in backward gear. The curve marked *1, 1* is that followed by the point *Y* in full forward gear, the curve *2, 2* is that followed when the reverse lever is in the center, and curve *3, 3* is that for full backward gear.

Among other things it is claimed for this gear that "It maintains uniform lead at all points of cutoff; a larger port opening at all points of cutoff; 5 per cent. travel of the piston required for full port openings; uniform cutoff; any cutoff from 75 to 85 per cent. can be had at full gear by lengthening the quadrant so that the reverse lever can be moved down, thus dropping the reverse yoke lower, which increases the travel of the valve and increases the cutoff at full stroke; late release, at quarter stroke releases at 85 per cent., that is, on 24-inch stroke with a 6-inch cut-off exhaust port opens when piston has traveled 20½ inches or 85 per cent. of stroke; late and balanced compression; excessive compression in the short cutoff is entirely eliminated; reduced back pressure because of quick complete release; lower terminal pressure which permits of larger exhaust nozzle; total absence of pre-admission and it produces 25 per cent. higher range of temperatures."

Young Gear—In relation to the Young valve motion there is considerable difference of opinion, and, as it is the valve alone that presents any new features, the gear will not be described here. In outward appearance it resembles the Walschaert.

Fink Gear—The Fink gear, shown in Fig. 16, although not strictly of the reversing type, is the least complicated of all link motions, and, while inferior to other gears for most conditions of service where reversing is required, has often

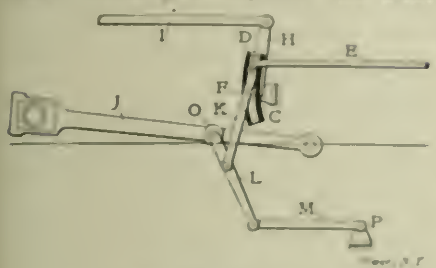

FIG. 18 JOY GEAR

been applied, either simply or with modifications. An ingenious application of it is exemplified by Fig. 17, which illustrates the gear used on a small reversible barring engine. It will be seen that in this arrangement the eccentric takes the form

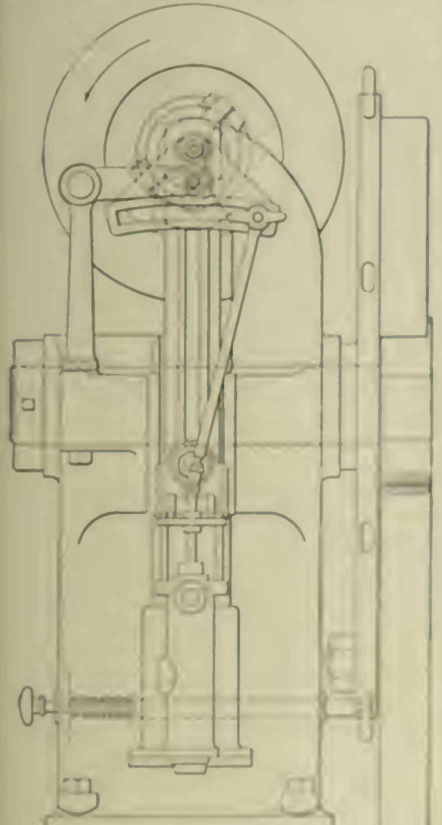

FIG. 17 FINK GEAR ON REVERSIBLE BARRING ENGINE

of a short crank on the end of the main crank shaft. There is no slip in the link block, because it is clamped in position for working anywhere in the curved slot. The link, it will be observed, is curved in the same direction as the Gooch link. This gear belongs to what is termed the radial type and has practically a constant lead. Other modifications of it have been made

but are in general more complicated than the one here shown.

RADIAL-, BEVEL- AND SPUR-GEAR DRIVE

Joy Gear—One of the most common methods of driving valves without using eccentrics is that embodied in Joy's valve gear, Fig. 18, which can be used on all types of engine and is especially adapted

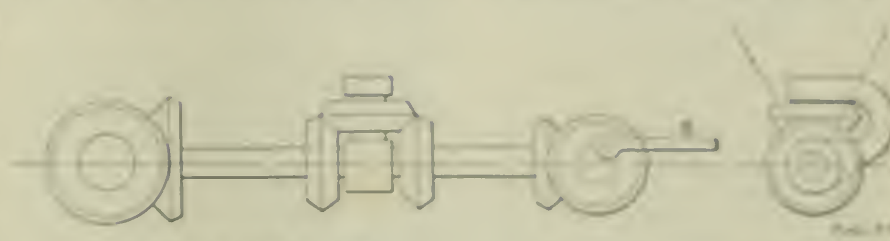

FIG. 20 BEVEL GEAR REVERSE

for marine and locomotive service. Fig. 19 illustrates the gear as applied to a marine engine. This gear gives a rapid motion to the valve when opening and closing and less compression at short cutoff than the link motion. The cutoff can be made nearly equal for all grades of the gear. With it constant lead is also to be secured.

Bevel Gear Reverse—In this gear, illustrated by Fig. 20, the reverse cross shaft indicated at the right has a motion coincident with the drum shaft on the other side and is driven by a series of seven bevel wheels. The reversing mechanism is actuated by the fourth gear and is movable up and down by hand or power, often by a small auxiliary engine. On each end of the reverse shaft is keyed a disk in which is formed a pin corresponding to an eccentric on other gears. It drives the valve mechanism by means of reach rods and gives them the same motion at all times. This is used mostly for hoisting engines, where the hoisting is done in balance, and the cutoff is under control of a regulator.

Sell's Spur Gear Reverse—This gear is a modification of the bevel-gear reverse, which it has largely superseded. Two eccentrics, set at [illegible] degrees apart, drive the shaft [illegible], Fig. 21, [illegible] second [illegible] gear wheels [illegible]. Reversing is accomplished by [illegible] the [illegible] through [illegible] to change the valve position.

These and similar gears are not, of course, to be taken as in any sense standard; they merely represent applications of perhaps well known mechanical principles which have been used in reversing engines designed for work of a special character, usually under conditions commonly found and with a view to some gain of definite advantages.

It is, however, a noteworthy fact that

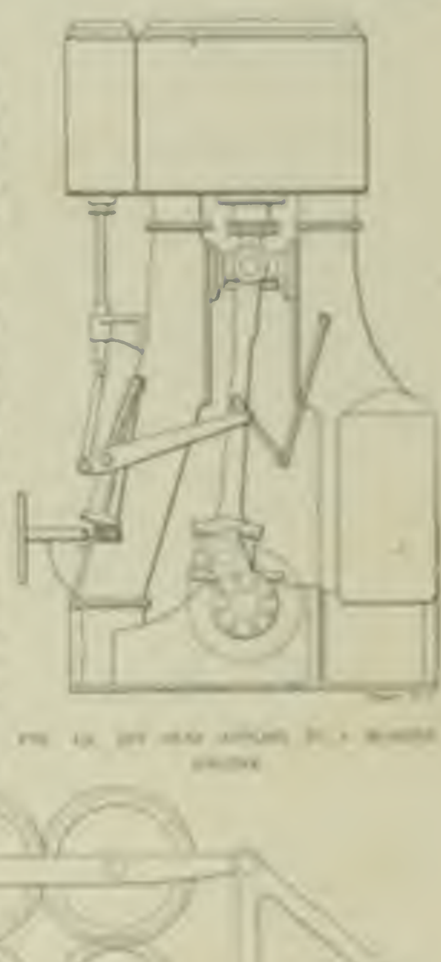

FIG. 19 JOY GEAR APPLIED TO A MARINE ENGINE

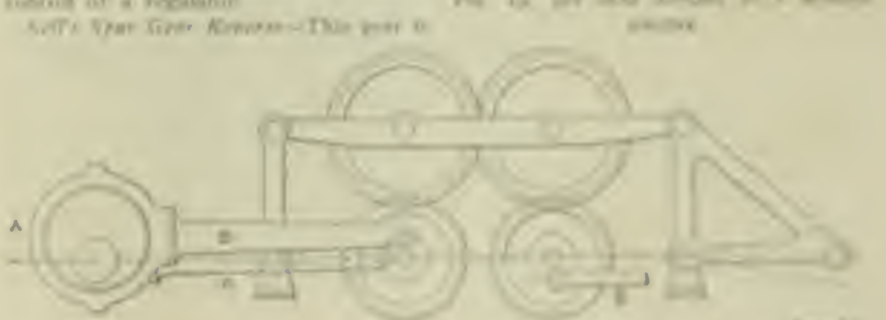

FIG. 21 SELL'S SPUR GEAR REVERSE

with the [illegible] Stephenson and Walschaert gears, these "freak" gears, as they may be termed, [illegible] ence book devoted entirely to them, with uniform diagrammatic sketches showing the various features of similarity and also the essential differences between them, would have in it much of value to the student of steam engineering.

Location and Repair of Troubles in Direct Current Motors

By R. H. Fenkhausen

When trouble develops in a motor, whether it is a failure to start or some other abnormal condition, a systematic course of action should be laid out and followed in each case until the trouble is located. The following tests, if carefully

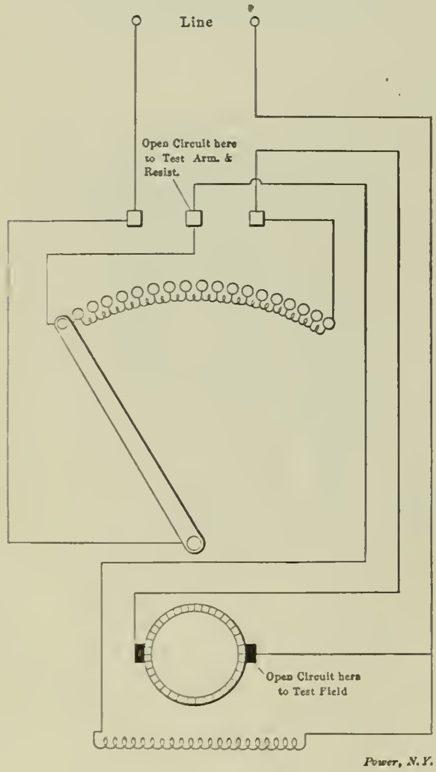

FIG. 1

made in the order given, will result in a speedy location of the fault:

In case the motor fails to start, first be sure that current is on the line, and see that the fuses are not blown, then inspect the brushes and make sure that they are not worn down enough to allow the brush holders to rest on the stops and prevent contact between the brushes and the commutator. If no trouble is found at any of these points, the load should be removed by taking off the belt, and the armature revolved several turns by hand to see if the bearings are free, after which another attempt to start the motor should be made. If it still refuses to start, the trouble is due to an open circuit, or in case of a newly installed machine either an open circuit or an incorrect connection.

Inspect all wiring and connections, to both the motor and the starting device, for loose or open connections and make sure that none of the wires is broken inside the insulation; this frequently occurs and is a very difficult trouble to locate blindly. If no fault is discovered the field-winding lead should be disconnected at the rheostat, the switch closed and the starting lever placed on the first contact for a moment and released. If an arc is drawn the continuity of the circuit through the armature and resistance is proved, and the field-winding circuit may be tested in the same way by replacing the connecting wire and opening the armature circuit by means of a match or piece of paper inserted between each brush and the commutator, and then testing as before. (See Fig. 1.)

If a motor sparks badly it may be due to overload, incorrect brush setting, flats on the commutator or trouble in the field or armature winding. The remedies for the first three troubles are obvious, but in case the windings are at fault the motor should be taken to the shop and repaired, as will be explained later.

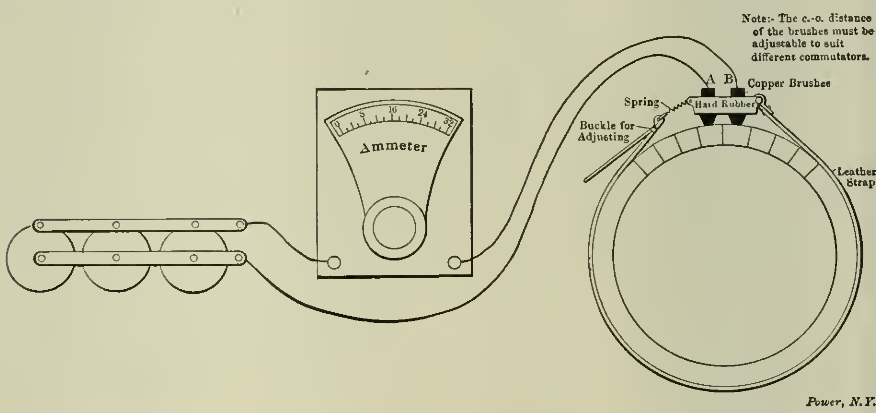

FIG. 2

Sparking due to overloads, improper brush setting or unbalanced field due to burned-out field coils is likely to be continuous, whereas sparking due to open coils, short-circuits or flats on the commutator will be intermittent in character and will occur once or twice per revolution. The sparking due to an open armature coil is readily distinguished by the deep pitting of the mica and rounding of the edges of the bars connected to the faulty coil.

Excessive heating of the windings of a motor may be due either to overload or to a partial short-circuit of the field or armature winding. If a motor becomes dangerously warm the load should be removed and the armature kept in motion, as the heat will be dissipated better than if the armature is stationary. The temperature should fall as soon as the load is removed; if it does not, the trouble will be due to a short-circuit and the motor should be stopped and the windings felt by hand.

A short-circuited field coil may be detected by its low temperature, as it will always be much cooler than the good coils. If two or three armature coils are hotter than the rest of the winding they are short-circuited either within themselves or by the commutator bars to which they are connected, but if the entire armature is hot, the cause will probably be found in a commutator partly short-circuited by oil-soaked mica insulation between the bars.

When the speed of a shunt-wound motor increases, after the field-magnet coils have been overheated, it may be taken as an indication that the field winding is partly burned out and some of the current is passing from layer to layer instead of traversing the entire winding.

In case trouble is located in the rheostat, it should be taken down and the resistance examined for an open coil, which if found may be bridged over until such time as it can be replaced. If the field circuit of the motor tests open, trouble should be looked for in the retaining magnet on the starting box, and if that is burned out or open-circuited in such a way as to make repairs very difficult, and the motor is urgently needed, the magnet terminals may be short-circuited and the rheostat lever tied in the running position. As this leaves the motor unprotected in case the power should be shut off and turned on again before the rheostat lever is released, the motor should be closely watched until such time as the proper repair can be made.

Should trouble be located in a field-magnet coil, the faulty coil should be removed from the motor and untaped. The cause of trouble will usually be found either in broken or short-circuited end connections which are easily repaired; but if the defect is in the inner layers of the coil, the wire must be unwound until the faulty place is located. If the insulation of the wire is so badly charred that it can be scraped off with the finger nail, a new coil is the only remedy. The burning out of a field-magnet coil is usually the result of a short-circuit of one of the other coils, which overloads the remaining coils and burns them out.

Open circuits in armature coils usually occur in the end connections leading to the commutator, where they are easily repaired without removing the armature, but in case the open circuit is inaccessible or the coil is short-circuited, and temporary repairs must be made, the faulty coil should be entirely disconnected and the commutator bars to which it was connected short-circuited until such time as proper repairs can be made. If a coil is short-circuited it will also be necessary to cut each turn of the coil or else sufficient heat may be developed to destroy the adjacent coils.

Most of the repairs previously mentioned can be made in a short time and without removing the motor from service, but in case the trouble is serious the motor must be taken to a shop, where proper facilities exist, for the accurate location of trouble and its speedy repair.

Owing to the low resistance of an armature winding the location of open, grounded, or short-circuited coils with a magneto or test bell is impossible and use must, therefore, be made of some instrument sufficiently sensitive to detect small differences in resistance, such as a Wheatstone bridge. These instruments are not often available and some substitute must be devised. Fig. 2 shows a testing outfit, the materials for which may be found in almost any plant, and which is sufficiently sensitive to locate an unsoldered or partly broken connection.

A few cells of dry battery having low internal resistance and high amperage should be connected in parallel, 1/16x[illegible] inch copper ribbon being used for connections, as shown. These batteries should be in series with a low-resistance ammeter having a 20- or 30-ampere range and flexible testing leads connected. All wiring should be at least No. 8 Brown & Sharpe gage, with all connections as short as possible, the idea being to make the resistance of the testing outfit small as compared with that of the armature. If terminals *A B* are brought in contact, the armature indication should be very nearly full scale. The brushes and ring shown in Fig. 2 should be applied to the commutator, with the brushes separated a distance equal to the thickness of one bar of the commutator. The brushes should then be advanced bar by bar and a reading taken each time, being sure the surface of the commutator is perfectly clean. If the armature winding and connections are sound, practically uniform readings will be obtained, which in the case of a 5-horsepower 220-volt motor will be in the vicinity of 10 amperes.

If a short-circuited coil or pair of bars is found, the reading will be higher, depending, of course, on the amount of the coil that is affected. If an open-circuited coil is found the reading will be very low, as the current must traverse the entire armature instead of one coil (see Fig. 3), and if two or more open circuits exist the ammeter will indicate zero (see Fig. 4). If the ammeter gives a reading much lower than the standard, but too large for an open circuit and the motor acted as if open-circuited, it will probably be found that a coil is open, but that the broken ends are in light contact inside the insulation. When the motor is started centrifugal force separates the ends and causes an open circuit, which closes again when the motor stops.

When testing for a ground one of the test terminals is clamped to the shaft and the other touched to each commutator bar until the one that gives the highest reading is found. The ground will either be in this bar or one of the coils connected to it.

Trouble with burned-out coils and open circuits is often caused by mica between commutator bars, and if there is reason to suspect this trouble all the bar leads should be taken out of the commutator. This will leave each bar without connection to any other. A pair of test terminals (Fig. 5) should be connected in series with a few 110-volt lamps and the mica between any two segments that will not stand the application of the test terminals without smoking or getting hot.

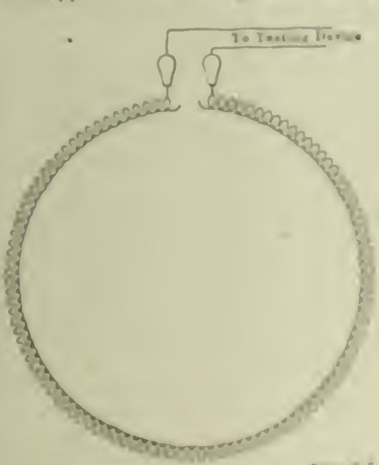

FIG. 3

FIG. 4

FIG. 5

When a commutator wears into one or two large flats it is often due to the segments having been cut at different times and not being of the same degree of hardness. There is no remedy for this, but conditions may be improved by taking the commutator apart and spacing the soft segments evenly around it. When new mica is to be placed in a commutator it must be carefully selected, for if it is too hard it will not wear as rapidly as the copper, and will project above it and cause sparking; and if it is not of the proper thickness trouble will be experienced in assembling the commutator.

A V-shaped tool, slightly rounded on the point and without lip should be used for turning commutators and only very light cuts should be taken; otherwise, small wedges of copper will be drawn over and imbedded in the mica, causing short circuits.

When polishing a commutator after turning only sandpaper should be used; if emery cloth is used small particles of emery will be imbedded in the copper and cause subsequent cutting.

An electric-power plant for Bogotá, Colombia, is projected, according to Consul-General Jay White. At present the streets of Bogotá are not lighted because the electric company, which has its power station [illegible] miles from the city, has not sufficient power to supply the necessary current for both house and street lighting. The site of the new plant is three miles from Bogotá, and [illegible] about the [illegible] of the city. The city could be well lighted with [illegible] arc lamps or with [illegible] lamps and [illegible] incandescent lamps. The cost for the [illegible] is estimated as follows: The [illegible] [illegible] [illegible] and incandescent [illegible] [illegible]

Some Live Steam Separator Tests

Showing Efficiency of Separation Decreases with the Velocity and Increases with the Percentage of Moisture in the Entering Steam

BY PROF. G. F. GEBHARDT*

A number of tests made at the Armour Institute of Technology on steam separators of various types and sizes tend to show that in practically all separators:

(1) The efficiency of separation decreases as the velocity of the steam increases.

(2) The efficiency increases as the percentage of moisture in the entering steam increases.

(3) The drop in pressure increases rapidly with the increase in velocity.

The few published tests of separators conducted by different investigators appear to confirm these results although comparisons are difficult on account of the meagerness of available data.

Fig. 1 gives a diagrammatic arrangement of the apparatus as used in the Armour tests. Steam is led from the boiler through the 8-inch pipe *A* and valve V_1 to the service separator *M*. The steam leaves this separator practically dry and saturated, the exact quality being determined by throttling separator T_1. From this point the steam passes through pipe *P* (the size of which conforms to that of the separator to be tested) to separator *S*, which is to be tested. The quality of the steam entering *S* is varied by a water spray *W*, the temperature of which is maintained at practically that of the steam leaving the separator *S* is checked by separator *B* (two sizes larger than separator *S*) and throttling calorimeter T_2. The pressure in the system is regulated by valves V_1 and V_2 and the pressure drop through separator *S* is determined by gages G_3 and G_4. The weight of steam entering separator *S* was determined by collecting the entrainment in chambers *D* and D_1 and the condensation from the surface condenser. The velocity was calculated, on the dry-steam basis, from

Q_1 = Quality of mixture entering separator,

Q_2 = Quality of mixture leaving separator,

E = Efficiency of separation.

Then

$$Q_1 = \frac{S}{S + W}. \quad (1)$$

$$Q_2 = \frac{S}{S + W - D}. \quad (2)$$

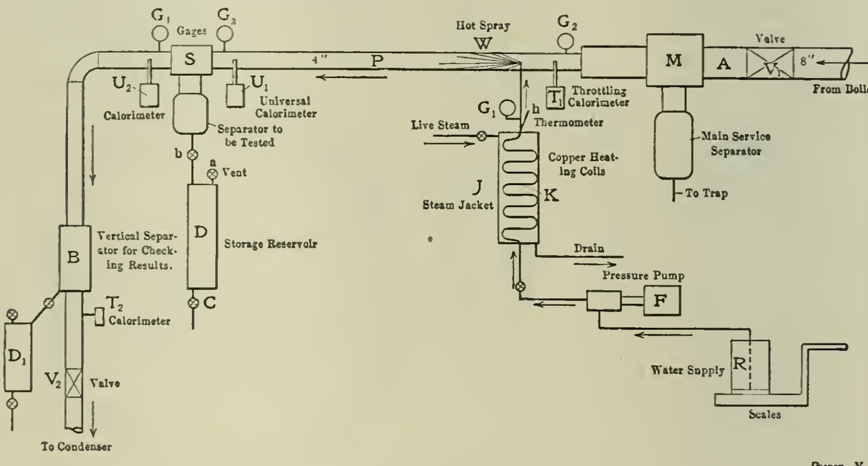

FIG. 1. ARRANGEMENT OF SEPARATOR AND APPURTENANCES

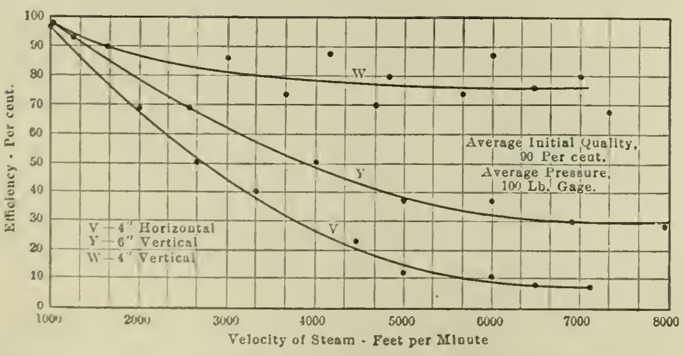

FIG. 2. EFFICIENCY DECREASES WITH VELOCITY

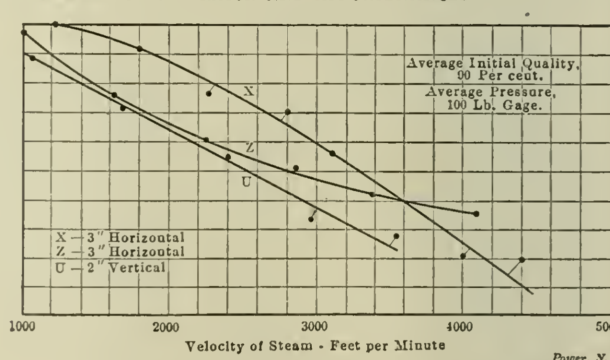

FIG. 3. EFFICIENCY DECREASES WITH VELOCITY

in pipe *P* by means of heating coils *K* and steam jacket *J*. Heating the spray in this manner minimizes the condensation in pipe *P* and insures a more intimate mixture of moisture and steam. The quality of steam entering and leaving separator *S* is determined by universal calorimeters U_1 and U_2. The moisture entrained by separator *S* is trapped in storage reservoir *D* and the weight determined. The quality of the steam the known area of pipe *P*. In draining reservoirs *D* and D_1, valve *b* is closed, vent *a* opened and the contents drained through valve *C*. All pipes and fittings were carefully lagged and all instruments calibrated before and during the test. Let

S = Weight of dry steam entering separator *S*,

W = Weight of water injected by spray *W*,

D = Weight of water removed from reservoir *D*,

This is on the assumption that steam leaving service separator *M* is dry and saturated. If the quality is less than 100 per cent., suitable corrections must be made.

$$E = \frac{D}{W}. \quad (3)$$

From equation (2)

$$D = S + W - \frac{S}{Q_2}. \quad (4)$$

This equation was used in determining

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D from the tests not made at Armour, and in which only S_1, Q_1 and Q_2 were given.

Five different types of separator were tested, and, since the parties for whom the tests were made were unwilling to have the name of the separator published, they will be designated as *U*, *V*, *W*, *X*, *Y* and *Z*.

Separator *U*: 3-inch vertical; no baffles; current reversed once.

Separator *V*: 4-inch horizontal with single baffle plate of the fluted type; steam current reversed once.

Separator *W*: 4-inch vertical with two baffle plates of the smooth type; steam current reversed once.

Separator *X*: 3-inch horizontal; several fluted baffle plates; no reversal of current.

Separator *Y*: 6-inch vertical, centrifugal type; current reversed once.

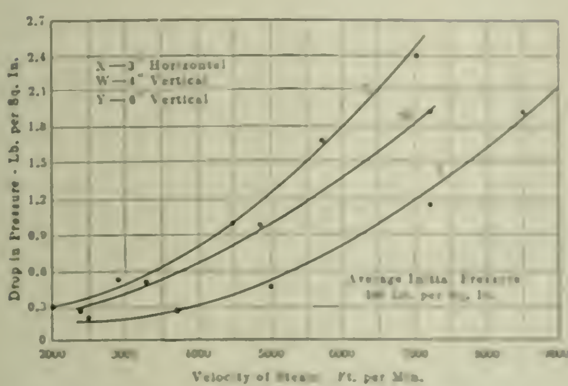


FIG. 5. INCREASE IN PRESSURE DROP WITH VELOCITY

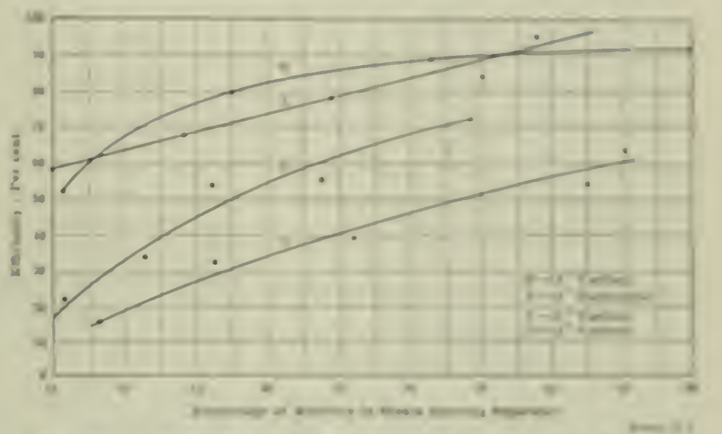


FIG. 4. EFFICIENCY OF SEPARATION INCREASES WITH PERCENTAGE OF MOISTURE

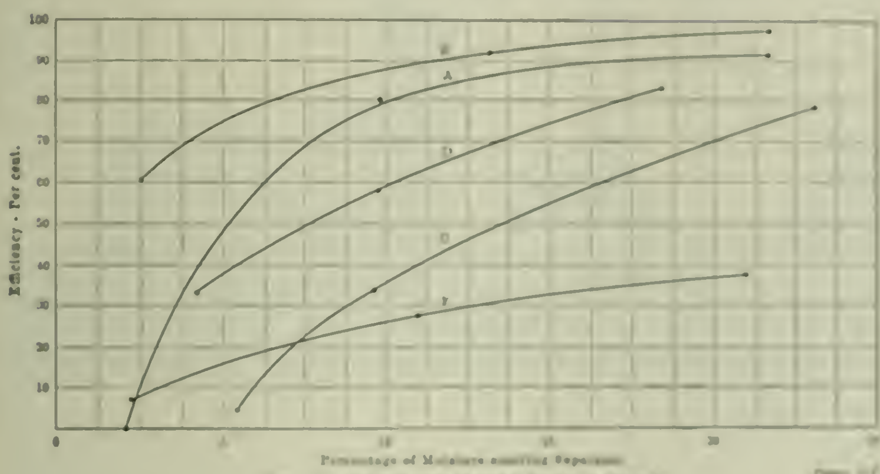


FIG. 6. EFFICIENCY CURVES FROM TABLE 1

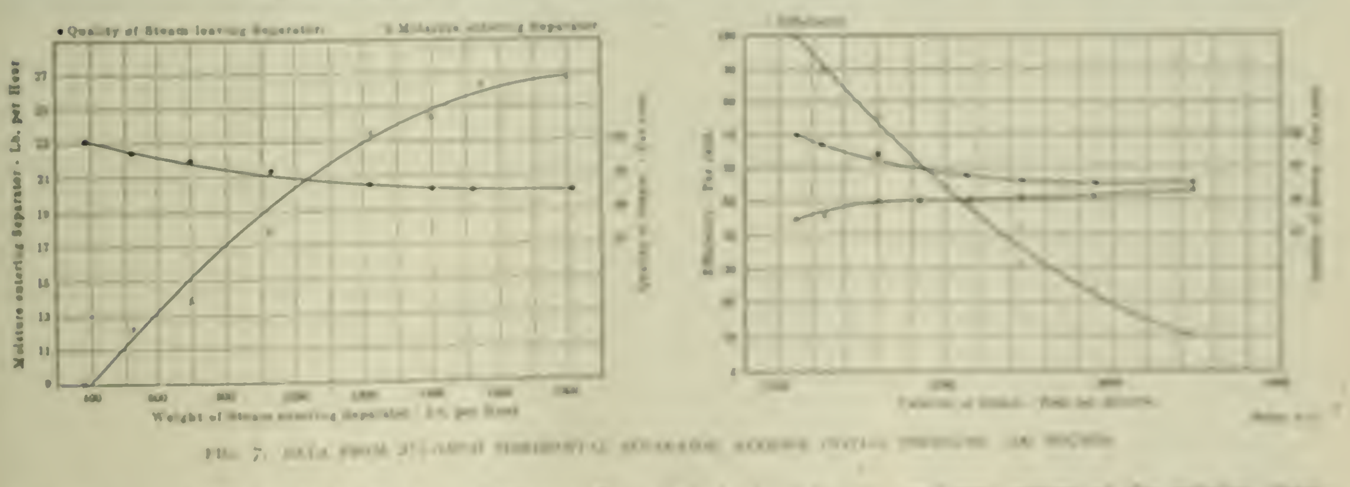


FIG. 7. DATA FROM 3½-INCH HORIZONTAL SEPARATOR [illegible]

Separator *Z*: 4-inch horizontal; current reversed twice; steam impinges on horizontal fluted baffle during reversal.

The influence of the velocity of the steam on the efficiency of separation is shown in Figs. 2 and 3. It will be noted that, the quality of the entering steam remaining constant, the efficiency of separation decreases as the velocity increases and reaches a point where the separator is practically useless.

From Fig. 4 it will be seen that the efficiency of separation increases as the percentage of moisture entering the separator increases. The velocities in Fig. 4 were not the same for all separators and hence the curves are not truly comparable, but a few scattering tests with constant velocities (not included here) show that the efficiencies vary substantially as illustrated.

Fig. 5 shows the increase in pressure drop for different velocities. It will be noted that the pressure curve has a characteristic similar to that for the flow of steam in pipes. The curves in Fig. 6 are plotted from the results of separator tests made by Prof. R. C. Carpenter, Cornell University, on several types of separators.* These curves are similar to those in the Armour tests, Fig. 4. In all these tests the efficiency increases with the moisture content of the entering steam, but there is a considerable variation between the various separators.

The curves in Fig. 7 are plotted from the results of tests at the University of Michigan on a 3½-inch Cochrane separator.

*[illegible]

TABLE 1. TEST OF 2½-INCH GREENAWAY STEAM SEPARATOR.

("The Engineer," March 15, 1906.)

Steam Passing, Lb. per Hour.	Velocity of Dry Steam, Ft. per Min.	Moisture in Steam Entering, Lb. per Hour.	Percentage of Moisture in Steam Leaving.	Efficiency, Per Cent.*
388.0	1095	9.00	0.00	100.0
525.3	1269	12.41	0.25	89.4
698.7	1600	13.69	0.50	75.5
927.1	1835	17.77	0.75	61.2
1218.0	2140	23.45	1.25	36.4
1401.0	2458	24.66	1.30	30.8
1516.8	2900	26.51	1.30	25.4
1815.8	3460	26.71	1.35	10.0

*Calculated by means of formula (4).

TABLE 2. TEST OF A 2½-INCH DETROIT STEAM SEPARATOR.

(POWER, January, 1902, p. 14).

Steam Passing in Lb. per Hour.	Velocity of Dry Steam, Ft. per Min.*	Quality of Steam Entering.	Quality of Steam Leaving.	Efficiency of Separation.†
312	540	88.80	99.90	99.2
429	726	87.06	99.86	99.0
450	840	96.00	99.80	95.5
582	1030	90.54	99.73	97.4
606	1035	90.20	99.70	97.2
732	[illegible]	90.50	99.50	95.0
798	1420	91.90	99.46	93.8
855	[illegible]	94.14	99.43	90.8
900	1505	91.30	99.40	93.5
1008	1850	94.19	99.00	83.6

*Pressure assumed to be 100 lb. gage for comparison.
†Calculated by means of equation (4).

TABLE 3. TEST OF A 2½-INCH LIPPINCOTT SEPARATOR.

("The Engineer," 1902, p. 547).

Steam Passing, Lb. per Hour.	Velocity of Dry Steam, Ft. per Min.	Moisture Entering, Per Cent.	Quality Leaving.	Efficiency, Per Cent.
526	780	24.00	99.92	99.7
747	1100	4.11	99.88	97.3
994	1569	9.45	99.69	97.3
1368	2640	5.00	99.6	92.4

Pressure assumed to be 100 lb. gage for comparison.

TABLE 4. TEST OF A LINDSTROM SEPARATOR.

("The Engineer," June, 1904, p. 439).

Per Cent. Steam Condensed.	Moisture in Steam Entering, Per Cent.	Moisture in Steam Leaving, Per Cent.	Efficiency, Per Cent.
20.0	52.8	0.66	98.9
38.5	49.5	0.22	99.5
48.0	38.5	0.42	99.0
58.0	38.5	0.97	97.5
91.0	39.0	1.20	96.0
95.0	25.5	1.10	96.0
143.0	14.0	2.11	85.0

rator.** The quality of the steam leaving the separator remains practically constant for a wide range in capacity. Plotted on the velocity and efficiency basis, however, the efficiency drops off rapidly with the increase in velocity. An inspection of the "quality" curves shows that although the moisture leaving the separator is very small, the weight of moisture entering is also small. In other words, only a small portion of the water is eliminated.

Tables 1, 2, 3, 4 and 5, taken from the tests of separators of various types and by different investigators, show a decreasing efficiency with increase of velocity. The efficiencies in these tables are high, but it will be noted that the velocities are comparatively low; by plotting these results and continuing the curves to velocities of 4000 feet per minute or more, the efficiencies will fall very low, as in Figs. 2 and 3. The practice of using separators larger than those designed for a given pipe size is apparently a wise one.

TABLE 5. EFFICIENCY TEST OF SIX STEAM SEPARATORS.

("Engineering News," September, 1891, p. 233).

Make of Separator.	Quality of Steam Before.	Quality of Steam After.	Efficiency Per Cent.
B	97.5	99.0	60.0
D	96.1	97.4	33.3
E	98.1	98.5	21.1
F	97.7	97.9	8.7
C	95.6	95.8	4.5
A	98.0	98.0	0.0
Steam with about 10% of moisture.			
B	87.0	98.8	90.8
A	90.1	98.0	80.0
D	89.6	95.8	59.6
C	90.6	93.7	33.0
F	88.9	92.1	28.8
E	88.4	90.2	15.5
Steam with about 20% of moisture.			
B	78.1	98.8	94.5
A	79.5	98.2	91.2
D	81.7	97.9	83.5
C	78.2	95.6	79.8
E	82.4	90.4	45.5
F	79.3	87.2	38.1

The conclusions drawn from the tests are based upon the performance of only a few small separators of different designs and under 6 inches in size and do not necessarily refer to all types and sizes.

A remarkable undertaking for the development of electric power is reported from Halifax, N. S. An application has been made to parliament for a charter authorizing the damming of the head of the Cumberland basin, the basin of Minas and several other streams emptying into the Bay of Fundy, with the object of utilizing the tidal flow to develop electric power for sale in New Brunswick and Nova Scotia. There is a tidal flow of about 40 feet in the Bay of Fundy, from which it is believed that an immense amount of power can be developed.—*Mechanical World.*

****The Engineer*, March 15, 1906.

How the Government Saves Money on Coal

The technologic branch of the United States Geological Survey reports that the plan inaugurated two years ago by the Government for the purchase of coal on its heating value has resulted in the delivery of a better grade of fuel without a corresponding increase in cost and with, therefore, a saving to the Government. At the present time, 40 departmental buildings in Washington, the Panama Railroad, more than 300 public buildings throughout the United States, navy yards and arsenals are buying their fuel supplies on specifications the prime element in which fixes the amount of ash and moisture.

Premiums are paid for any decrease of ash below 2 per cent. from the standard at a rate of $0.01 per ton for each per cent. Deductions are made at an increasing rate for each per cent. of ash when it exceeds the standard established by 2 per cent.

It has been demonstrated by the technologic branch, which has charge of the analyses of the coal, that under these specifications the Government has been getting more nearly what it pays for, and paying for what it gets.

The purchase of coal on specifications is but one of the activities of the Government looking toward a more efficient use of the fuel resources of the country. Engineers of the Survey are studying the problem in all its phases at the experiment plant, in Pittsburg, Penn. The investigations, by suggesting changes in furnace equipment and in methods of firing the coal, are indicating the practicability of the Government purchasing cheaper fuels, such as bituminous coal and the smaller sizes of pea, buckwheat, etc., instead of the more expensive sizes of anthracite, with a corresponding saving in price. The fuel bill of the Government now aggregates about $10,000,000 yearly, the saving on which, through securing coal containing less ash, alone amounts to $200,000.

Since the Government has been purchasing coal on the basis of its heating value a growing interest has been manifest on the part of manufacturers and the general public in this important subject and a demand has been created for authentic information concerning the results accomplished. In response to this demand the results of the Government's purchases of coal under the heat-value specifications for the fiscal year 1907-8 have been assembled in a bulletin just issued by the Survey in the hope of promoting a better understanding of this method of buying fuel. John Shober Burrows, the engineer in charge of this part of the fuel problem, has included in the bulletin a list of the contracts with abstracts of the specifications for the current fiscal year.

In explaining the nature of the specifications, Mr. Burrows says:

"Government specifications are drawn with a view to the consideration of price and quality. For manufactured articles and materials of constant and uniform quality they generally can be reduced to a clear statement of what is desired. For coal, however, the variation in character makes this impracticable.

"This lack of uniformity is the feature recognized and provided for in the coal specifications prepared by the Geological Survey. Under these specifications, bidders are requested to quote prices on the various sizes of anthracite, a definite standard of quality being specified for each size, and to furnish the standard of quality with price for bituminous coal offered. Awards are then made to the lowest responsible bidder for anthracite and to the bidder offering the best bituminous coal for the lowest price. The specifications become part of the contract, and the standards of quality form the basis of payment for coal delivered during the life of the contract. For coal delivered which is of better quality than the standard, the contractor is paid a bonus proportional to the increased value of the coal. For deliveries of coal of poorer quality than the standard, deductions are made from the contract price proportional to the decreased value of the coal. The actual quality and value of coal delivered is determined by analysis and test of representative samples taken in a specified manner by agents of the Government and analyzed in the Government fuel-testing laboratory at Washington. The necessity of paying for coal on a sliding scale was fully discussed by D. T. Randall in a recent paper."

The advantages of buying coal on specifications are explained by Mr. Burrows as follows:

"The advantages of this system of purchasing coal may be briefly summarized as follows:

"Bidders are placed on a strictly competitive basis as regards quality as well as price. This simplifies the selection of the most desirable bid and eliminates controversy and criticism in making awards.

"The field for both the Government and dealers is broadened, as trade names are ignored and comparatively unknown coals offered by responsible bidders may be accepted without detriment to the Government.

"The Government is insured against the delivery of poor and dirty coal, and is saved from disputes arising from condemnation based on the usual visual inspection.

"Experience with the old form of Government contract shows that it is not always expedient to reject poor coal, because of the difficulty, delay, and cost of removal. Under the present system rejectable coal may be accepted at a greatly reduced price.

"A definite basis for the cancellation of contract is provided.

"The constant inspection and analysis of the coal delivered furnishes a check on the practical results obtained in burning the coal."

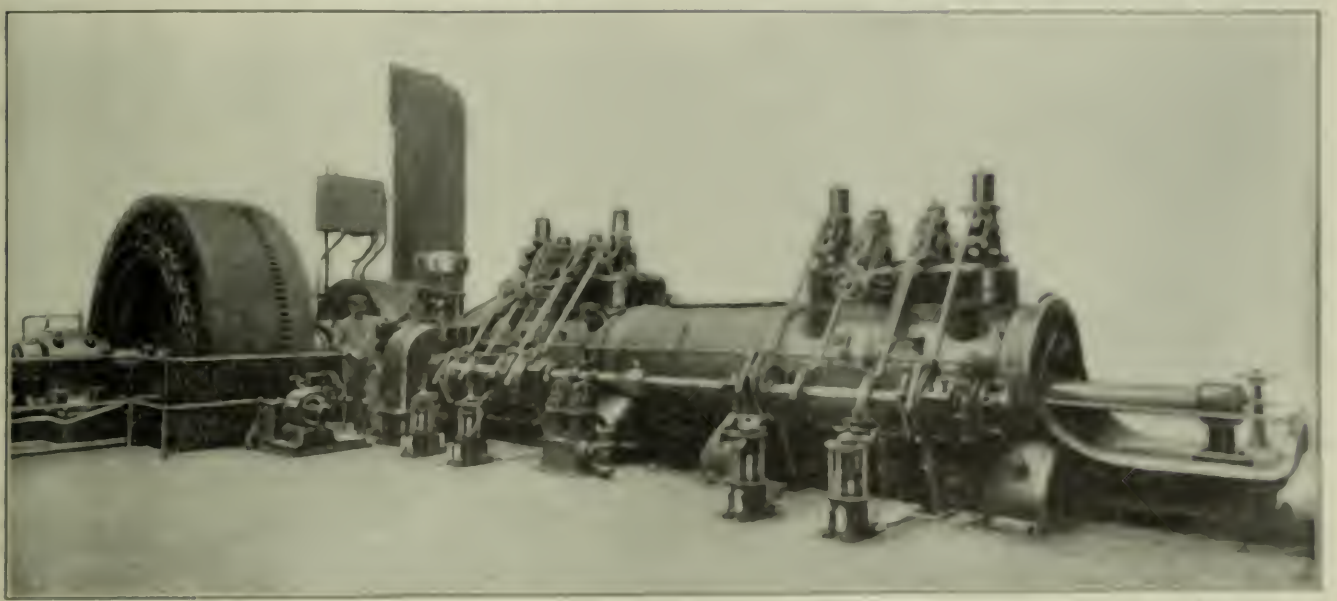
A few years prior to the adoption of the present system the necessity for a uniform standard in the purchase of coal became apparent to a few of the Government departments, and the idea of purchasing on the heat-value basis was introduced. It proved successful, especially in the treasury department, under which purchases are made for the postoffices and other public buildings throughout the United States. The treasury department had at that time a well-equipped laboratory and was thus enabled to do all of the necessary testing. Other departments were unable to follow the example of the treasury department because of lack of laboratory and proper facilities. In 1904, at the Louisiana Purchase Exposition in St. Louis, the Geological Survey began a comprehensive study on a practical scale of the utilization of coal, J. A. Holmes being placed in charge of the work. These investigations are still in progress at Pittsburg, Penn., and they have resulted in making authentic information of great practical value available to the public as well as to the Government departments.

This work led up to the development of a general and uniform specification plan for purchasing the Government coal supply.

A Nuernberg Gas Engine Running on Mixed Gases

By J. B. Van Brussel

There was recently installed in the power plant of an English steel works, a gas engine of the Nürnberg type, which is giving continuous service on a fuel composed of coke-oven and blast-furnace gases, mixed with air, of course. The engine is directly coupled to a three-phase alternator generating current at 550 volts and 50 cycles; this current is supplied directly to various motors at the colliery, coke ovens, steel works, etc., while for use at the works [illegible] power for pumping, [illegible], grinding mill, etc., the [illegible] is transformed to [illegible] volts. The engine is of the standard double-acting tandem type with cylinders 39 inches in diameter and a stroke of 51.2 inches. It gives a continuous output of 900 brake horsepower. At each end of each cylinder there are a single inlet valve and an exhaust valve, operated by means of eccentrics; there is also a gas-inlet valve regulated by a cut-off, under the influence of the governor, which regulates the quantity of gas in the mixture to suit the load.



A 900-BRAKE-HORSEPOWER NUERNBERG GAS ENGINE

The engine fuel consists of 10 per cent. coke-oven gas and 90 per cent. blast-furnace gas, the latter being obtained from a furnace delivering 120 tons of pig iron per twenty-four hours. The furnace is provided with only a single bell, and after leaving the furnace the gas enters a very large dust catcher from which the dust is drawn every other day. From the dust catcher the gas passes through a main 164 feet long into the scrubbers, which consist of eighteen vertical wrought-iron pipes, 15 inches in diameter and 46 feet high. The coke-oven gas pipe joins the blast-furnace gas pipe before the gas enters the scrubbers. Water is injected into the condensers twice a week for three hours. This serves to remove any dust which may have collected there. The boxes on which the scrubbers stand are cleaned once daily, being flushed out by a stream of water supplied through a rubber hose. After leaving the scrubbers the gas is finally cleansed in a Theisen washer before passing to the engine. Because of the scarcity of water in the neighborhood of the works, the water is used several times over in the washer, for a period of a fortnight. The dirty water flows from the Theisen washer to settling pools, and the clean water is pumped to an elevator tank, whence it flows once more to the Theisen washer. By this practice the actual consumption of water for cleansing the gas is said to be only 0.25 liter per cubic meter of gas, and the quantity circulated is from 1.75 to 2 liters per cubic meter of gas. The cleansing is very effective; the content of dust per cubic meter of gas amounts to only 0.013 to 1.007 grams, consequently it has been possible to run the engine continuously for seven months, Sundays excepted. One cubic meter of the coke-oven gas has been estimated to contain about 2.5 to 3 grams of sulphur. To reduce this sulphur, which has an injurious effect on the exhaust pipes, etc., a special purifying plant has been installed which reduces the sulphur to less than 0.25 gram per cubic meter.

Each time the blast-furnace bell is lowered the pressure of the gas falls from 4.5 inches of water to zero, rising again as soon as the bell is closed; but notwithstanding this, the gas engine has run very regularly, and the governor has been able to deal with all the variations of gas pressure and composition. The calorific value of the mixture is from 125 to 135 B.t.u. per cubic foot. If a tuyere at the blast furnace has to be changed and the blast taken off, air is admitted to the furnace through the tuyere peepholes, and, the furnace bell being closed, the furnace acts by virtue of its natural draft as an ordinary gas producer. The quantity of gas then delivered is sufficient to supply the engine.

With the exception of a steam engine for the blowing plant and one for the rolling mill, there is no steam equipment now in operation at the steel works where this gas-engine plant is installed, which indicates the degree of reliability that is confidently expected of the engine.

Heat Value of Coal from Dulong's Formula, Based on Ultimate Analysis

By N. A. Carle

Coal is organic matter that has undergone chemical changes and to which mineral impurities have been added. The chemical changes of carbon, hydrogen and oxygen from cellulose through the various stages to anthracite is indicated by the following table showing the average ultimate analyses:

Material.	Carbon.	Hydrogen.	Oxygen.
	Per Cent.	Per Cent.	Per Cent.
Cellulose	44.4	6.2	49.4
Wood	50.0	6.0	44.0
Peat	59.0	6.0	35.0
Lignite	69.0	5.5	25.5
Bituminous coal	82.0	5.0	13.0
Anthracite	95.0	2.5	2.5

These figures show that the transformation is accompanied by an increase in the percentage of carbon and a decrease in the percentages of hydrogen and oxygen. Sulphur and nitrogen are usually present, especially in bituminous coal and anthracite, but in showing the transformation of the elements carbon, hydrogen and oxygen, the percentages of sulphur and nitrogen are not included. The table is given merely to show that the elements of any fuel will vary in the percentages of carbon, hydrogen and oxygen.

Ordinary fuels contain foreign matter usually classed as impurities, consisting of moisture, nitrogen, sulphur, ash, dirt, etc. Of these, the sulphur has capacity to produce heat, but the nitrogen is inert and is usually classed with the moisture, ash, dirt, etc., as impurities.

The heat value of a fuel may be determined with more or less accuracy by any one of three methods, namely, chemical analysis, combustion in a calorimeter, or actual trial under a steam boiler. The first two methods give what may be called theoretical values and the third the practical value. The accuracy of the first two methods depends on the precision of the method of analysis or calorimetry adopted and upon the care and skill of the operator. They give with considerable accuracy the heat value which may be obtained under the conditions of perfect combustion and complete absorption of the heat produced.

The results of the third method are subject to numerous sources of variation and error, and may be taken as approximately true only for the particular conditions under which the test is made. There may be more or less imperfect combustion and numerous and variable losses. It may give the highest practical heat value if the conditions of grate area, draft, heating surface, method of firing, etc., are the best possible for the particular fuel tested, and it may give results far beneath what can be accomplished if the conditions are adverse or unsuitable to the fuel.

This article is intended to cover only the determination of the probable total heat of combustion from the chemical analysis. The calculation of the heat value of any fuel from the chemical analysis assumes that the heat value of the fuel will vary in accordance with some definite law based on the relative amounts of carbon, hydrogen, oxygen and impurities.

The total heat of combustion of any fuel is approximately equal to the sum of the heat values which could be produced separately by the combustion of its constituent parts. When oxygen and hydrogen are present in the proportion of one part of hydrogen to eight parts of oxygen, by weight, water is formed and these constituents have no effect in making up the value of the total heat of combustion. If a large quantity of water is thus formed, the latent heat of its vaporization must be deducted from the probable total heat of combustion. However, for the commercial fuels ordinarily encountered in the regular market, the heat necessary to vaporize the amount of water formed during combustion can be neglected.

The formula in general use is that known as Dulong's formula and is as follows:

$$Q = 14{,}500\ C + 62{,}000\ \left(H - \frac{O}{8}\right) + 4000\ S,$$

where

Q = B.t.u. per pound of fuel,

C = Percentage of carbon by weight per pound of fuel,

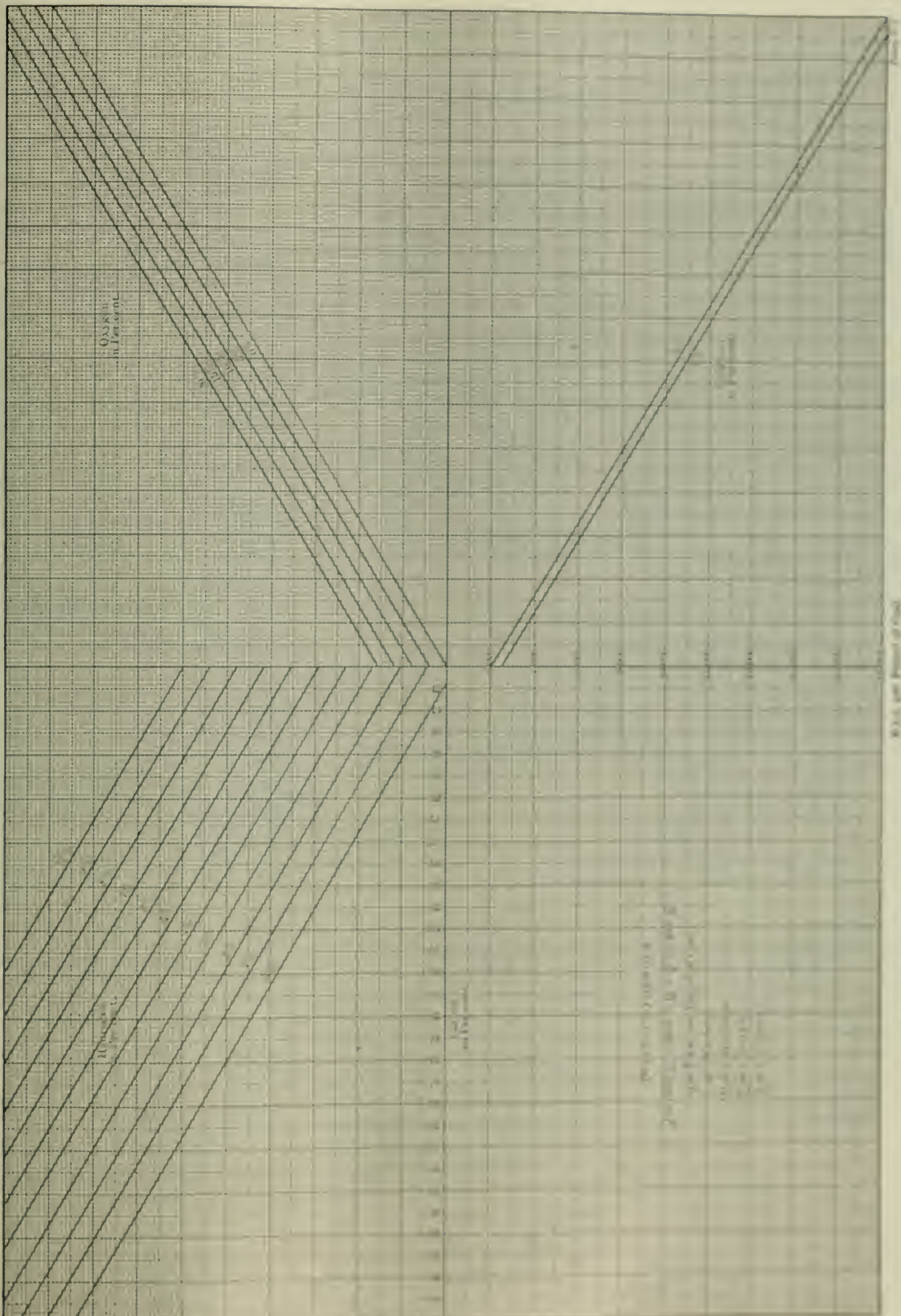
H = Percentage of hydrogen by weight per pound of fuel,

O = Percentage of oxygen by weight per pound of fuel,

S = Percentage of sulphur by weight per pound of fuel.

The impurities consisting of moisture, nitrogen, ash, dirt, etc., are not taken into account directly in the formula, but the percentages of the constituent parts in the formula are those per pound of fuel and their sum will be less than 100 per cent. by the amount of the impurities which are considered inert.

The chart, on page 839 is intended to show graphically the heat value of fuel as calculated by Dulong's formula. It is to be noted that the oxygen values subtract from the sum of the carbon and hydrogen values. This allows for the formation of water by the combination of hydrogen and oxygen, if they exist in the proper proportion. The added heat value due to the



sulphur is small because the percentage of sulphur is usually small and its heat value is low. In fact the sulphur can usually be neglected. The chart indicates very clearly that the elements carbon and hydrogen are the governing factors in the heating value of any fuel.

Examples

(1) If the ultimate analysis of a bituminous coal showed the following proportions, by weight, what would be the heat value per pound of this coal according to Dulong's formula?

	Per Cent.
Carbon	70
Hydrogen	5
Oxygen	10
Sulphur	2½
Impurities	12½
	100

Starting with 70 per cent. carbon, on the horizontal scale, read up to 5 per cent. hydrogen, then across to 10 per cent. oxygen, then down to 2½ per cent. sulphur and across to approximately 12,600 B.t.u. per pound of coal.

(2) Suppose the ultimate analysis of a semibituminous coal showed the following values by weight:

	Per Cent.
Carbon	80
Hydrogen	5
Oxygen	8
Sulphur	0
Impurities	7
	100

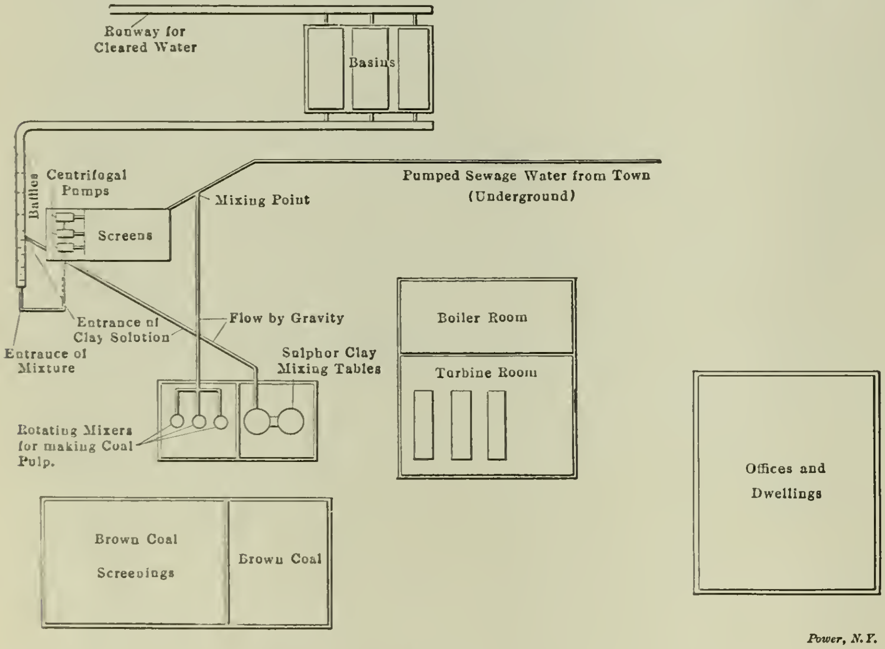
What would be the heat value per pound of this fuel according to Dulong's formula?

Starting with 80 per cent. carbon, read up to 5 per cent. hydrogen, then across to 8 per cent. oxygen, then down to 0 per cent. sulphur and across to approximately 14,100 B.t.u. per pound of coal.

Sewage and Brown Coal as Fuel

By R. W. Rogers

An interesting departure in the use of lignite, known as *jünger braun kohle*, is exhibited in the city electric-light station of Copenick, a town near Berlin with a population of some 30,000 and containing a number of factories, such as nitric-acid works, die works, washeries, etc. About three years ago it was decided to install an electric-light plant, and after careful consideration conclusions were reached to make some use of the city sewage waters as a possible fuel medium, and at the same time eliminate the contamination of the neighboring river water. In the process finely ground coal is used as a deodorizer in connection with a clay containing sulphur, aluminum sulphate, as a cleansing agent. Thus the object of the plant was to clean the waste water and give a practical use for the brown-coal dust, which otherwise is of very little value. The coal dust used is simply mine screenings with a chemical analysis of 61.5 per cent. carbon, 5.5 per cent. hydrogen, 33 per cent. oxygen and a heating value of 9000 B.t.u. per pound.



GENERAL OUTLINE OF COPENICK PLANT

A summary of the process is as follows: The brown-coal screenings are ground up fine and mixed with clear water to form coal pulp. This pulp is led by gravity to the intake of the sewage water, and mixed in the general ratio of one pound of coal to 8 cubic feet of sewage water. This solution is pumped by centrifugal pumps to an open conduit provided with numerous baffle walls and with a sufficient incline to reduce the initial velocity of about 9 feet per second to less than 1 foot per second at the outlet. Near the entrance to the conduit the sulphur clay is added, which is in the form of a liquid mixed in the proportion of one pound of clay to 16 U. S. standard gallons of water. This solution flows by gravity from elevated mixing tanks, and 1 cubic foot of the solution to 75 cubic feet of sewage is admitted to the conduit. The final mixture continues a zigzag path around the baffle walls, which gradually reduce its velocity of flow before it enters the clearing basins.

These basins are three in number and are approximately 700 feet long by 150 feet wide, with a slope of about 1 foot in 200 feet. In these basins a rapid settling takes place, leaving the water practically clear. It is then conducted to the neighboring river free from all contaminating ingredients. The three basins are used as follows: One is being filled while the second is allowed to evaporate and the third is being cleared of its *schlammkohle*, as the product is called. In summer a basin is cleared every three weeks, while in winter it generally takes from five to six weeks to obtain the product.

The product obtained from the basins looks like brown coal and is handled very easily, being dug out and carted to the storage bins. Owing to the moisture content, which varies from 25 to 35 per cent. in summer to 60 or 70 per cent. in winter, a correspondingly greater or less amount of brown coal is burned with it. On the average one pound of brown coal to four of the *schlammkohle* is used in summer, while in winter it is necessary to burn half as much brown coal as *schlammkohle*. The grate is composed of narrow slanting bars, and the resulting ash is hard, but easily removed. The product naturally varies in heating value from time to time, depending on what factor is most active during the period of settling, and as a consequence no definite figures can be given.

Commercially, the plant is reported as being highly satisfactory, the cost of operation per kilowatt-hour being 1.25 cents, while the fuel cost is 0.25 cent. The electrical plant consists of three 1000-kilowatt turbo-generators. As to the waste-water end, the plant has a capacity of from 1,000,000 to 1,760,000 cubic feet of waste water per day of 24 hours, and its initial cost in round figures was about $36,000. The plant has been in operation since April 18, 1907, and in its operation requires six firemen, six engineers and one man to tend the water-clearing end, the entire force working in eight-hour shifts.

A few other items in connection with the waste-water plant will undoubtedly be of interest. The time of properly mixing 200 pounds of the sulphur clay is one hour; 5.35 cubic feet of coal pulp gives one pound of *schlammkohle*; 350,000 cubic feet of waste water gives from 65 to 90 pounds of *schlammkohle*. The average percentage of sulphur in the resulting product is 16 per cent.

Catechism of Electricity

1041. *Show a diagram which illustrates this last method applied to two induction motors.*

Fig. 289 illustrates this case. The stator winding of the motor *b* is connected in series with the rotor of the motor *a*, which consequently starts with a strong torque. The motor *b* receives its current at a reduced frequency and therefore starts also with good torque.

1042. *How is one to know the kind of work that can economically be performed by an induction motor?*

An induction motor works well where it can run at full speed with a load that requires to be started only occasionally. It will usually be economical and satisfactory when applied to the same kind of work that could be done well by a direct-current shunt-wound motor. When working at or near full load and at constant speed the efficiency and power factor of an induction motor are at the best.

1043. *In what respect is an induction motor preferable to a synchronous motor?*

It requires less attention.

1044. *What effect does an induction motor have upon the current in the circuit on which it is running?*

It causes the current in the supply circuit to lag behind the voltage and therefore impairs the power factor of the circuit.

1045. *What effect does a synchronous motor have upon the current in its supply circuit?*

It produces a leading current if working under a steady load and with strong field excitation. If, therefore, synchronous motors are connected to the same line with induction motors the leading currents produced by the former tend to neutralize the lagging currents produced by the latter.

1046. *In starting an induction motor by the resistance method, what precaution should be observed regarding the starting resistance?*

Care must be taken before closing the main switch to see that the starting resistance is not short-circuited. If the starting resistance is short-circuited the motor will take excessive current from the line and it may not start at all.

1047. *How long should the starting resistance be left in the motor circuit?*

Only during the starting period. As the motor comes up to speed the resistance should be gradually cut out, and each step of the cutting-out process should be only of such duration as will permit the motor to come up to the maximum speed for that step. At the final step, the rotor winding is practically short-circuited through the brushes. The total time for starting should not exceed thirty seconds.

1048. *When resistance is used for controlling the speed of an induction motor, cannot this resistance be left in the armature circuit as long as desired?*

Yes, because this resistance is specially designed to carry the full current continuously.

1049. *What effect upon the normal output of an induction motor has the resistance generally used for speed control?*

A motor designed for 50 per cent. speed control usually has a resistance of ample capacity to reduce the speed to 50 per cent. of normal without affecting the normal full-load torque. The horsepower output of the motor at the lower speed is therefore 50 per cent. of the normal output and varies in about the same proportion for other speeds less than normal.

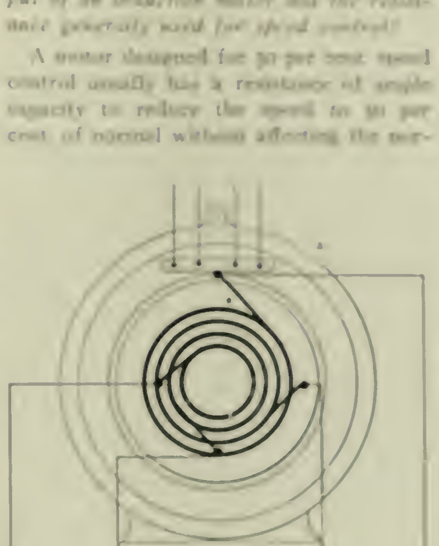


FIG. 289. ARRANGEMENT FOR STARTING AN INDUCTION MOTOR AT LOW FREQUENCY

1050. *If an induction motor fails to start, what may be the cause of the trouble?*

A broken wire or faulty connections. The current fails or is shut off at the station. Excessive friction in the bearings. A blown fuse. The motor switch open. A heavy overload.

1051. *In case the motor stops during operation, where may the trouble be found?*

The same defects given in answer to 1050 will cause a motor to slow down or stop during operation.

1052. *What important points must be considered in the operation of induction motors in which the starting resistance is introduced in the armature circuit through contact rings and brushes?*

The contact rings should be kept clean. The brushes should make proper contact with the rings when the armature is at rest and should be clear of them when the armature has reached its normal speed. New brushes should be installed as soon as there is any danger of the brush-holders striking the rings, and they should be sandpapered to the shape of the ring so that contact will exist over the entire face of the brush. Failure to do this will cause poor contact and sparking, which soon pits the rings and necessitates turning them down to a smooth surface. A little sparking at the brushes and some noise when starting, however, should not occasion alarm, as this lasts but a short time and ceases when the armature has come up to speed and the contact between the rings and brushes has been broken.

1053. *If it becomes necessary to take out the armature, what precautions should be taken in handling it?*

Do not pick up the rotor with a sling, unless it has a spreader to keep the rope or chain from injuring the winding. Do not take out the rotor and set it on the floor without placing a thick, heavy mat under it, or else supporting it by blocks under the shaft so that the rotor core is clear of the floor.

1054. *What mechanical defects may cause trouble?*

The bearings may become worn and need renewing, in which case the rotor may strike the stator core. The bearings may become scratched and roughened by grit or dirt in the oil. If any such foreign matter is seen, the bearings should be cleaned and the oil renewed. In no case should old oil be used without cleaning it.

1055. *What special attention should be given the starting switch or handle?*

It must not be left in the "starting" position while the motor is connected to the circuit. It must be moved to the "off" position when the motor is shut down.

1056. *Is grease or oil preferred for the bearings?*

[illegible]

1057. *What is frequently the cause of oil coming in contact with the windings?*

Loose bearings caused by the oil being too thin on the bearings, the armature shaft not being level, or the end [illegible] on the bearings not being properly [illegible].

Decrease in Weight of Lignite in Transit

Results of Experiments with Texas Lignite to Determine Changes in Weight and Heat Value Due to Temperature and Humidity Conditions

BY ARTHUR C. SCOTT

There has been more or less contention between shippers and consumers of lignite concerning shortage in weights of carloads delivered, and I believe that such contention is in many instances due to misunderstandings, first, as to the necessary decrease in weight that must occur in transit due to the properties of the lignite and, second, as to the fact that a smaller weight of lignite at the consumer's plant as compared with the weight at the mine does not necessarily mean that the consumer has lost money in proportion to the shortage; on the contrary, the fact seems to be established by data and results that follow that the consumer is actually the gainer in the transaction, provided the loss in weight is not abnormal.

My attention was first directed to the matter because of a shortage in weights of carloads of lignite furnished to the University of Texas by various lignite dealers, and in order to obtain satisfactory information on the matter an attempt was made to calculate the approximate decrease in weight that should occur in transit and, by testing the lignite under different conditions, to determine the loss in heat units due thereto. Through the courtesy of F. E. Merrill, of the Bastrop Coal Company, I was allowed to inspect the mine at Glenham, Tex., and on April 11, 1908, personally obtained from three different localities in the mine samples of lignite as it was being picked out by the workmen. The writer himself placed the samples of lignite, selecting some lumps and some fine material, in glass jars which were sealed in the mine and taken in that condition to the University of Texas. I also went with the superintendent of the mine and the pit boss over the principal portion of the mine, and in no case found water in any considerable quantity. Probably not more than a bucketful of water was seen anywhere in the mine, although there was, of course, some moisture in the air.

The lift from which the samples of lignite were taken was about 87 feet below the surface, and the mine was satisfactorily ventilated. The lignite was picked out with no evidence of any blasting having been done, and the layer of lignite, which varied from about 3 feet to 5½ feet in thickness, everywhere showed good, clean coal. No seams of dirt or rock were observed anywhere interlain with the lignite, and the latter, as brought to the surface in small cars by the elevator, is clean lump, requiring no screening, and is loaded directly into cars, weighed on railway scales and shipped.

Moisture

The three samples of lignite which were taken from the mine to the university were tested for moisture content immediately after the jars were opened, with the following results:

No. 1. Moisture evaporated in one hour by heating at 104 to 107 degrees Centigrade	28.2%
No. 2. Moisture evaporated in one hour by heating at 104 to 107 degrees Centigrade	28.0%
No. 3. Moisture evaporated in one hour by heating at 104 to 107 degrees Centigrade	32.2%

A lump of the lignite was soaked for twenty-four hours in water, and subsequently a test for moisture, made as for the other samples, showed 39.1 per cent. moisture. This indicates that, taking the average of moisture content of the three samples from the given data, amounting to 29.4 per cent., it is possible for the lignite to contain 9.7 per cent. more moisture than it does contain after it is taken directly from the mine, under the general conditions of this particular mine.

Calorific Value

Two attempts were made to obtain the calorific value of samples containing 28.2 per cent. moisture as it came from the mine, but each of the charges exploded in the open calorimeter before a determination could be made, because of the amount of moisture present. Sample No. 2, containing 28 per cent. moisture, was then tried; and a determination was made which showed 7574 B.t.u. per pound. It was evident that the amount of moisture with which a determination could be made was at the limit for the 28 per cent. value, and the other samples were therefore not investigated farther in that respect. The average B.t.u. of the three samples, when a portion was dried at 104 to 107 degrees Centigrade for one hour, was 11,003 per pound of lignite.

Loss by Air Drying

A portion of each of the three samples previously referred to was placed in a tin box, open at the top, and the boxes placed in the thermometer and hygrometer house of the meteorological station at the university. Each sample was weighed twice a day for several days, and once a day thereafter for nearly two weeks, an accurate record of temperature and humidity conditions of the air being kept by means of a recording thermometer and a recording hygrometer placed close to the samples. At the end of the test period for the evaporation of moisture from the samples, the average values of temperature and humidity were ascertained; the charts upon which were recorded the values of humidity were checked with a polar planimeter in order to obtain an accurate average of the humidity during the time that the lignite was exposed, and the results agreed very closely with the average of the records of humidity made each time that the samples were weighed.

The lignite which was exposed in the three samples consisted of lump and moderately fine material which was intended to be as nearly as possible an average of the quality of the coal as loaded upon the cars. The weights taken in the beginning for each of the three samples were as follows:

No. 1	268.80 grams
No. 2	315.65 grams
No. 3	308.70 grams

The percentage of loss of each of the samples was found to be very nearly the same as on the remaining lignite, so that an average is given in the following table of the loss for the three samples. The table also gives the average humidity and the temperature corresponding for the day when readings were taken and the percentage of loss calculated:

1	83	75	2.47
2	84	77	4.73
3	93	68	6.94
4	95	66	6.72
5	83	70	8.15
6	77	74	9.51
7	82	75	11.11
8	67	71	12.58
9	59	67	15.76
10	69	69	18.52
11	69	67	19.48
12	59	63	20.61

Average temperature for first week	72 degrees Fahrenheit
Average temperature for twelve days of test	70 degrees Fahrenheit
Average temperature for one year previous to date of making test	66 degrees Fahrenheit
Average humidity for twelve days of the test	75 degrees Fahrenheit
Average humidity for month of April, 1907	73 degrees Fahrenheit
Average humidity according to "Monthly Weather Review," for one year previous to date of making test	73 degrees Fahrenheit

It will be obvious that the temperature and humidity conditions under which the test was made were about the same as the average over a year's time, and therefore they are fortunately of value in calculating the average loss due to evaporation.

throughout the year. The table shows that on the fourth day of the test there was a slight gain in moisture over that of the day previous, but this is due, without doubt, to the high humidity, the average being 95 for that day.

After exposure to the air, as described for twelve days, during which time the average loss of the samples was 20.6 per cent., determinations were made of heat values, and an average of 9764 B.t.u. per pound obtained. The heat values obtained for the dry lignite (dried for one hour at 104 to 107 degrees Centigrade) averaged 11,003 per pound, as already stated. The data given as to the calorific value of the lignite as a whole show that it is very desirable to determine the precise moisture content of the fuel when comparing determinations of B.t.u. per pound, since the greater the amount of moisture contained in the lignite when the calorific test is made, the lower will be the number of heat units per pound.

Weight Lost in Transit

The specific gravity of average lignite appears to be about 1.25, which would make the weight of a cubic foot about 78 pounds. The size of a car marked "For Lignite Only," with a rated capacity of 80,000 pounds, was found to be 34 feet 4 inches long, 4 feet 2 inches deep and 8 feet 6 inches wide. Assuming that the lump fuel, as loaded upon the car, allows more or less air to circulate to a depth of 6 inches, the number of cubic feet so affected would be 146, and 146 cubic feet of lignite weighing 78 pounds per cubic foot would amount to 11,388 pounds. According to the table, 2.47 per cent. of moisture is lost on the first day, or 281 pounds. After the second day the loss would be nearly twice the amount, and so on up to the twelfth day, when there would be a total loss of something more than one ton on a 40-ton car.

It must be remembered in this connection that the samples which I exposed were standing still, while the lignite on a car is moving for a considerable portion of the time consumed in transit, and whenever the car is in motion there will be a greater rate of evaporation from the surface of the coal than if the lignite were stationary for the same length of time. How much greater the evaporation would be could only be determined accurately by experiment, of course.

Another noticeable and very important result shown by the tests is the effect of alternate wetting and drying; this causes the coal to slack and fall to fine material very readily. It is, therefore, probable that after a carload of lignite in passing from the mine to its destination, is allowed to stand out in the rain, and afterward the sun and movement of air over the surface of the car and the fuel dry it considerably and then another rain strikes the car, considerable of the lignite which started from the mine as lump would be reduced to fine material. When lumps of lignite are exposed to the air-drying process, but water other than the moisture of the air does not reach them, they do not fall to powder but retain their original shape, with the exception that fine cracks run in all directions through the lumps. Of course the lumps can be broken then much more readily than before, and as soon as lumps in that condition come into contact with water they are readily reduced to powdery condition.

Change in Heat Value in Transit

Considering, now, the question of relative number of heat units which would be obtained by the consumer when the coal in transit has been subjected only to evaporative conditions, and presuming that rain has not fallen upon the coal between the mines and its destination, the tests show, for one pound of lignite in the condition at the mine referred to, an average of 7574 B.t.u. per pound. After exposure for twelve days 20.61 per cent. by weight has evaporated, according to the test. If the lignite remained on the car for the full length of that time, the comparative results would be shown as follows: In a carload (80,000 pounds) of lignite having 7574 B.t.u. per pound, there would be 605,920,000 available B.t.u. in the fuel at the mine. It has been shown that for an assumed depth of circulation of air of 6 inches for this carload 11,388 pounds would be affected by evaporation. Since 20.61 per cent. by weight would evaporate in twelve days, the amount lost would be 2347 pounds. This amount subtracted from the 11,388 pounds leaves 9041 pounds, which tests 9764 B.t.u. per pound. The number of available heat units, then, in the top 6 inches of the carload would be

$$9041 \times 9764 = 88,276,324.$$

The remaining weight in the car is 68,612 pounds, and the available heat units for this part of the carload would be

$$68,612 \times 7574 = 519,667,288$$

B.t.u. Then the total heat units available in the carload, therefore, would be

$$88,276,324 + 519,667,288$$

or 607,943,612. Now, the car started out with 605,920,000 available heat units, and there would be, therefore, a gain in available heat units amounting to 2,023,612 B.t.u. on the whole carload, which amounts to one-third of 1 per cent.

It might appear at first thought that there is a mistake here, that the car would not possess more heat units after it has been out twelve days than it had when it started from the mine; but as to the actual heat units contained that is true; the gain is in the available heat units; when the lignite contains a higher percentage of moisture a larger part of the contained heat units are used in the evaporation of the moisture and are, therefore, not available to the consumer for useful purposes. It is evident, therefore, that if a carload of lignite be not rained upon in transit, even though it be on the road for several days, there will probably be no loss in available heat units to the consumer and, moreover, the cost of handling the lignite in the boiler room is slightly reduced, because there is less weight to handle for the same number of available heat units obtained.

It is of material advantage to the consumer to unload the cars into bins and allow the lignite to dry out somewhat before it is used. If the lignite is rained upon, and slacks as a result, of course the loss would occur largely because of the fine material falling through the grates, and would amount to whatever part of the carload is thus wasted. It appears that the large shippers and consumers of lignite might profit materially by building rain sheds to protect cars of lignite that are likely to remain for some days at the terminal of the shipping lines.

The results of the tests above should indicate clearly that a decrease in weight in transit is to be expected, and is certain to occur, and the tests were carried out with such care that I consider that a reasonable approximation may be made as to the probable amount of such decrease for any given case. Of course, the amount lost due to the movement of air over the surface of the cars due to their motion is indeterminate from the present data and I intend to pursue the investigation further to clear up that point if possible. The assumption of 6 inches as the depth to which the air actively penetrated in producing evaporation was made after consulting several consumers of lignite on the point and averaging all opinions concerning the matter.

I propose to visit other mines where probably the moisture content and calorific value of the lignite differ somewhat from those at [illegible], repeat the experiments already made and make supplementary ones, with a view to obtaining results that will further benefit producers and consumers and tend to conciliate unpleasant controversy between them.

Consul Ralph J. Totten writes from Puerto Plata that there are very few windmills used in Santo Domingo, while tanks are much in demand. If Spanish-speaking salesmen could be sent to interest [illegible] the utility of the windmill in connection with agriculture, and much [illegible], a demand could be created. Many portions of this country, especially [illegible], suffer from lack of moisture in the dry season. This difficulty could be overcome by windmill and tank irrigation. [The consul forwards a list of hotel and [illegible] who might be interested in [illegible] which is on file in the Bureau of Manufactures (Department of Commerce and Labor).]

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Packing for Steam Engine Piston

One of the first metallic piston packings consisted of a bull ring and two packing rings, the packing being adjusted by means of springs and packing bolts.

This packing answered its purpose very well when the adjusting was done by men who thoroughly understood doing so, but it was not at all unusual for an engineer to put too much pressure on the packing springs, resulting in a badly cut cylinder and rings. Finally the Z-spring shown in the piston, Fig. 1, was introduced. It was fast becoming the favorite packing, when the "snap-ring" packing was introduced. There being no danger of getting too much pressure on the packing rings by their use, this design of spring soon replaced all other springs for use in large cylinders, but for some reason never came into general use in small cylinders.

As compared to the spring packing the "snap-ring" type could not be considered an improvement.

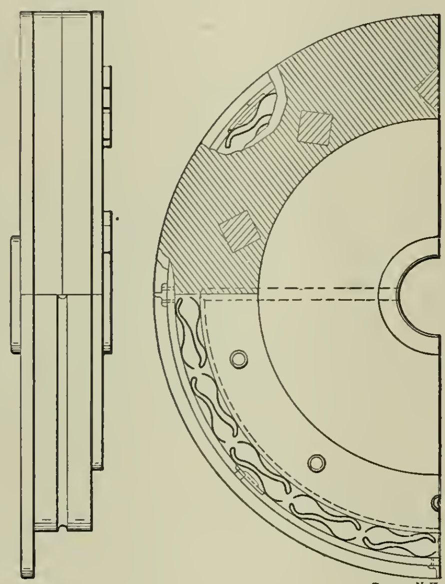


FIG. 1

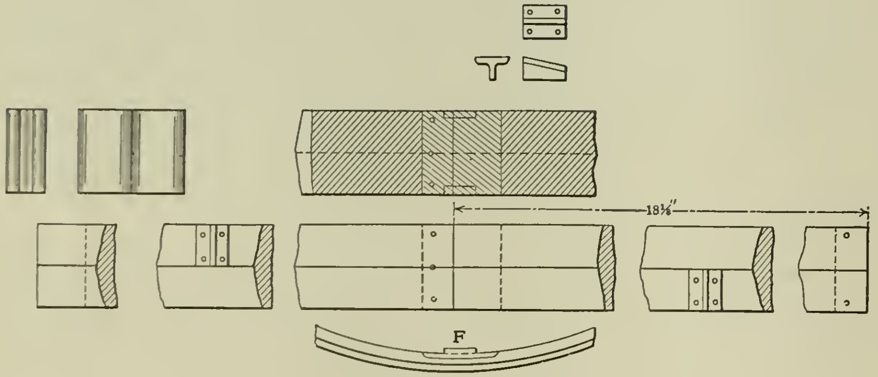


FIG. 3

As a rule, packing rings of all kinds are made from a hard, close-grain metal, usually iron, but I have seen them made from composition metal in a 30-inch piston. Regardless of what hard metal they are made of, the packing rings will wear to a very sharp knife-edge that acts very much like a scraper on the walls of the cylinder. While the hard metal will give lasting qualities to the rings, it will also greatly increase the cutting power of the sharp edges.

It is claimed that a ring must be made of hard metal or it will not be "resilient." This quality can be given a ring made of soft iron by simple round-wire springs, in the shape of rings of the same diameter as the inside diameter of the rings.

One of the first "snap-ring" packings brought out had small "ports" for the live steam to get back of the rings. It was soon discovered that the ports were not required, as the live steam got back of the rings, anyway.

Another very objectionable feature in snap-ring packing is the shoulder worn at each end of the cylinder.

Fig. 2 shows a design of piston packing free from the defects inherent in piston packings as now made. In the cylinder is shown a side elevation of a piston head in half-section. Leading from the packing-spring space into the passage in the piston rod is shown an opening that allows any steam back of the packing rings, due to leakage at the joints of the rings, to escape readily, so that at no time is there more than the pressure due to the springs on the packing rings. The steam can be led to the condenser or exhausted

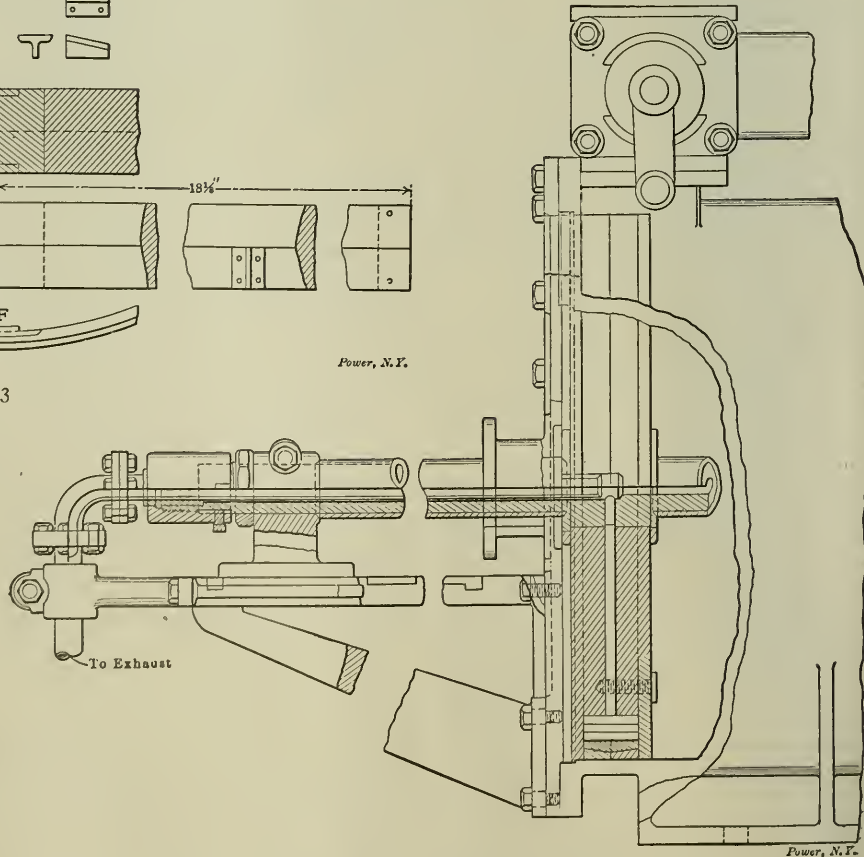


FIG. 2

into the air. If the steam is led to the condenser, the effect of the vacuum on the packing must be given some little consideration when adjusting the springs. Any weakness the springs may develop can be remedied by shims or liners between the springs and the spider.

The bull ring and packing rings are made to form parallel wedges. This allows the packing rings to become self-adjusting for wear at the follower and spider. I believe the angles of the wedges should be more acute than I have shown them in the drawing. The packing will be much more resilient if the members are made in sections.

In connection with the half-plan view of the piston head is shown a side elevation of it, Fig. 1, exposing in half section the shoulder on the spider against which the packing springs bear. The groove shown in the face of the shoulder is a channel for the ready escape of steam due to leakage. Fig. 3 shows a distorted plan view of two sections of the bull ring.

A. H. Hale.

Denver, Colo.

Water Column Connections

The accompanying sketch shows the way the water columns were connected in a small plant in Ohio. The old boiler was properly connected. When boiler *B* was installed it was passed by the inspector before being fired up. As will be seen, there is a 1½-inch nipple on boiler *B*, in which is a cross with a 1¼-inch line to the water column, a ¾-inch line to a whistle and a 1½-inch line across to boiler *A*, which is extended to feed a deep-well pump, a boiler-feed pump and an injector. It will not be hard to imagine how the water acts in the glass on boiler *B* when the boiler-feed and deep-well pumps are running.

With the boiler-feed pump on, the water in the glass would show 2 or 3 inches higher than in the boiler, and when the deep-well pump was started the water would rise about 5 or 6 inches.

It is not necessary to say that after the boiler was put in service it was not long before the water column on boiler *B* was connected independently of the cross line.

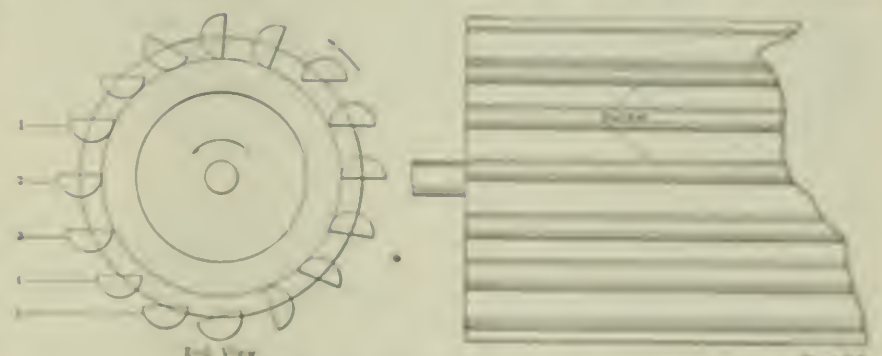
B. L. Monroe.

Fremont, Ohio.

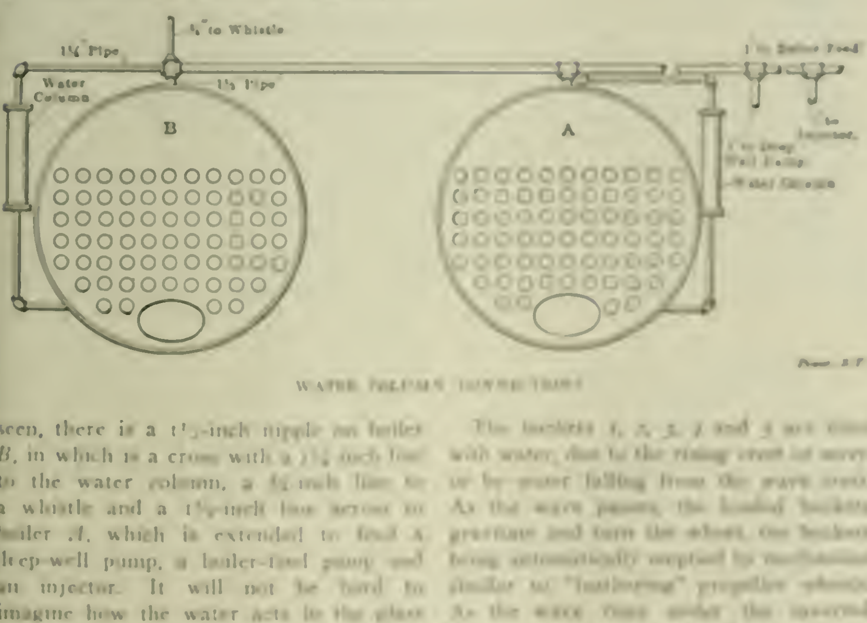
The "Snee" Wave Motor

The description of the "Snee" wave motor in the March 2 number was very interesting. I have read numerous articles relating to this device and had concluded it was in the class in which you put it.

The accompanying sketch is a mere idea, with possibly some features that might prove practical. The bottom of the wheel would be just above the level of the water when undisturbed. I am inclined to think it would at least be as successful as the "Snee" motor.



MR. KOELZ'S WAVE-MOTOR IDEA



WATER-COLUMN CONNECTIONS

The buckets 1, 2, 3, 4 and 5 are filled with water, due to the rising crest of wave, or by water falling from the wave crest. As the wave passes, the loaded buckets gravitate and turn the wheel, the buckets being automatically emptied by mechanism similar to "feathering" propeller wheels. As the wave rises under the inverted buckets it will tend to lift and exert power in the direction of rotation of the wheel as indicated by the arrow.

The direction of the wave motion should have no effect upon the operation and the wheel could be made to operate in either direction by a reversal of the buckets.

Frank G. Koelz.

Milwaukee, Wis.

Graft

I have read with a good deal of interest the letters appearing [illegible] in regard to the subject of graft. Graft permeates the whole business fabric regardless of the position occupied or the amount of salary received by its victims. Engineers are by no means the only class who stoop to this sort of thing, so that when any subject is discussed as applied to engineers, purchasing agents, master mechanics, millwrights, superintendents or whoever, it should not cause others who might belong to any of these classes to get "sore."

That the recipient of graft is dishonest and on the same level with the thief, I am sure every honest man will admit. It seems to me that the blame for this condition of things, which is so prevalent, should not rest so heavily on the victim as on the employer who offers it. The desire to obtain something for nothing is a trait in human nature which lies pretty near the surface and it isn't to be wondered at that many an otherwise honest man falls a victim when temptation comes to him.

When I first came to New York I was told by an employer that I could never do business here without graft, and that in every deal he figured on a certain sum was included as a graft to the engineer or mechanic who "had the say" in the transaction. After more than nine years I am still able to pay my bills and have no prospect of going out of business. [illegible] is the foundation upon which all supplies should stand or fall. So long as I handle a material having merit above that of my competitors I know that I can do business without graft. As a matter of fact, in the eleven years that I have been in the supply business I and my agents have had very little trouble on this score.

Some of my friends are among engineers and I am sure they are as "straight as a string." I have no reason to believe that the graft evil is any [illegible] engineers than with those who occupy positions where the [illegible] can get the work.

Charles F. Chase.

New York City.

Finding Capacity of Tank in Gallons

Recently there appeared a short rule for finding the capacity of a tank in gallons, as follows: "Multiply the square of the diameter in feet by half the length in inches." This was followed by the remark that the result is about 3 per cent. *too low*. This rule-of-thumb, while concise and simple, gives the result about 2 per cent. *too high*.

The rule is evidently found as follows: Let D equal the diameter of the tank in feet and L its length in inches; then its volume in cubic inches is

$$\frac{\pi}{4} 144\, D^2 L.$$

Taking

$$\pi = \frac{22}{7}$$

and dividing by 231, the number of cubic inches in a gallon, we have: Capacity in gallons equals

$$\frac{22 \times 144\, D^2 L}{7 \times 4 \times 231} = D^2 \left(\tfrac{24}{49} L\right).$$

The enunciation of the rule is then apparent from the formula, since

$$\tfrac{24}{49} L$$

is almost one-half the length. But if we use one-half instead of $\frac{24}{49}$, we get a value larger than the true result by

$$\tfrac{1}{98} D^2 L, \text{ or } \tfrac{2}{98}\left(\frac{D^2 L}{2}\right).$$

That is, the result as calculated is 2 per cent. too large. Thus a tank 4 feet in diameter, length 18 inches, holds by actual calculation 141 gallons. The rule gives

$$4 \times 4 \times 9 = 144 \textit{ gallons},$$

and if 2 per cent. of this, or 2.88 gallons, is taken off we have 141.12 gallons, the correct result.

This may appear to be a small item, but its chief trouble is that the rule as given made the result appear to lean toward the safe side, when in fact it does not. It might be assumed in some case coming up that the 3 per cent. would be a safe margin of allowance and lead to error.

W. L. Benitz.

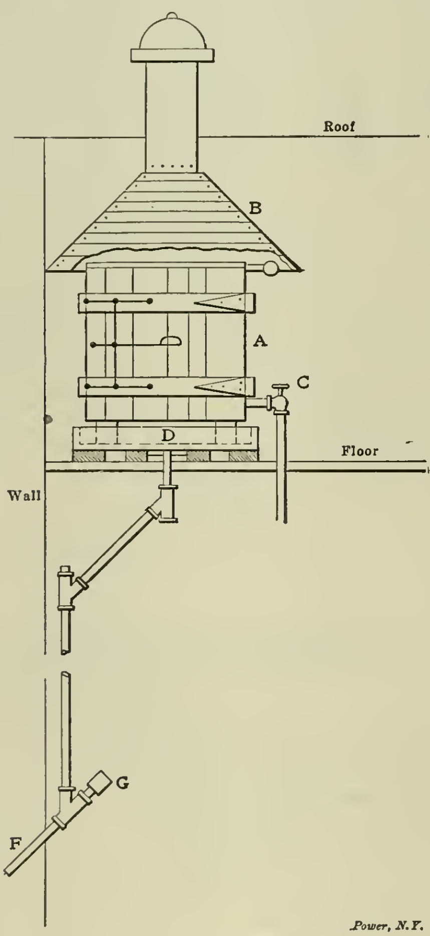
Notre Dame, Ind.

Piping a Steam Box

A steam box used for steaming yarn in a woolen mill was a continuous source of trouble, wherefore the following changes and improvements were made:

Whenever the door A of the box was opened, a cloud of steam would escape into the room, condensing on the machinery and rusting it. This was remedied by putting a hood B over the box, with an outlet through the roof. A slide in the top of the box allows the steam to escape through the hood before the door is opened.

Although the door was made of 2-inch cypress planks, two heavy iron hooks are required to keep it from warping. They are made in such a way that the attendant can open the box without being burned. A valve is required for the live-steam inlet at C. The heavy galvanized-iron pans D rusted through in a few weeks, so we made one of No. 28 gage copper with a brass floor flange sweated on the bottom for the waste-pipe connection. This pan was lined with 1 inch of concrete, with a piece of heavy-wire screen to keep



PIPING A STEAM BOX

the cement from cracking. Four bricks were used to support the box.

Originally the 1-inch waste pipe was connected by 45-degree ells. This pipe frequently choked with rust and dirt, and it was changed to 1½-inch galvanized pipe, connected by Y-branches. Now the pipe can be cleaned out by simply removing the plugs and using an iron rod. The pipe F was outside of the building, and frequently froze in winter. This was remedied by a bushed coupling at G, with a small pipe going through and projecting at F. A cup of hot water poured into the coupling G melts the ice, and the accumulated water comes down with a rush.

Charles Haeusser.

Albany, N. Y.

Air Pumps

One apparent assumption has been, and still obtains, that for a given vacuum a certain air-pump capacity is necessary, without considering in the least the probable variations due to the temperatures and quantities of circulating water. The capacity is usually taken as cubic feet per pound of steam condensed. The practice that a larger air-pump capacity is necessary as the vacuum is increased has some truth in it, provided the conditions are identical, but conditions are the ruling factors.

Consider the varying conditions possible under which an air pump may have to work: The condensed steam may be of low temperature or approaching the vacuum temperature, the circulating-water inlet may be abnormally cold or very little rise may take place, while the amount of air present may be excessive, or it may be practically air free, and after this all kinds of artificial conditions may be created. Another thing of very great importance is the degree of completion of condensation reached by the steam.

Treating first the influence of the temperature of the condensed steam, the most casual student appreciates the fact that the capacity of the pump is increased if the temperature of the mixture of vapor and water entering the pump is low. Another and probably greater influence of this cold water is that of producing on the top side of the bucket a vacuum differing from the condenser by a greater amount than if hotter water were there. This reduction in temperature can be overdone.

Another great advantage gained by the large differences of pressure at the top of the bucket and condenser is the resulting flow of the air and vapor which has a very marked effect upon the results obtained. With hot water approaching temperature due to vacuum, the vapors also have a higher temperature, thus weight for weight these have a greater volume than cold ones, comparatively reducing the volumetric capacity. It is possible to get water so hot as to cause any capacity of air pump per pound of steam to be too small; the vacuum difference between the top and bottom of the bucket being very small, little flow takes place.

In the case of incomplete condensation a different state of affairs exists, and is due entirely to an overloading of the condenser or a shortage of circulating water. The effects are soon evident as, assuming the water passing to the air pump to be cold compared with the temperature of saturated steam at the vacuum obtaining, it is discharged so much hotter that the temperature of the water leaving is as high as that of saturated steam at the condenser pressure, or even slightly higher. Under these conditions the vacuum will gradually fall off until the condenser predominates, or in other words creates a point of equilibrium.

Cause and effect here are not hard to trace and locate. In this case the falling off is due to a large percentage of water vapor, which retains its latent heat and, being present in the air-pump suction pipe, gains access to the pump. The condensed steam takes up the latent heat of this vapor on the discharge or compression stroke of the pump. Thus, a loss of possible vacuum takes place from several causes under conditions such as the temperature of the air-pump suction pipe, the capacity requisite to deal with the gases and the temperature of the vapor on the vacuum forming side of the bucket.

The cases dealing with the air which causes a breakdown in a condenser have already had considerable attention drawn to them by Professor Weighton, D. B. Morison and Professor Josse, but it must not be forgotten that the quantity of air going into a condenser is not nearly as detrimental as the quantity left in. The mixture of air and vapor can only be withdrawn when the temperatures obtaining correspond to the mixture at the various vacua and when the inducing action is such as to avoid all air-pocketing effects. But these temperatures are not necessarily the rules of the situation, as probably in many cases they are the sequence of the pump's rarefying capabilities.

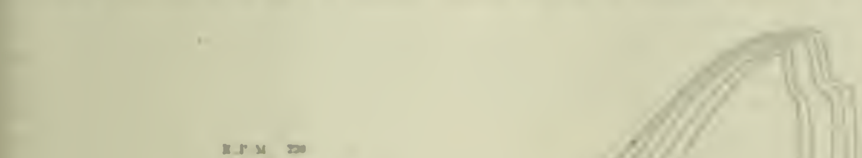
Instances do occur when the pump's capacity and temperatures are such that with a very increased quantity of air the only apparent difference is the power required to work the pump; this indicates that under these conditions the pump has a percentage of its capacity to spare.

G. H. Robinson.

Hartlepool, England.

What Ails the Diagrams?

The accompanying diagrams are from a Harrisburg four-valve engine. A number of engineers have examined them, but none has arrived at the right conclusion as to what is the matter.

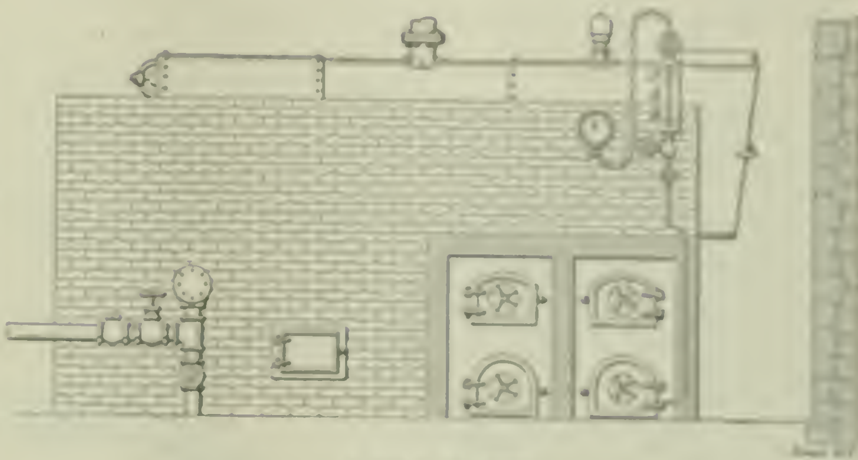


Wark & Ferry Co.

Philadelphia, Penn.

An Oddly Set Boiler

The peculiar expedients which must often be devised in the erection of power generators and machinery in places where the economical utilization of space is the thing most to be desired, or where the



AN ODDLY SET BOILER

work must be adapted to adverse conditions in the shape of narrow and restricted quarters, insufficient head room, etc., are exemplified in the accompanying sketch, which shows the method resorted to in setting the furnace for a horizontal return-tubular boiler, in order that it might be crowded into the space set apart for a boiler room in the basement of an apartment building.

In all essential details the setting conforms to the usual practice with boilers of the type in question, except that the exigencies of the job necessitated placing the furnace [illegible] of the boiler, as shown.

Another objectionable feature of the arrangement is the close proximity of the basement wall to the flue breeching, which makes the job of cleaning the tubes particularly annoying, inasmuch as it has to be performed with a scraper having a [illegible] made up of [illegible].

A. J. Dixon.

Chicago, Ill.

Kerosene in Boilers

While I do not say that kerosene will clean the scale from every boiler, I know it got the [illegible] of a bad lot at one time. I had only one Manning boiler to run an electric plant with. We had a spring that supplied pretty water enough, with the help of a few [illegible]. In a short time we had a pretty dirty boiler, and sent some of the water to be analyzed and some of the scale to be tested for a compound. We used two barrels of the compound and the boiler kept getting worse.

One night I took a piece of scale and stood it up in a pail with about 2 inches of kerosene in it. The next morning the scale was so soft it would [illegible] to be lifted out of the pail. I decided to try kerosene. I [illegible] oil feeder and kept it feeding drop by drop day and night, and in about a week the scale began to come down in [illegible] from [illegible] to 1 inch thick, and some of it was a foot long. For two weeks or more I had to blow the boiler down every morning and take a bucket of scale from the tube sheet. In a couple of months I had a practically clean boiler.

Now, [illegible] of the kerosene oil [illegible]. [illegible] I think it would do any good to pump 2 gallons a day, [illegible] I also think [illegible] something to do with it.

I have found that kerosene will [illegible] [illegible] will not attempt to say that it will not, but I will say that I never had any trouble from it. Even if it did do so, I should have said that the oil did a good job. While I do not belong to the oil trust, I am booming kerosene for boiler scale in some cases.

E. A. Young.

Isabella, Tenn.

Bridgewalls in Theory and Practice

Mr. Wakeman's Fig. 1 is unquestionably wrong, as the wall is too close to the shell of the boiler. Fig. 2 is worse, as it would undoubtedly, in addition to choking the draft, fill to a considerable extent the combustion space back of the bridgewall. But the engineer referred to was certainly right in his theory, his error in Fig. 1 being in too small a space between wall and shell which should be 8 inches instead of 3½ inches.

Mr. Wakeman says, in effect, that the bridgewall is only a barrier to prevent firing coal too far back. In his case and in many others he is certainly right, but he fails to recognize that it is also possible, if properly done, to make it a great aid to combustion, especially in burning the gas from "soft" coal. It is also true, but to a less extent, in burning "hard" coal.

I. J. Babcock.

Chicago, Ill.

Exhaust Steam for Heating

On the editorial page of the March 23 number is an article on the use of exhaust steam for heating. The trouble with this idea is that judgment is not always used. While it is well known that if all the steam that a simple and cheap engine will exhaust can be used for heating purposes, there are cases where it requires some foresight in order to use it economically.

One of these cases is the heating of buildings through about six months of the year. That may require all the steam, and during a large part of the remaining time exhaust will be going to waste. Should the engine be large enough to run noncondensing for the winter, it will be too large for summer, when running condensing.

Another point has come under my observation. A mill has water and steam power. They have the idea that as long as the steam is used for heating it costs nothing for power and so they do not run their wheel in winter, but do all their work with the engine, and on warm days a great deal of exhaust goes to waste.

Whether there is saving or loss by this proceeding is not known, as they keep no record of coal burned and only know that at the end of the year a certain amount of money has been paid for coal, but as they have been told that exhaust costs nothing for heating they carry out the practice stated.

Another case is of a concern that put in a condensing engine 18 and 36 by 42, running at 120 revolutions. For some reason the exhaust from this engine is 12 inches in diameter.

With a vacuum of 28 inches in the exhaust pipe, and that pipe being just perceptibly warm to the hand, at 450 horsepower there is but 10 pounds vacuum in the cylinder, and at 500 horsepower but 9 pounds. What it will be when the engine gets its load of 650 horsepower remains to be seen. The ports of the engine are about right for 75 revolutions.

In the vicinity is an engine 16 and 30 by 42, running at 100 revolutions, with a 12-inch exhaust. The exhaust is used for heating in winter and works well. This engine never has had a condenser.

The first-named concern has been advised to expend about $3000 to change its piping so as to use the exhaust in winter, with the single idea that it is cheaper to run noncondensing when it is possible to use the exhaust for heating, and reference is made to the second-named concern as using a compound engine for heating the shop.

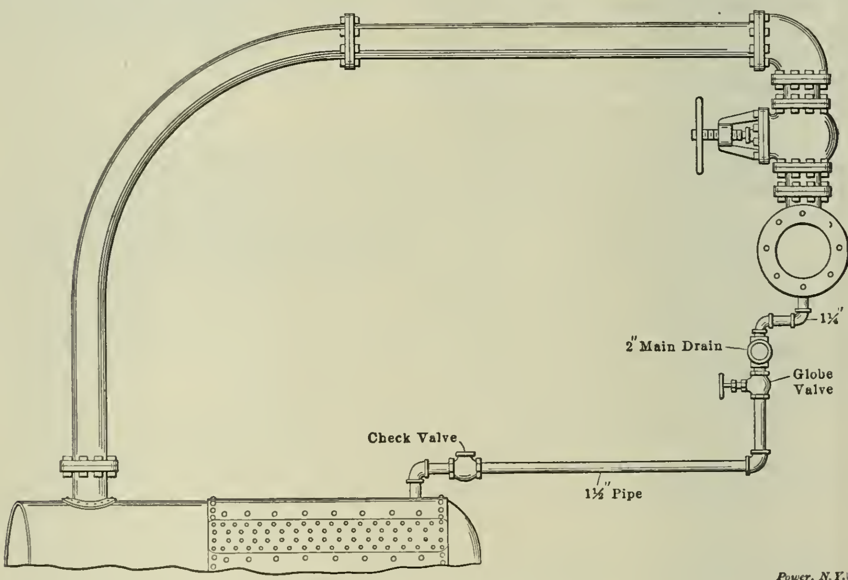
Now the second engine having a 30x42 cylinder and a piston displacement of 700 feet per minute will give 3430 cubic feet of steam into the 12-inch exhaust per minute. The first engine, with 36x42 cylinder and piston displacement of 840 feet per minute, will give 5938 cubic feet per minute into the 12-inch exhaust pipe. The first engine is all choked up, and when the condenser is off, it requires more extra coal than is required to heat the factory; and should the resistance of piping for using the exhaust be added, when the full load is put on the engine it would require new boilers to carry a higher pressure to get the work out of the engine, and the probability is that these advisers will some time succeed in getting this concern to go to all this expense, because the advisers have not the judgment to see that there are limitations to all rules.

W. E. Crane.

Broadalbin, N. Y.

Draining a Main Steam Pipe

In a certain power plant in which six water-tube boilers are being installed, it is proposed to dispose of the water of condensation from the main steam header in a manner which appears to be a somewhat novel departure from the conventional practice. Each boiler is to be connected to the header by means of a long sweep bend and horizontal lead, as shown in the accompanying illustration. It is designed to tap the tees, to which the leads from the boilers will be coupled, for 1¼-inch pipe connections, by which it is intended the water of condensation shall be carried to a 2-inch main drain pipe of the same length as the header, and running parallel thereto. This drain pipe is, in turn, expected to discharge a portion of its contents into the steam space of each boiler in service, through a 1½-inch branch pipe connecting to the drum of the boiler, on top and close to the back head; each branch being furnished with a horizontal check valve and globe valve as shown.



DRAINING A MAIN STEAM HEADER

Water accumulating above the check valve to the hight of the main drain pipe will have a head of about 20 inches, and it is expected that the pressure, due to this head, will be sufficient to compensate for whatever disparity may exist between the steam pressure in the drum and the steam pressure in the header.

A. J. Dixon.

Chicago, Ill.

Cause of Engine Wreck

After reading the article in the March 23 number, on "A Cause of Engine Wreck," by W. E. Crane, I should like to ask if, in running a Corliss engine with momentarily heavy loads and then having all the load suddenly thrown off, there would not be a checking in the speed of the engine before the governor would drop from its highest plane to the point where the intake valves would again open to admit steam?

This has been my experience, and I find a Corliss engine to be much steadier and still not get enough steam to produce motion on no load, with about 1/16-inch valve opening for small- or medium-sized engines.

The governor being blocked in its highest position on a Murray-Corliss engine with which these tests were made, the cam rods would, of course, be adjusted in reverse of the one spoken of in Mr. Crane's article, on account of the inside opening of the steam valves.

LEROY H. WHEAT.

Redfield, S. D.

The Valve Leaked

The accompanying diagrams were taken from a 14½ and 23 by 16-inch tandem compound engine direct-connected to a 200-kilowatt 250-volt three-wire generator, designed to operate at 250 revolutions per minute.

When the diagrams were taken the generator was running as a two-wire machine connected to the outside busbars. The engine was governed by a single-weight shaft governor attached to the high-pressure valve only. The low-pressure valve was connected to an eccentric on the inside hub of the wheel, having the same travel at all speeds. The engine and generator were not new, nor were they designed to operate together, but were purchased to help over the fall and winter peak loads. The engine was first sold for a condensing unit, and when first started up the speed would drop way down when any load was applied. The speed was increased to 268 revolutions per minute at no load and would drop to 230 with a small load. The exhaust was piped to the atmosphere and the usual treatment of taking off and adding weight and tension to the springs was tried, as well as new leaves in the springs, but "nothing doing." A new spring of heavier leaves was put in in place of the old one and a strip of iron ¼ inch wide was riveted to the exhaust side of the low-pressure valve, and when starting up with a light load the receiver gage would show a vacuum until the ammeter read 200 amperes. The diagram, shown in Fig. 1, was then taken.

Between the high- and low-pressure cylinders there was a brass check, grooved [illegible] inch deep, intended for packing. The low-pressure cylinder was taken off and we found that sleeve to be badly worn on the lower side. Repairs were made by putting soft packing in place of the brass, and on starting up again the diagrams, shown in Fig. 2, were taken. By comparing the diagrams in Figs. 1 and 2 an idea can be had of how much steam

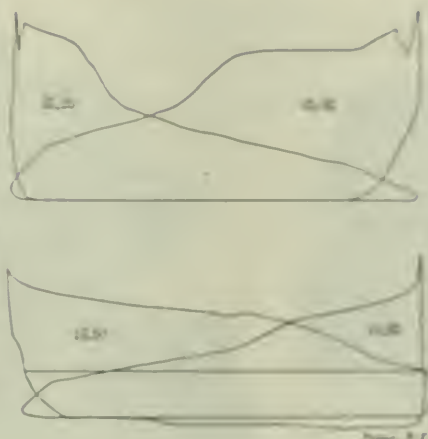


FIG. 1

was leaking through from one side of the high-pressure cylinder to the low-pressure exhaust. The valves had been set to even up the high-pressure cylinder load some time on the start.

Next we adjusted the high-pressure valve, which was some improvement, and we ran through the winter that way, when

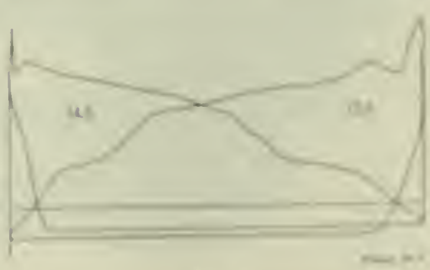


FIG. 2

the unit was disposed of. I found in running this engine that the speed would drop with the load, something I never saw in an automatic governor engine. I supposed that all automatic governing adjusted steam to match the load. The engine showed better economy at half load than full load.

[illegible]

[illegible], N. Y.

An Engine Accident

In the March 30 number Thomas [illegible] has described an engine accident and thrown a little light on a perplexing condition. Without going into a discussion of the merits of his indicator diagrams, it is safe to say that a piston rod should have sufficient area to withstand full boiler pressure when applied to the piston. The pressure applied to the piston can never exceed this point, except in case of water being trapped in the cylinder, or similar accident, and if the rod is large enough safely to handle this pressure, it is not clear how any failure of the low-pressure cylinder to carry its share of the load could jeopardize the high-pressure rod. If the engine carried steam full stroke on the high-pressure side and the low-pressure side were uncoupled entirely, the engine could be expected to make a very creditable struggle to maintain rotation, until overcome by the load. And even if blocked in one condition, and the throttle valve thrown wide open, there could not be any possibility of tearing the rod asunder.

It would be very easy to show that the one-third of the rod remaining was sufficient to pull the load, but it will be hard indeed to find an engineer who does not know that such an argument could be presented only by persons either too ignorant of the practical side of mechanics or too [illegible] to be honest.

When a blacksmith wishes to cut a piece of small bar which does not need a clean cut, he usually "nicks" or "nicks" it on the "hardy" at the point he wants it to break. A few blows on the end soon breaks the bar in two. To do this does not require any such application of power as would be required without the nick. It will be seen that the piston rod under discussion followed this same train of events, as being marked by an initial crack, each stroke of the engine [illegible] until the slight deflection of the rod on the weakened point, and if the rod were taken to pieces it would be only a matter of time before it broke.

If I were a manager, in a similar case I should give the engineer-in-charge a chance to explain. I would get from him one thing I was paying him for—expert knowledge on a special subject. If through lack of proper command of language he failed to make himself clear, I would consult with an outside specialist of established reputation. In doing so as a manager, not an engineer, I would not feel that I was illustrating a lack of wisdom with a solitary case of my line.

[illegible]

[illegible], N. J.

A New York dentist was seriously injured by the explosion of a heating boiler in the basement of his house. A considerable amount was done to the house, also.

Small Steam Turbines*

By George A. Orrok

The papers upon steam turbines which have been presented before the society have dealt with the larger types of apparatus and have been written to show the reliability, efficiency and general desirability of this type of prime mover.

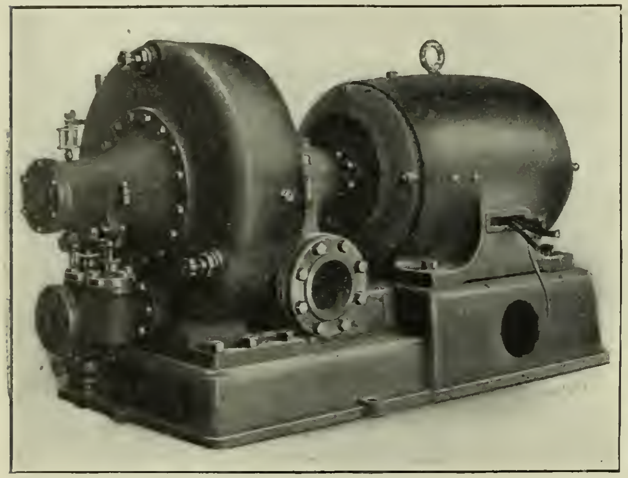


FIG. 6. STURTEVANT STEAM TURBINE, 30-INCH

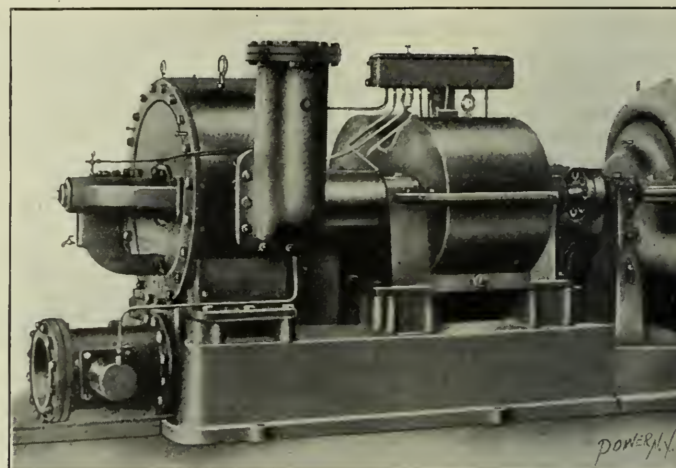


FIG. 1. HIGH- AND LOW-PRESSURE DE LAVAL TURBINE

This paper treats of the smaller sizes of steam turbine from the standpoint of the designing and operating engineer, describing the commercial machines in sufficient detail, with reference to the service to which they have been applied, and giving certain facts concerning their operation which may be of advantage to the engineering profession. Curves of steam consumption are given which show in a general way what may be expected of these machines under certain conditions.

At the present time seven machines are on the market and can be obtained in various sizes from 10 to 300 horsepower with reasonable deliveries. These are the De Laval, Terry, Sturtevant, Bliss, Dake, Curtis and Kerr turbines. Three other machines are nearly at this stage of development and patents have been applied for on several others.

Many thousand horsepower of these turbines have been sold and are in successful commercial service. The following figures as to sales in the sizes from 10 to 300 horsepower have been obtained from the manufacturers:

De Laval,	De Laval Steam Turbine Company	70,000 h.p.
Curtis,	General Electric Company.....	70,000 h.p.
Terry,	Terry Steam Turbine Company...........	15,000 h.p.
Kerr,	Kerr Turbine Company.	10,000 h.p.
Sturtevant,	B. F. Sturtevant Company.	....
Bliss,	E. W. Bliss Company	....
Dake,	Dake-American Steam Turbine Co...........	......

All of these machines are of the impulse type; that is to say, the steam is expanded in a nozzle and the kinetic energy of the jet is absorbed by passing one or more times through the buckets of the turbine rotor. In the De Laval turbine only one moving element and one steam pass are used, which necessitates a very high bucket velocity. In the Terry, Sturtevant, Bliss and Dake turbines a series of return passages are provided. The steam returns two or more times to the same rotor and the bucket speed is much lower. In the Kerr turbine the steam is used in stages with one bucket wheel in a stage; while in most of the Curtis machines two or three stages are used with two or three rows of moving buckets, separated by stationary guide blades, in each stage.

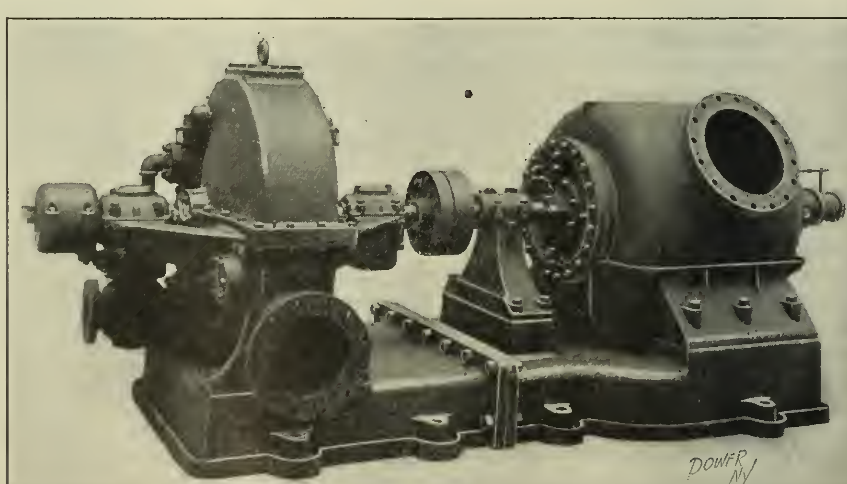


FIG. 2. TERRY STEAM TURBINE, 36-INCH

Compound machines of the other types have been made, but are not as yet produced commercially.

By far the larger number of these machines are used in connection with extra high-speed electric generators, the next application being to centrifugal fans for high pressures. Centrifugal pumps adapted to high rotative speeds have been rather generally introduced in the last few years and it is becoming usual to connect small turbines direct to these machines. The small space required and the simplicity obtainable in a 100-horsepower turbine at speeds of from 800 to 1200 revolutions per minute have been important factors in their introduction.

The first of the small turbines to be put on the market was the De Laval, made by the De Laval Turbine Company, of Trenton, N. J., and introduced in this country about 1896. This machine is of the pure impulse type; the steam being expanded in the nozzle down to the exhaust pressure, and the resultant velocity transferred to the wheel in one steam pass. The bucket speed is quite high, ranging from 600 to 1300 feet per second. Eight sizes of wheel are made, generating from 10 horsepower to 500 horsepower, with one nozzle in the smallest size and eight or more in the 500-horsepower size.

The high bucket speed necessitates the use of gears of special construction, which have been very successful. The design,

*Paper presented at the spring meeting of the American Society of Mechanical Engineers, Washington, D. C., May 4-7, 1909.

construction and economy of this type have been discussed in Volume 25 of *Transactions*, page 1056.

The Terry turbine, made by the Terry Steam Turbine Company, of Hartford, Conn., has been manufactured for about 10 years, although the commercial ma-

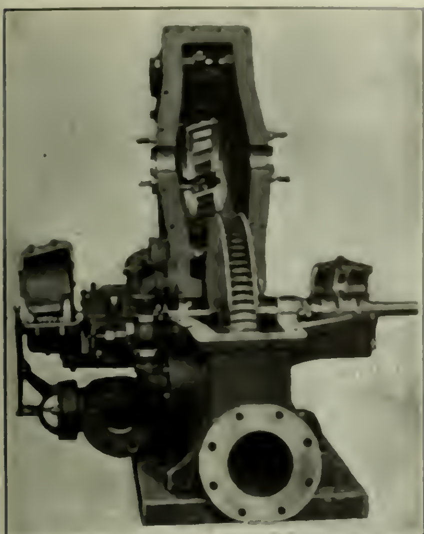


FIG. 3 TERRY TURBINE SHOWING CONSTRUCTION

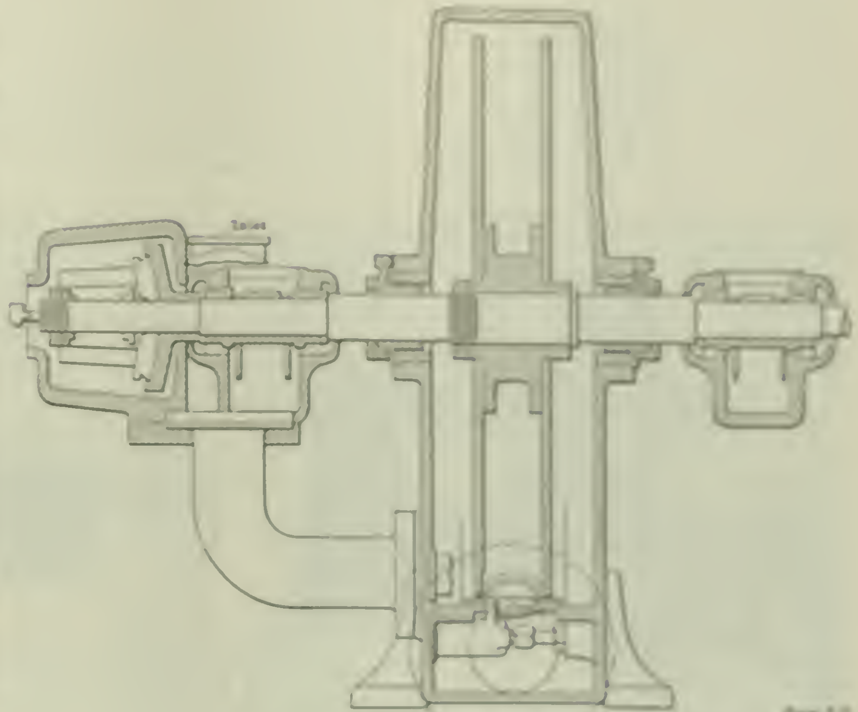


FIG. 4 [illegible]

FIG. 5 [illegible]

[illegible]

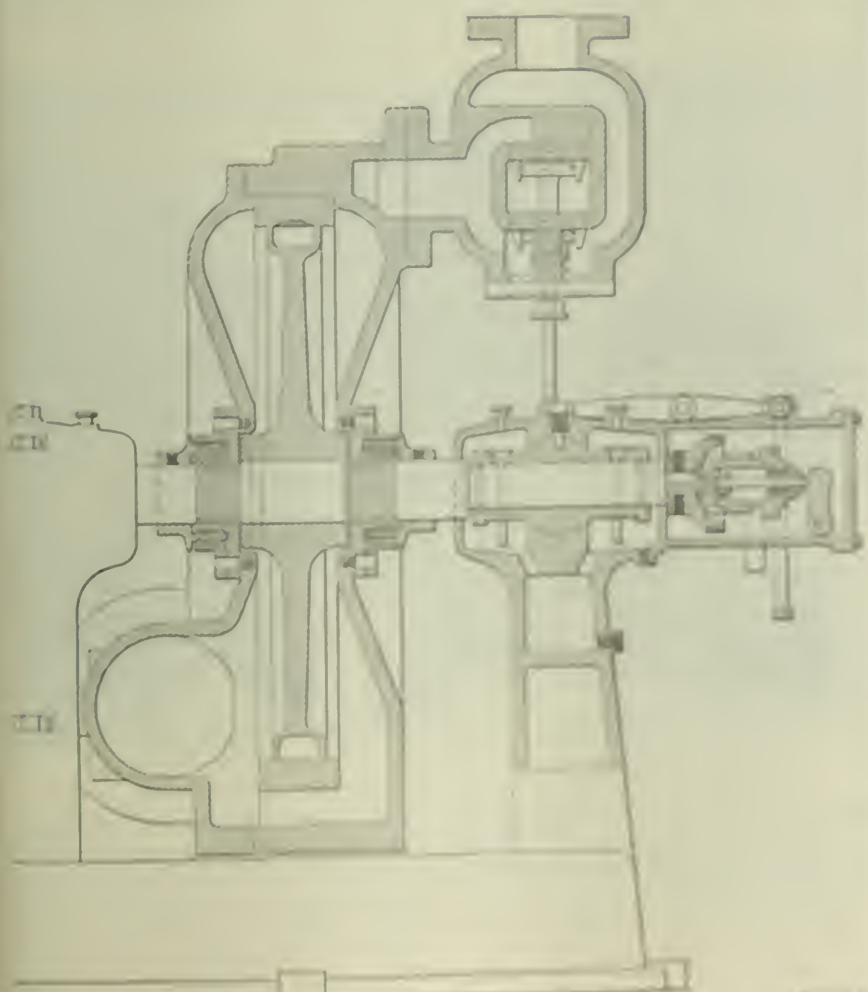


FIG. [illegible]

The sizes of wheel manufactured at the present time are 12-, 18-, 24-, 36- and 48-inch, and the number of nozzles varies from two on the 12-inch wheel to eight or ten on the 48-inch wheel.

The Sturtevant turbine, made by the B. F. Sturtevant Company, of Hyde Park, Mass., has been in the development stage for three or four years and quite a number of machines have been sold. The present type of turbine may be called "standard," however, and four sizes of wheel are built, 20-, 25-, 30- and 36-inch, developing from 3 to 300 horsepower. The turbine is of the multiple-pass type similar to the Riedler-Stumpf. The casing is cast solid with one end. The nozzle and return-chamber ring are inserted from one side and the wheel is milled from the solid. The return passages are from eight to twelve in number and are milled on the inside of the return-chamber ring. They are partitioned and are similar in shape to the buckets. The nozzle lies in the plane of the side of the wheel.

The Bliss turbine, formerly known as the American, made by the E. W. Bliss Company, of Brooklyn, N. Y., is of the same type as the Terry and Sturtevant and has been on the market only a few months. The casing and steam chamber are cast solid with one side and the nozzle and return chambers bolted in. The wheel is milled from a steel casting, or forging in the smaller sizes, and the partitions separating the buckets are inserted and held in place by three bands of steel shrunk on the face of the wheel. The return passages are peculiar in having no partitions. Two sizes of wheel have been built, the 42-inch and 30-inch, but designs have been developed for the 12-, 18-, 24-, 36-, 48- and 60-inch, covering powers from 10 horsepower to above 600 horsepower.

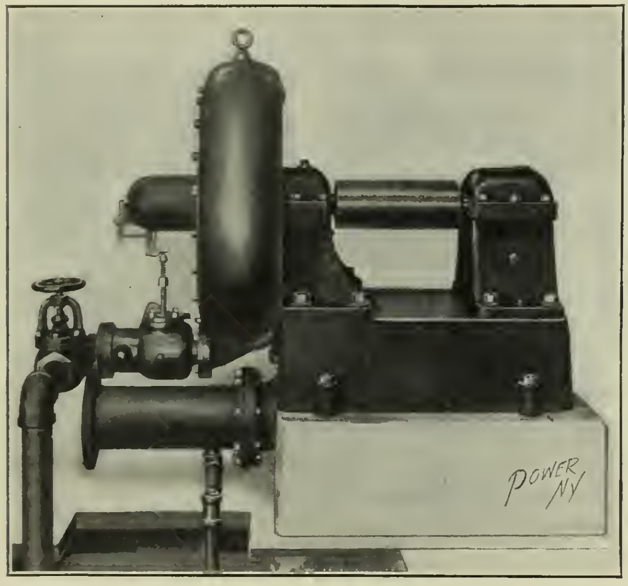


FIG. 8. BLISS TURBINE, 30-INCH

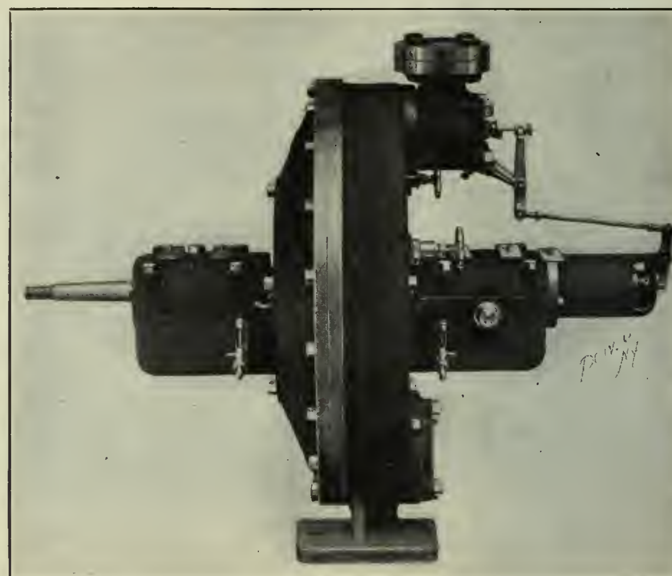


FIG. 9. DAKE TURBINE, 24-INCH

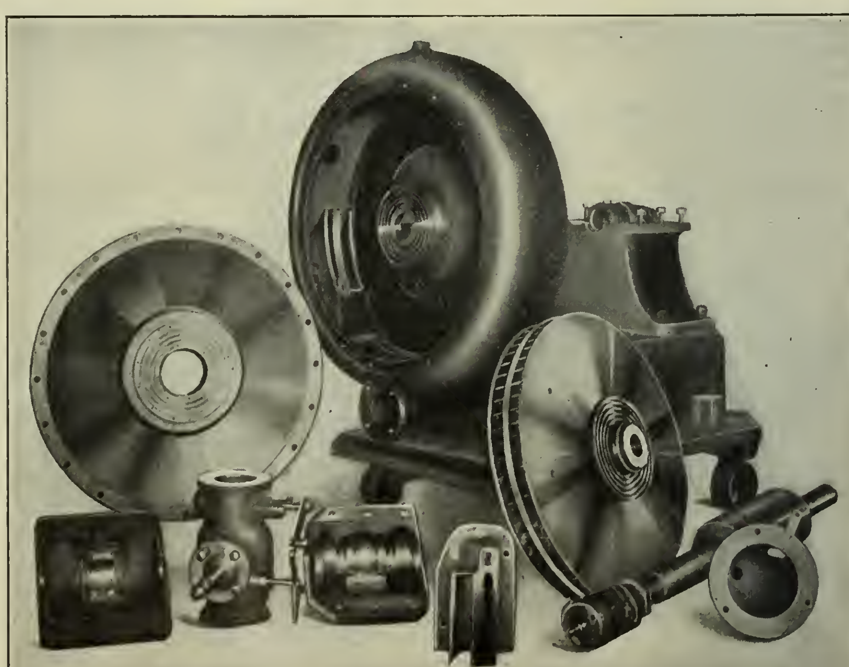


FIG. 10. BLISS TURBINE PARTS

The Dake turbine, made by the Dake-American Steam Turbine Company, of Grand Rapids, Mich., is a single-stage impulse turbine. The wheel is made of two bucket disks, with milled buckets and inserted partitions, bolted together over a wheel center. In their Headlight turbine the governor is inclosed between the sides of the wheel. The nozzles and return passages are placed between the bucket disks. The machine is built in sizes of from 5 to 100 horsepower, the diameter of the smallest wheel being 12 inches.

Coincident with the development of the large Curtis turbines, the General Electric Company, at its Lynn works, has developed and placed on the market a line of small generating sets ranging from 5 to 300 kilowatts. This range is covered by eight sizes, the smallest machines being single-stage with two or three passes per stage. The buckets and nozzles are of the well known Curtis type.

The Kerr turbine, made by the Kerr Turbine Company, of Wellsville, N. Y., is of the compound-impulse type. It is generally built in from two to eight stages. The buckets are of the double Pelton type, inserted like saw teeth in the wheel disk. Four sizes of wheel, 12-, 18-, 24- and 36-inch, are made and cover a range of from 10 to 300 horsepower. The nozzles are in the plane of revolution of the wheel and are screwed into the stage partitions and held in place by a lock nut.

As in large turbines, details of these

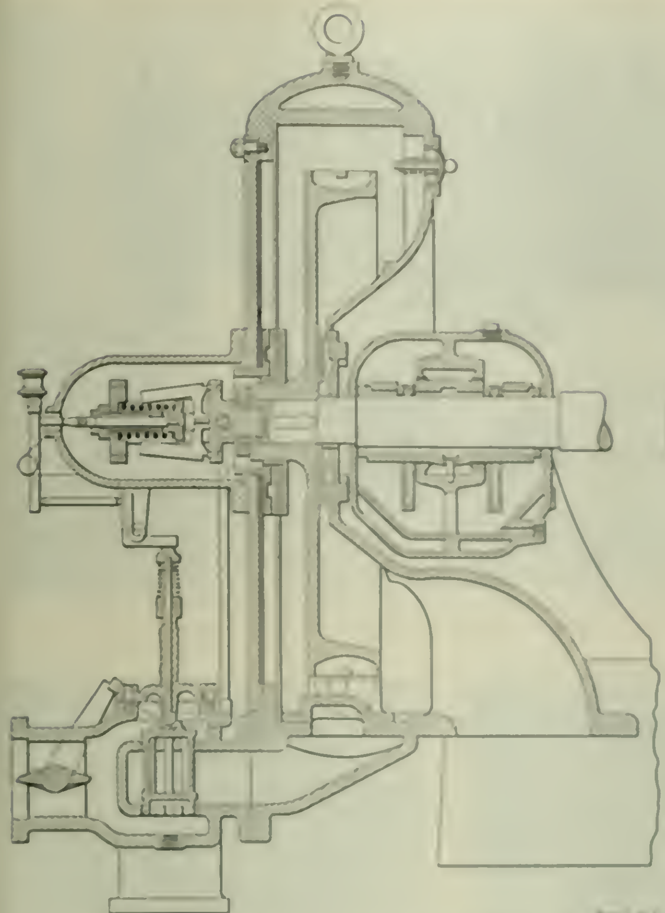


FIG. 11. SECTIONAL VIEW OF BLISS TURBINE

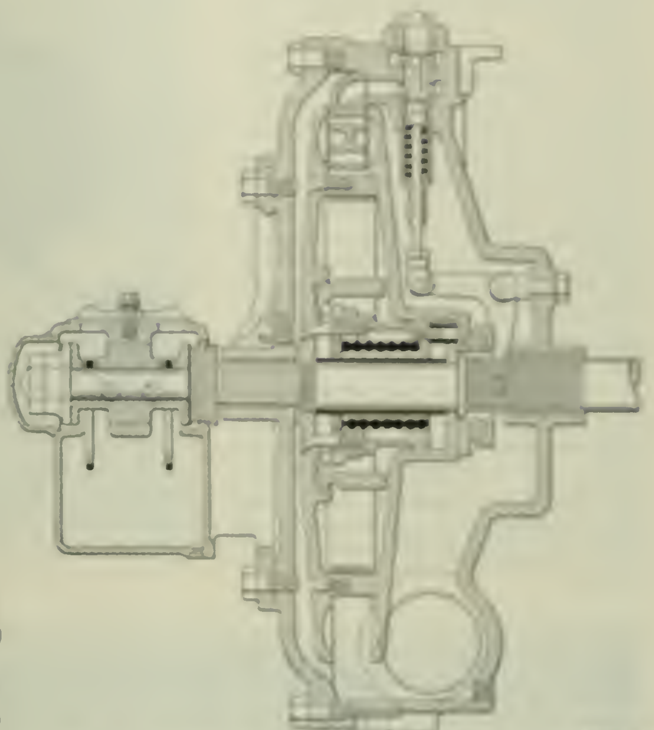


FIG. 12. SECTION OF DAKE [illegible] TURBINE [illegible]

FIG. 13. CURTIS TURBINE, 50-HORSEPOWER

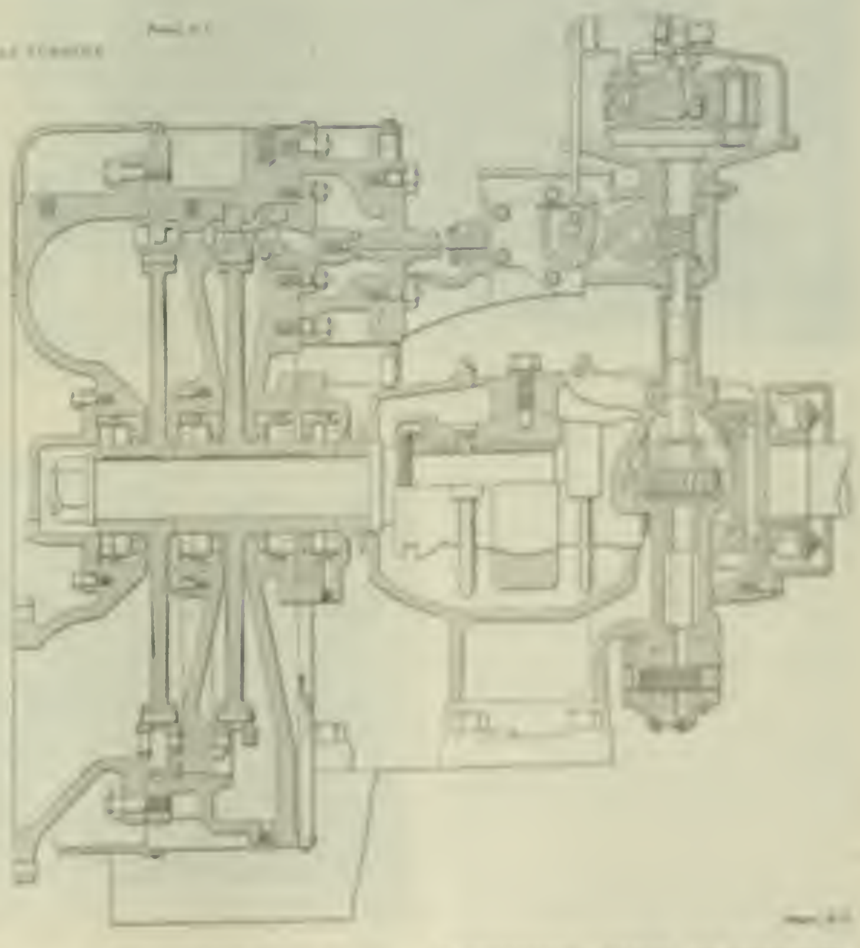


FIG. 14. SECTION OF CURTIS [illegible] TURBINE, [illegible]-HORSEPOWER

small turbines, to which reference has been made, show the skill and knowledge of the designer, and that the same problem may be solved in different ways is well illustrated by the sections here reproduced.

Description of Details

Nozzles. The diverging nozzle is used by all makers except Kerr, whose multi-speed wheel requires a converging nozzle. In the De Laval, Sturtevant and Kerr turbines the nozzles are screwed into their seats; that of the Terry is held in place by a bolt. The nozzles of the Curtis, Dake and Bliss turbines are reamed out of the solid. The larger sizes of the De Laval machine which have been put on the market lately have a large number of reamed nozzles instead of the older construction.

Buckets. The constructions employed in the Curtis and De Laval wheels are well known and have been described many times. The Terry, Dake, Bliss and Sturtevant buckets are practically semicircular in form. The Terry bucket is constructed entirely of steel punchings assembled between grooves in the two steel disks forming the sides of the wheel. The Sturtevant wheel is milled out of a steel casting. The Bliss buckets are milled out, but the partitions are inserted and held in place and steel rings are shrunk on. The Dake buckets are turned out of the solid, the recesses for the partitions milled out and the partitions inserted; the wheel is then bolted together. The Kerr buckets are very similar to the original Pelton buckets and are inserted in the wheel in a manner similar to the De Laval buckets.

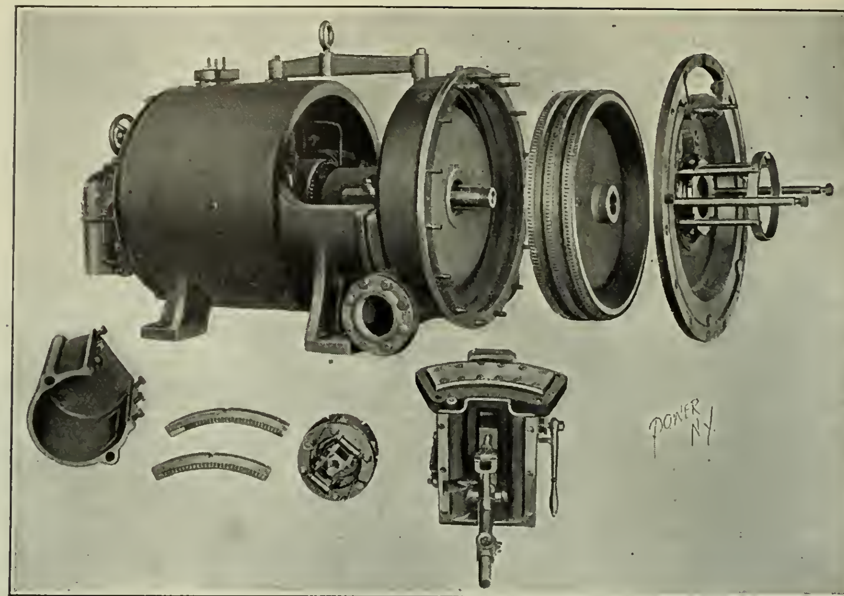


FIG. 14. CURTIS TURBINE IN PROCESS OF ASSEMBLING

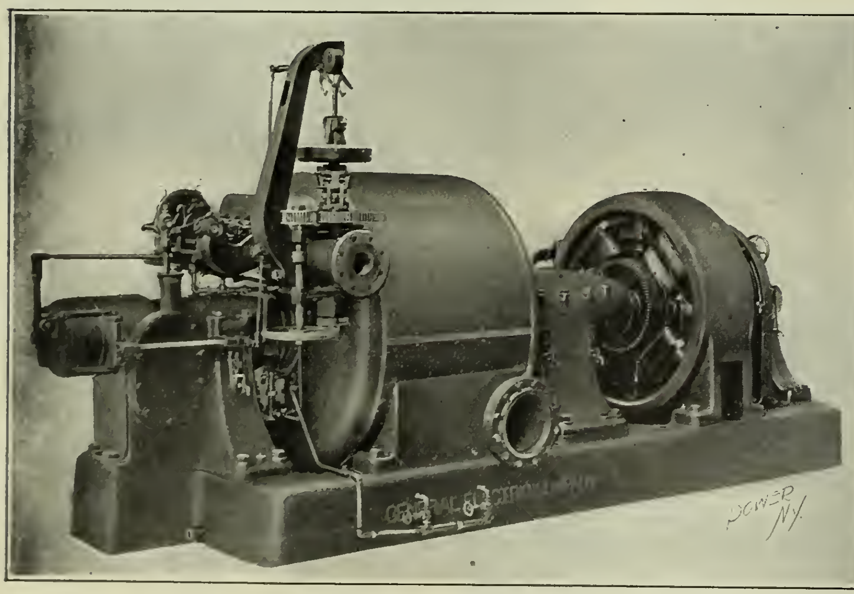


FIG. 16. CURTIS TURBINE, 200-HORSEPOWER

Return Chambers. The Sturtevant returns are milled out of the solid ring. Bliss casts them in the nozzle piece and finishes them by hand; Terry casts each one separately, finishes by hand and assembles with bolts; Dake casts the return chambers solid, mills the passages and covers them with a shrouding.

Wheel Centers. De Laval, Curtis, Sturtevant and Bliss make the wheel centers of steel castings or forgings integral with the wheel. Terry uses a steel casting, but bolts the wheel disk to it. Kerr uses a screwed coupling, the inner part cut in three pieces and keyed to the shaft with round keys, clamping the wheel disk. Dake's wheel centers are an integral part of the wheel in small sizes, but in the larger machines are steel castings, in some cases a part of the shaft.

Governors. De Laval, Terry, Sturtevant, Bliss, Dake and Kerr use a flyball governor on the shaft end, which actuates the throttle valve through a system of levers. Curtis uses the flyball governor on the shaft for small sizes and slower-speed spring-controlled governors of different forms for the larger sizes. The Sturtevant, Bliss and Curtis machines are provided with an emergency-stop governor as well as the throttling governor.

Glands. For noncondensing machines glands are not troublesome, as the difference of pressure between the casing and atmosphere is rarely more than a few pounds. Terry uses a bronze ball-and-socket gland with a long loose fit on the shaft. Sturtevant and Dake use a set of ring packing, either cast iron or bronze. Bliss has a labyrinth packing without contact. Kerr has a floating bronze bush with soft packing behind it. Curtis uses a metallic packing held in place by a gland ring, and for condensing service a carbon-ring packing, steam-sealed.

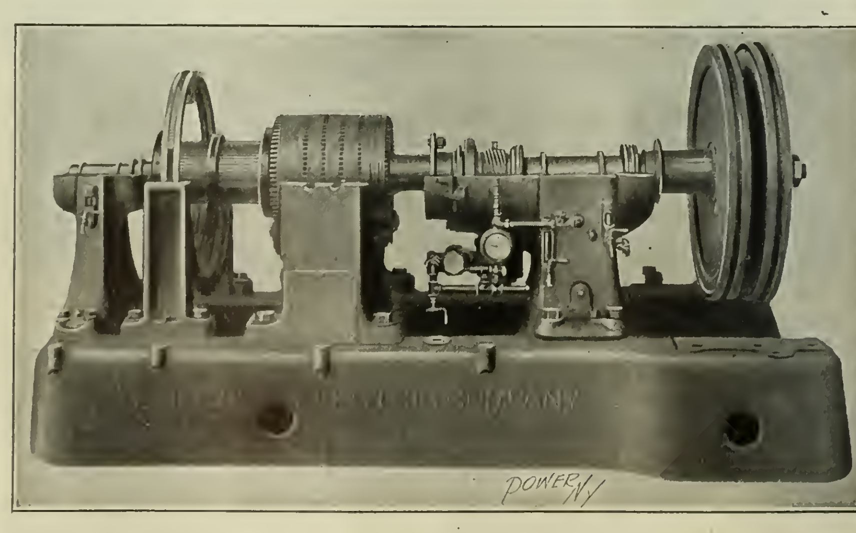


FIG. 17. REVOLVING ELEMENT OF CURTIS TURBINE IN BEARINGS

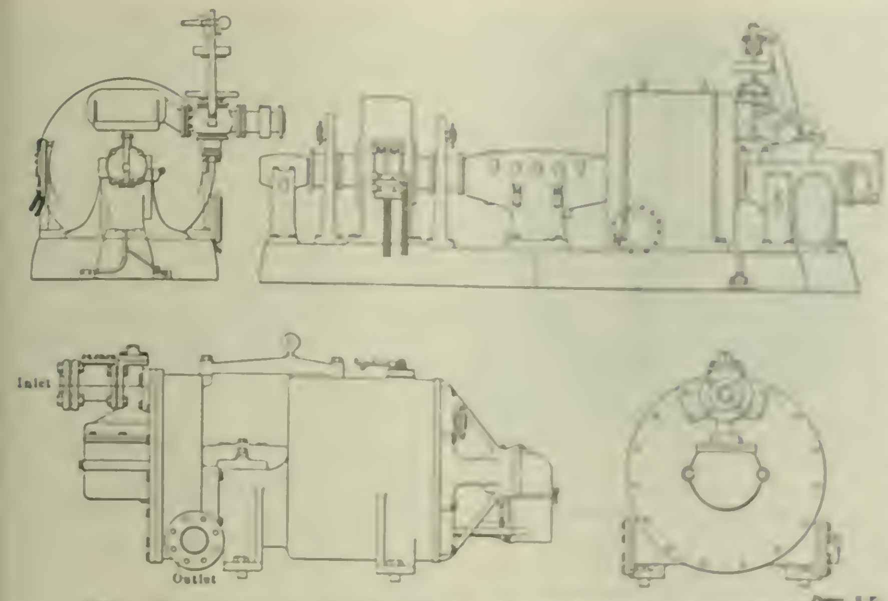


FIG. 18. DIAGRAMS OF CURTIS TURBINES, 300-HORSEPOWER AND 50-HORSEPOWER

water jackets or water-cooling pipes for an emergency cold-water circulation. The [illegible] of the thrust is [illegible] at the same time.

Operation. These machines are nearly automatic in their operation. When the turbine is once properly set, the coupling properly adjusted and the bearings supplied with oil, the machine may run for years without an overhauling. The bearings need be looked after to see that no heating takes place and that the ring is carrying the oil to the shaft. The coupling should be examined from time to time to make sure that no thrust is communicated through it to the turbine. With these precautions a three months' continuous run is common and a number of turbines have to my knowledge run more than 18 months without a cent spent on them for maintenance. Apparently there is no wear in nozzles, buckets and steam chambers. The only wearing parts are the

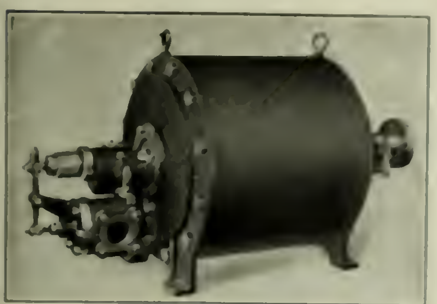


FIG. 19. KERR TURBINE 18-INCH

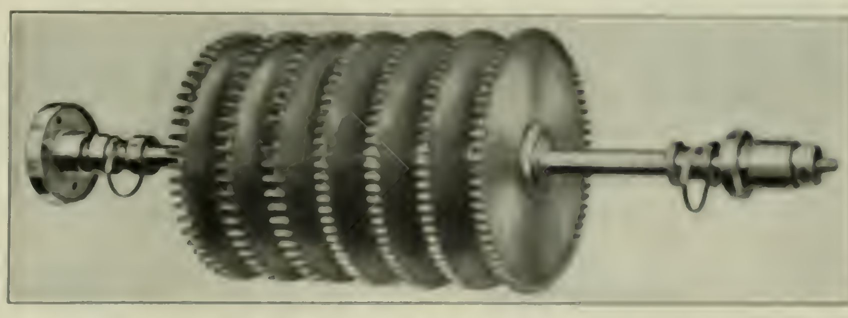


FIG. 20. COMPLETE ROTATING PART OF 18-INCH 7-STAGE KERR STEAM TURBINE

Clearance. In none of these machines is clearance an important factor. The clearance between buckets and guide passages on a 24-inch wheel is usually from 1/16 to 3/32 inch when hot. Striking or rubbing is practically unknown.

Thrust. Theoretically, there should be no thrust in any turbine of these types. Practically, there is always a very small thrust one way or the other. This thrust is usually taken care of by small thrust collars or washers next to the bearings. Thrust from the outside is prevented by the use of a flexible coupling between the turbine and the machine it drives.

Bearings. The bearings are always ring-oiled with large oil reservoirs, sometimes, on the larger sizes, provided with

bearings and these are practically permanent.

These machines may be taken apart and reassembled in half a day [illegible] in two hours. The [illegible] machines may be overhauled in an [illegible] time.

[illegible] Turbine. The [illegible] turbine made by William [illegible] & Son, New York, is a [illegible] turbine resembling in construction the Dow turbine as formerly illustrated [illegible] years ago. Some experimental machines have been built, one of which was tested at Columbia University, and any commercial machine will soon be on the market.

James Wilkinson, of Providence, R. I., has a small impulse turbine nearly in the commercial stage. A number of these machines are running, and within the next few months it is expected they will be on the market.

The [illegible] turbine, lately completed by the [illegible] Company and tested at [illegible], is another promising turbine.

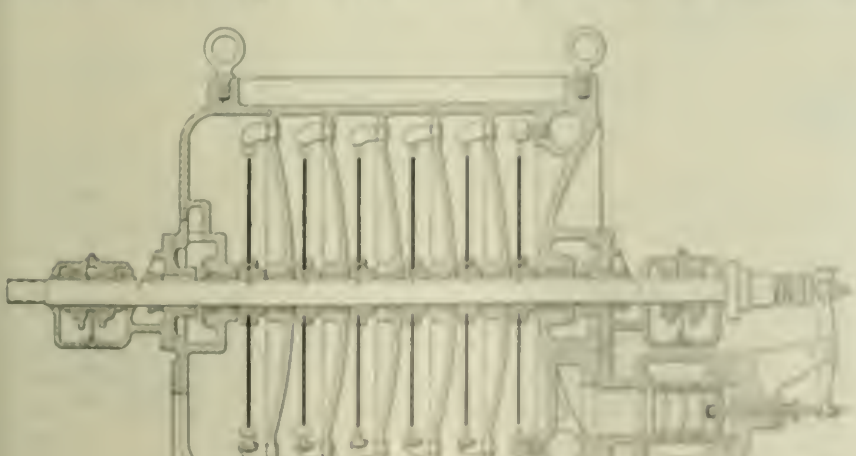


FIG. 21. SECTIONAL VIEW OF KERR TURBINE, 18-INCH

[illegible]

The success of these turbines [illegible] from the [illegible] that the Curtis turbine [illegible] and 200-horsepower sizes. These curves represent the average of a large number of tests and have been corrected to bring them to standard conditions. The averages were consistent, and the variation from the average in any case was not large.

The curves for the Terry turbine were plotted from 14 tests made at East Pittsburg by the Westinghouse Machine Company. The curves for the Bliss turbine were plotted from 24 tests made at Stevens Institute by Prof. F. L. Pryor. The curves for the Kerr turbine were plotted from tests made by the Kerr Turbine Company in its testing plant at Wellsville, N. Y.

There seems to be no change in steam economy with use. It may be too early to make this statement, but machines running regularly for three years have shown no increase in steam consumption.

The field of the small steam turbine is somewhat narrow when compared with the high-speed steam engine. The small turbine has its place, however, and with the development of a more economical machine at the lower speed ranges, will have a much wider field. The turbine-driven centrifugal fan, for both high and low pressures, will have an increasing use, and the centrifugal turbine-driven pumps have marked advantages over reciprocating apparatus because of the absence of

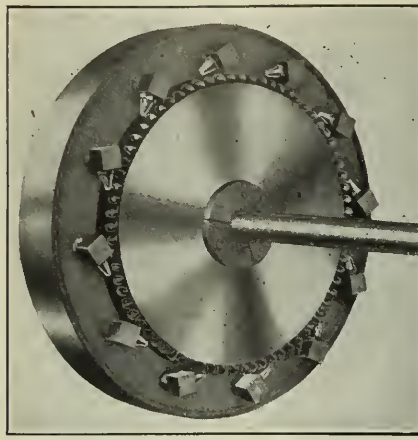


FIG. 22. ONE STAGE OF KERR TURBINE, SHOWING NOZZLES AND WHEEL

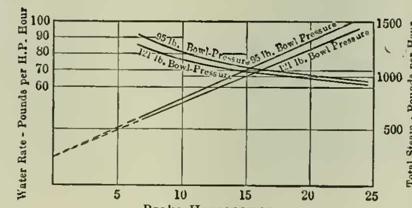


FIG. 26. STEAM-CONSUMPTION CURVES, STURTEVANT TURBINE

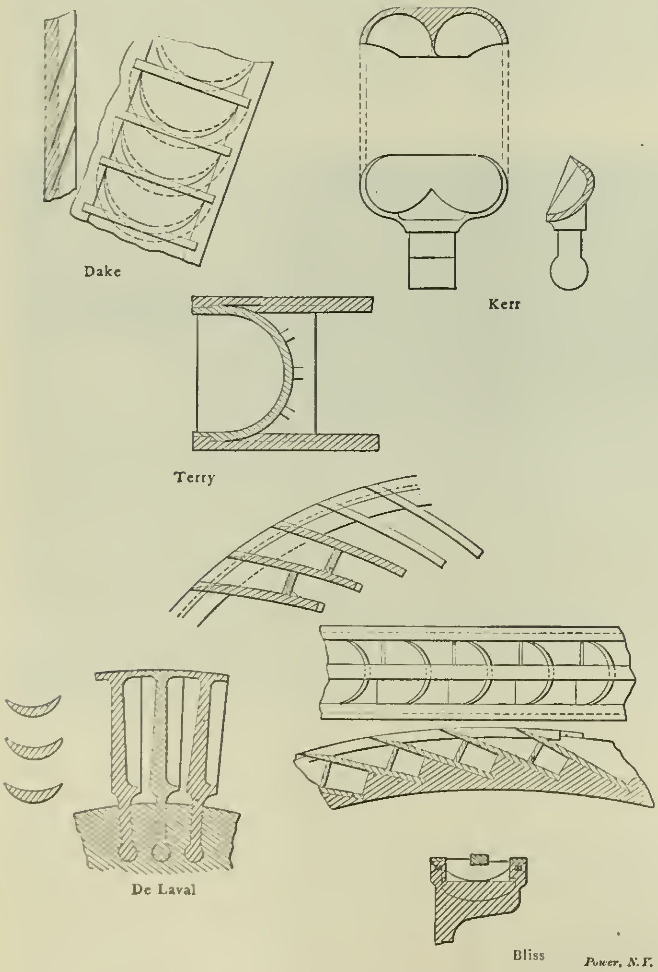


FIG. 23. TYPICAL TURBINE BUCKETS

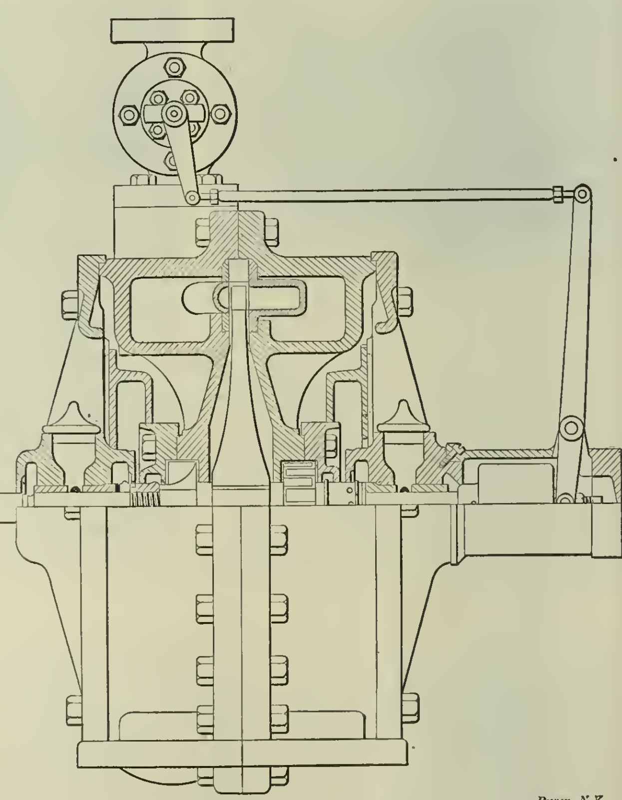


FIG. 24. SECTION OF WILKINSON STEAM TURBINE, 20-INCH

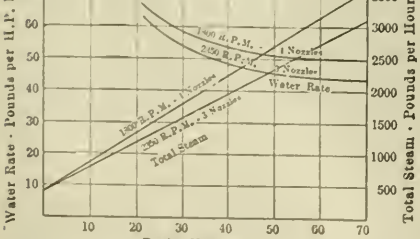


FIG. 25. STEAM-CONSUMPTION CURVES, TERRY TURBINE

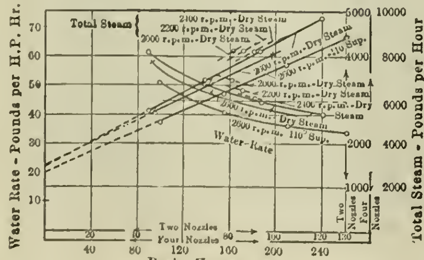


FIG. 27. STEAM-CONSUMPTION CURVES, BLISS TURBINE, NONCONDENSING

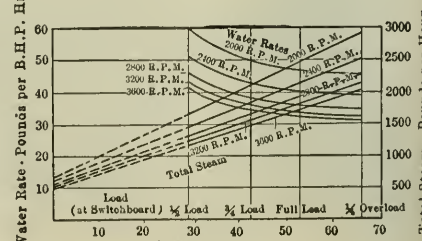


FIG. 28. STEAM-CONSUMPTION CURVES, 200-HORSEPOWER CURTIS TURBINE

shock on the pipe line and their adaptation to space conditions.

The promise of development on these lines has led many manufacturers to enter the small-turbine field and the great expansion of the large-turbine business

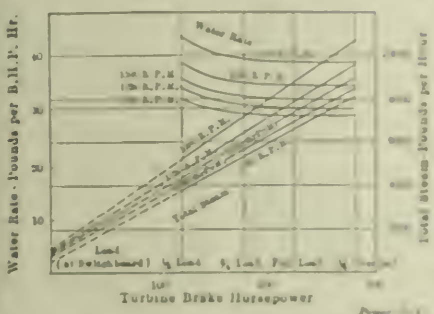


FIG. 29. STEAM-CONSUMPTION CURVES, 50-HORSEPOWER CURTIS TURBINE

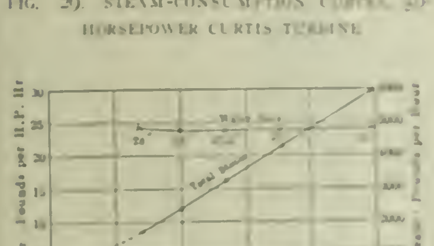


FIG. 30. STEAM-CONSUMPTION CURVES, 24-INCH KERR TURBINE

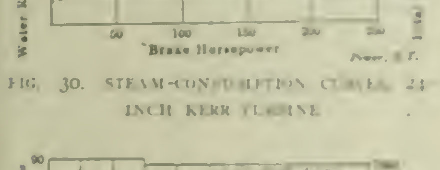


FIG. 31. LOAD CURVES OF KERR TURBINE

without doubt presages a like future for the small steam turbine.

Peat Society Meeting

There will be a meeting of the New York section of the American Peat Society, at the Technology Club, Syracuse, N. Y., May 15, from 3 to 5 and 7.30 to 10 p.m. Among the papers to be presented are the following: "Production of Ammonia from Peat," by Herman C. Woltereck; "Present State of Peat Gasifying with Recovery of Ammonia," by Prof. Charles A. Davis; "A Peat Producer with Peat Coke as Byproduct," by Dr. Otto Zwingenberger.

The first summer convention of the Society of Naval Architects and Marine Engineers will be held at Detroit, Mich., the latter part of June.

Marine Producer Gas Power*

By C. L. Straub

Only recently has such progress been made in the development of gas power for marine work as to warrant its early adoption in commercial service. Two years ago, less than 300 horsepower in the aggregate was being developed by marine producer-gas power installations; these were experimental in nature and were of the German Capitaine type. There are now installed and accepted 23 Capitaine marine plants, aggregating 2035 horsepower, a partial list of which follows:

(a) "Emil Capitaine." Launch, 60-boiler horsepower, four-cylinder single-acting, four-stroke-cycle engine; boat 60 feet long, 10 feet beam, 4 feet deep, ran an average speed of 10 miles for 10 hours on 412 pounds of anthracite.

(b) "Rex." Sea-going Swedish boat, 102 feet long, 22 feet beam, carries 340 tons on 9-foot draft; fitted with a three-cylinder single-acting, 45-horsepower engine running at 300 revolutions per minute.

(c) "Capitaine." Tow boat at Ghent; length 47 feet, beam 12 feet, draft 7 feet; fitted with a three-cylinder, single acting, four-stroke-cycle engine of 105 boiler horsepower at 240 revolutions per minute.

(d) "Duchess." A canal barge; length 71 feet, beam 7 feet 2 inch, carries 30 tons cargo on 4-foot draft; fitted with double-cylinder, single-acting, four-stroke-cycle engine of 25 boiler horsepower.

(e) "Dusseldorf." Tug at Hamburg; fitted with a four-cylinder, single-acting, four-stroke-cycle engine of 60 boiler horsepower at 240 revolutions per minute.

(f) "Leo." Tug fitted with a three-cylinder, single-acting, four-stroke-cycle engine of 45 boiler horsepower at 240 revolutions per minute.

(g) "Wilhelm." Combination freight and passenger Rhine boat, fitted with a four-cylinder, single-acting engine of 175 boiler horsepower at 240 revolutions per minute.

(h) "Badenia." Rhine freight boat, fitted with a two-cylinder, single-acting, four-stroke-cycle engine of 30 boiler horsepower.

(i) "Kattwyk." A canal freight boat, fitted with a three-cylinder, single-acting, four-stroke-cycle engine of 45 boiler horsepower.

(j) "Marie." A canal freight boat, fitted with a three-cylinder, single-acting, four-stroke-cycle engine of 35 boiler horsepower.

(k) "Hamburg." A combination freight and passenger Rhine boat, fitted with a four-cylinder, single-acting, four-stroke-cycle engine of 175 boiler horsepower.

(l) "Vorwärts." A Volga freight boat, fitted with a four-cylinder, single-acting, four-stroke-cycle engine of 60 boiler horsepower.

(m) "Nr. 26." A canal freight boat, fitted with a four-cylinder, single-acting, four-stroke-cycle engine of 60 boiler horsepower.

In addition to the above there are a number of freight boats, the dimensions and names of which I am unable to obtain; their power plants varied in capacity from 30 to 175 horsepower each.

(n) H. M. S. "Rattler." An old gun boat, 165 feet long, 25 feet beam, originally fitted with a triple-expansion engine. The gas engine is four-cylinder, single-acting, four-stroke-cycle, with cylinders 20 inches diameter by 24 inches stroke, developing 800 brake horsepower at 130 revolutions per minute. This engine is started by means of a mixture of gas and air which is pumped into the cylinders at a pressure of about 90 pounds per square inch. This installation was designed entirely by the Capitaine works at Dusseldorf. The total weight of the entire plant, including the donkey boiler for working the pumps and auxiliaries, is 54 tons, as compared with 138 tons in the case of the displaced steam engine. A consumption of 7300 pounds of coal was made for a measured distance of 95 knots at an average speed of 10½ knots per hour. The cost per mile for fuel, with coal at $30 per ton, is 8.9 cents, United States money. This boat made a maximum speed of 11.5 knots and stood against a 7½-knot current at 130 revolutions per minute of the engine shaft.

All of the above plants are, in design and construction, practically identical in operation on anthracite, coke or hard charcoal (charcoal) fuel and are made as restricted by the design to use those of fuel in commonly obtained in the scope of application. The development of a simple marine gas producer for use with any class of solid fuel is a necessity, if the subject is to be successfully realized.

The writer is fortunate in having been connected with some earlier American developments in both stationary and marine gas-power plants, which enables him to draw a comparison between a typical steam and a possible gas installation.

*Abstract of a paper presented at the Washington meeting of the American Society of Mechanical Engineers, May 4, 1909.

Three years have been devoted to the modification of the down-draft stationary bituminous producer for marine service. The work involved a reduction in the size and weight of the generators; complete revision of the scrubbing, gas-cleansing and exhausting mechanism; elimination of all gasholders, storage receptacles, mixing chambers, etc. The modified plant uptodate shows a light, compact producer, which while retaining the same rate of combustion as the stationary apparatus, has materially reduced dimensions and weight of shells, brick lining, fittings, etc. The economizer boilers which were used in stationary work have been replaced with light air-heating economizers. The gas coolers no longer contain any coke nor broken material, nor wood trays, and are built of very light, noncorrosive sheet metal, and arranged for either vertical or horizontal mounting, the latter lending itself nicely to location in space which would be otherwise wasted in the vessel. The cooled and partially cleansed gas is drawn through the producer plant by a centrifugal gas-cleaning exhauster, driven by direct-connected motor. The gas passes directly from the exhauster, under pressure, through an automatic pressure-regu-

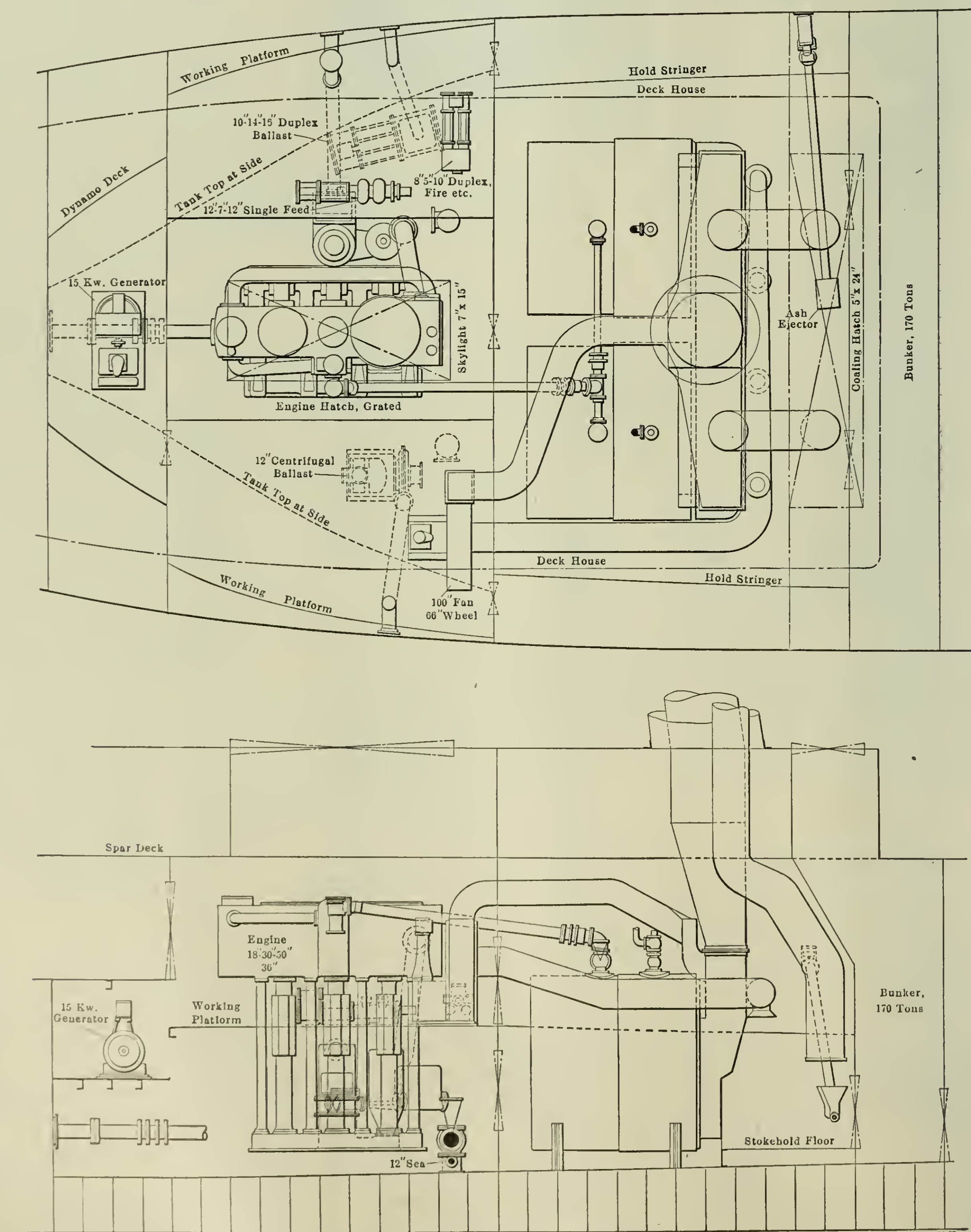


FIG. 1. PLAN AND ELEVATION OF 1000-HORSEPOWER STEAM-POWER EQUIPMENT INSTALLED IN LAKE FREIGHTER

lating valve to the engine manifold. That the plant is adaptable for marine service, with regard to space occupied and weight, may be seen from the following conservative estimate:

Plants of from 100 to 500 horsepower weigh from [illegible] to 70 pounds per horsepower, including all auxiliaries, piping, etc.

A Comparison of Producer-gas and Steam Equipments

Undoubtedly the natural opportunity at [illegible]

[illegible]

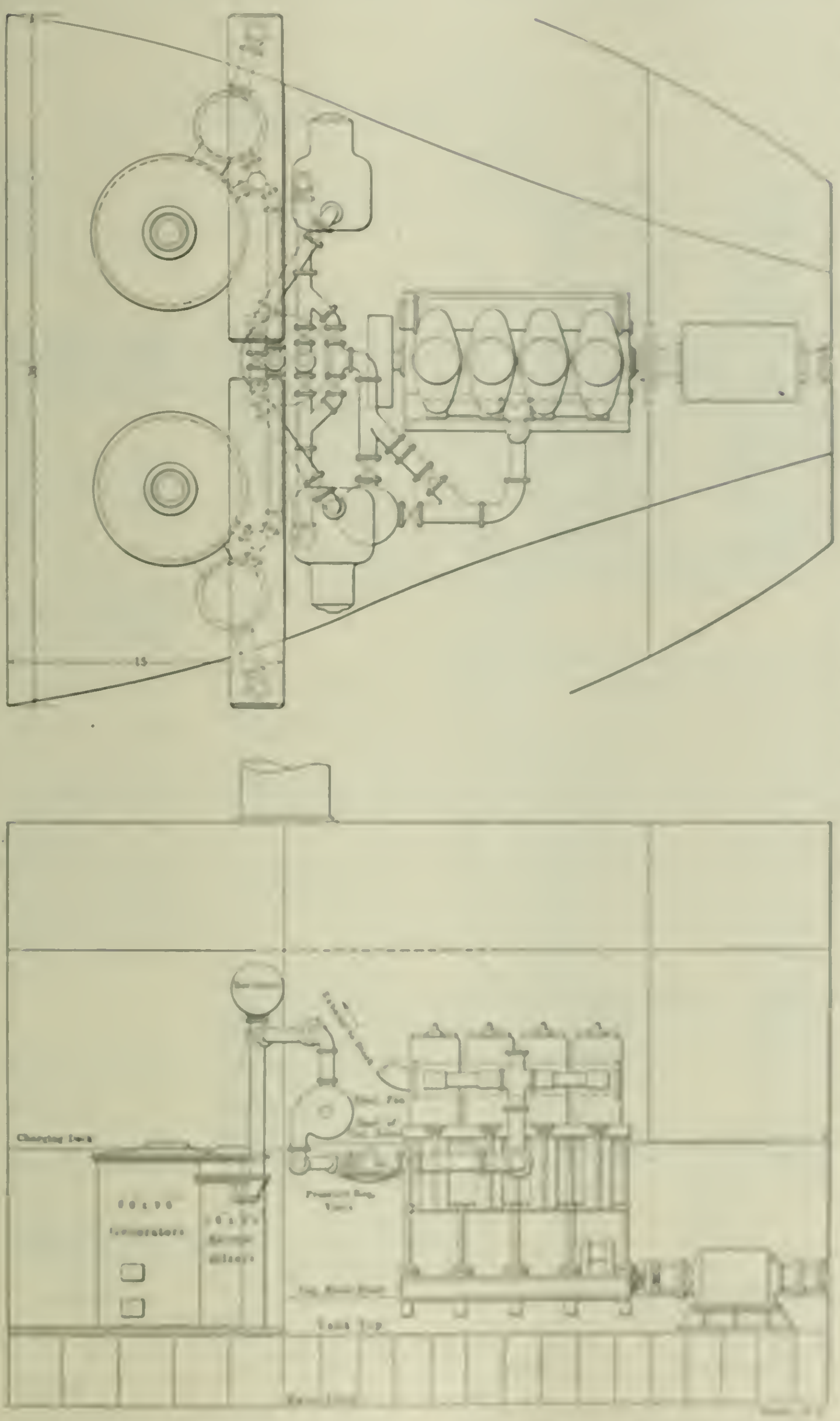


FIG. [illegible] PLAN AND ELEVATION OF [illegible] MARINE PRODUCER PLANT

each occupy from 0.4 to 0.[illegible] square foot per horsepower, and weigh from [illegible] to 90 pounds per horsepower, including all auxiliaries, piping, etc.; plants from [illegible] to 1000 horsepower occupy from [illegible] to 0.45 square foot per horsepower, and [illegible]

the present time for marine gas power lies in commercial service, in which [illegible] [illegible] [illegible] of the Great Lakes. [illegible] gine is a four-cylinder, double-acting, reversing type, having cylinders 24 inches bore by 36 inches stroke, delivering 1000 boiler horsepower at 100 revolutions per minute. The reversing is accomplished by means of compressed air, which is used to shift the cams from the head to the stern position. Compressed air is admitted to the cylinders by timed cams in proper cycle. The crank shaft of the engine is rigidly coupled to the shaft of the screw.

The illustrations show a column-framed engine. Since making this layout, the design of the engine has been modified to meet all of the present marine conditions now found in marine-engine design on the lakes. In fact, with the exception of the condenser shown on the steam drawings, the gas-engine frame will be very similar to the steam engine.

For the generation of current to drive the auxiliaries, there will be installed a double-cylinder, double-acting gas engine, direct-connected to a 50-kilowatt direct-current generator. All of the pumps and auxiliaries will be motor-driven. A smaller direct-connected unit operating on oil will be used for pumping air, blowing fires, or other service, when the gas plant is down. Allowing a distance of 4 feet 3 inches between the forward bulkhead and the engine room and the forward side of the flywheel, which distance is 1 foot greater than that in the steam installation, we have an overall distance between forward and after bulkheads in the engine room of 19 feet 6 inches.

As previously stated, two arrangements of producer equipment are shown. The four-generator plant, Fig. 3, consists of four 6-foot by 9-foot generators, each fitted with independent economizers. The forward pair and the after pair are connected independently to two horizontal gas scrubbers, which are shown slung under the main deck beams. The gas passes from these scrubbers to independent motor-driven centrifugal gas-cleaning fans, whence it is delivered, either through common connection to a purge or blowoff pipe which also acts as a bypass, or through two gas-pressure regulator valves to the air- and gas-mixing valve at the engine manifold. The 6-foot generators require only one cleaning door each. As a result a single cleaning space suffices for the four machines, allowing them to be grouped with reference to athwartship space, so as to give ample room on each side of the vessel for coal bunkers. The total space occupied by the producer plant is 21 feet 10 inches athwartship, and 15 feet between forward and after bulkheads. The producer-room weight, including generators, economizers, piping, and scrubbers, complete, of the four-generator set, is 110,000 pounds. This weight is estimated, but has been carefully checked and completely covers all the mechanism. In addition to the above mechanism, there will be a heating boiler which is shown on the main deck. This boiler will serve to furnish low-pressure steam for heating the vessel and supplying hot water for washing down decks, etc. This boiler, with water, will weigh about 8000 pounds.

The two-generator producer plant, which will undoubtedly be the one installed, will consist of two 8-foot diameter by 9-foot 6-inch generators, connected to independent air economizers and each fitted with an independent horizontal scrubber, located athwartship under the main deck beams. The gas outlet at the scrubbers will be connected with a crossover, so that either exhauster may operate either or both producer plants. The exhausters are installed in duplicate and are connected with common purge or blowoff and common gas outlets leading either through one pressure-regulator valve, or through a bypass direct to the air- and gas-mixing valves at the engine manifold.

On account of the fact that the 8-foot generators require two cleaning doors set at 120 degrees, the double-generator unit plant will require the full athwartship space in the producer room. The approximate floor space occupied, therefore, will be 30 feet athwartship and 15 feet between forward and after bulkheads. The producer-room weight, including generators, economizers, piping and scrubbers

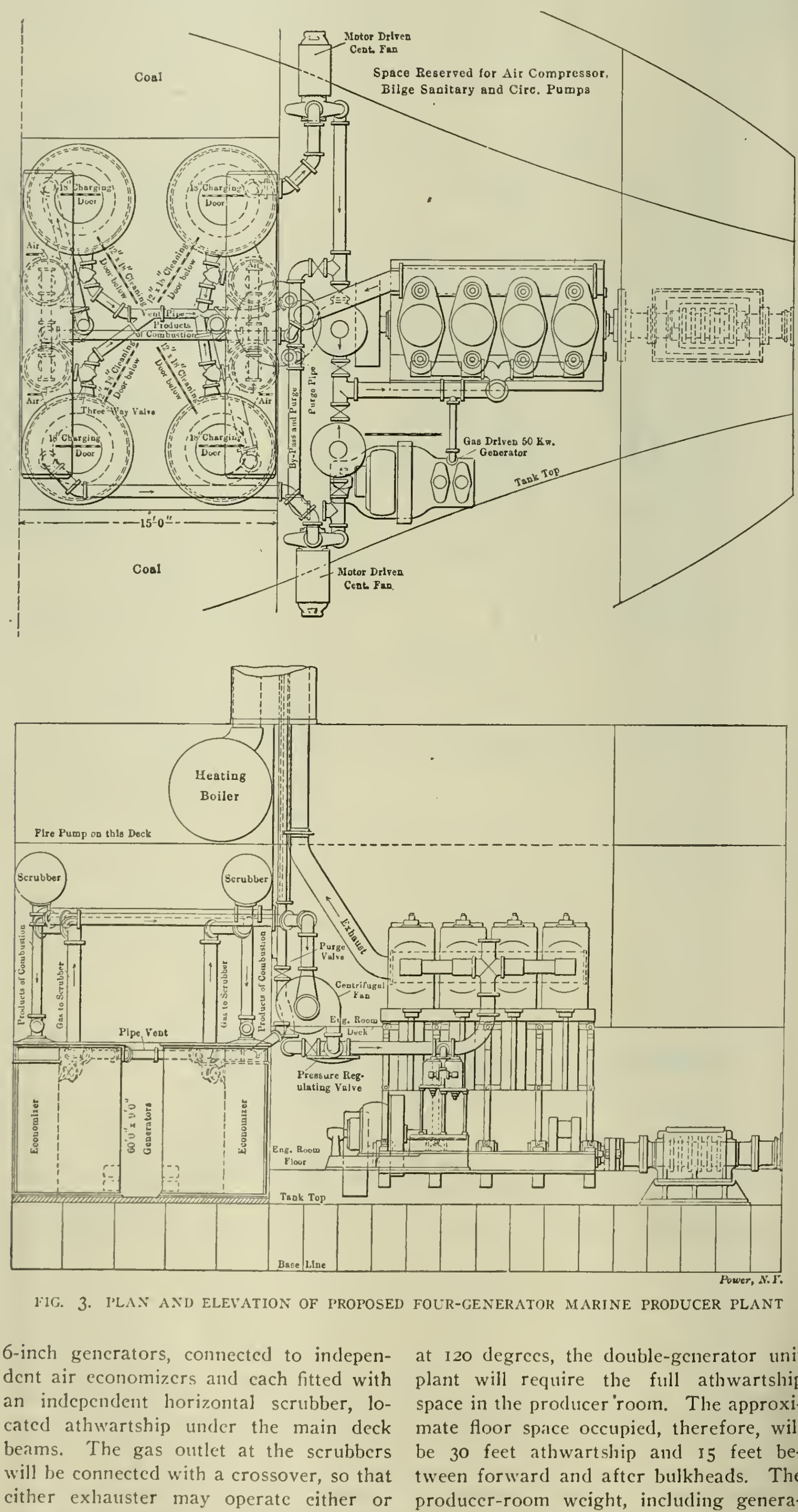


FIG. 3. PLAN AND ELEVATION OF PROPOSED FOUR-GENERATOR MARINE PRODUCER PLANT

complete for the two-generator set is 82,000 pounds. This weight is estimated, but has been carefully checked and completely covers all of the machinery. As in the case of the four-generator plant, a low-pressure boiler for heating service will be installed. In the two-generator plant, however, this boiler will be located on the producer-operating floor, that one set of firemen may suffice for both.

TABLE 1. COMPARISON OF POWER PLANTS FOR GREAT LAKES FREIGHT CARRIER.

Length overall	306 ft. 0 in.
Beam	45 ft. 0 in.
Depth	24 ft. 0 in.
Displacement	Tons gross
Cargo	4,200 net pounds at 18 feet draft
Speed	12 statute miles per hour on 900 indicated horsepower.

STEAM.	GAS.
ENGINE ROOM	ENGINE ROOM.
Three-cylinder triple-expansion condensing engine, 18&30& 50 by 36 in., 1050 i.h.p. at 90 to 95 r.p.m.	Four-cylinder, four cycle, double-acting, gas engine, 24-inch bore by 36-inch stroke 1000 b.h.p. at 95 r.p.m.
Auxiliaries steam-driven	Auxiliaries motor-driven
Length between bulkheads, 22 ft.	Length between bulkheads, 19 ft. 6 in.
Engine room weights, including auxiliaries and piping, 182,000 pounds.	Engine room weights, 105,000 pounds.
BOILER ROOM.	PRODUCER ROOM.
Two single-ended Scotch boilers fitted with economizers, forced draft. Length each boiler, overheads 11 ft.	Two down-draft gas producers and auxiliaries.
Mean diameter, each, 11 ft. 10 in.	Diameter of shell, each generator, 8 feet.
Two 42-in. furnaces each	Inside diameter of generator lining, 6 ft. 3 in.
244 2½-in. tubes, each	Height of shell, each generator, 9 ft. 6 in.
Grate surface, each, 36.75 sq. ft.	Grate surface, each generator, 20.67 sq. ft.
Heating surface, each, 1642 sq. ft.	
Boiler room weight, water in boilers, no fuel, 170,000 pounds.	Producer room weights, no water, no fuel, 82,000 pounds.
Length boiler room, 24 feet.	
Length boiler room, including bunkers, 30 feet.	Length of producer room, including bunkers, [illegible] feet.
	Square feet producer room, 430.
	Square feet per horsepower, 0.43.
Square feet boiler room, including bunkers, 900.	Square feet producer room with four generators, [illegible]
Square feet per horsepower, 0.9.	Square feet per horsepower, four generators, 0.[illegible]
Bunker capacity, 340,000 pounds.	Bunker capacity, 160,000 pounds.
Total weight of machinery and fuel, 692,000 pounds.	Total weight, machinery and fuel, 347,000 pounds.
Total length of machinery space, including bunkers, 52 feet.	Total length of machinery space, 34 ft. 6 in.
	Saving in weight, [illegible] pounds.
	Saving in fore-and-aft length, 17 ft. 6 in.
	Saving in cargo space, 17 ft. 6 in. by 42 ft. beam by 24 ft. depth = 11,[illegible] cu. ft.

The builders of this proposed apparatus are prepared to guarantee one brake horsepower hour on one pound of good bituminous coal, averaging 13,500 B.t.u. per pound.

Babcock & Penton, who have spent several years on the problem of the substitution of gas for steam, have suggested that the coal bunker, which will be placed above the charging deck of the producer, should have a capacity of about [illegible] tons of coal. The bunker will run from the charging deck to the deckfloor and will have doors opening directly adjacent to the charging doors of the generators, so that little or no coal [illegible] on the operating deck will be required.

In making the comparison shown in the [illegible] table, it is unnecessary to go into the cost of fuel, labor, hours of service, etc., as these elements vary with every class of service. In this particular proposition, it will suffice to state that the [illegible] who have been working on this problem for over two years have conservatively figured that with the saving in fuel and the increased cargo carried, the cost of the complete plant will be saved in two years of operation.

A marine bituminous gas plant, similar in construction and operation to the one described but of [illegible] horsepower capacity, has been in commercial operation driving a six-cylinder, single-acting, reversing marine gas engine for over a year. The results obtained give ample security for the statements made in this paper.

Notes on Belting

On the death of Col. Samuel Webber, the well-known New England millwright and engineer, his notebooks were left to his son, William O. Webber of Boston, who presented at one of the recent meetings of the National Association of Cotton Manufacturers some of the data therein contained relating to the measurement of power required for the operation of cotton-mill machinery. Among these notes was the following relating to the use of belting:

Good oak-tanned leather from the back of the hide weighs almost exactly one avoirdupois ounce for each one-hundredth of an inch in thickness, in a piece of leather one foot square, so that

[illegible]

Assuming an average working strain of [illegible] pounds per square inch and using the rule for velocity in feet per minute for each inch in width to transmit one horsepower:

Rule—Multiply the denominator of the fraction expressing the thickness of the belt in inches by [illegible] and divide it by the numerator.

[illegible]

If, however, we use the actual thickness as [illegible] the [illegible] as follows:

[illegible]

so that the safe working strain per inch in width would be as follows:

[illegible]

and the safe load on a [illegible]-inch belt running at [illegible] feet per minute would be:

[illegible]

of its former value, showing slight differences except in the medium, double and 3-ply cases.

Good, well-[illegible] rubber belting [illegible] will be as follows:

[illegible]

The thickness of rubber belt does not necessarily govern the strength, but the weight [illegible] as follows:

[illegible]

and the safe load on a [illegible]-inch belt running at [illegible] would be:

TABULATED RESULTS

[illegible]

Should the arc of contact on the smaller pulley be less than 180 degrees, the [illegible] should be multiplied by the following per cent.:

[illegible]

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Contents PAGE

The "Salem's" Disability

The turbines of the scout cruiser "Salem" were opened on Wednesday, April 28, at the works of the builder, the Fore River Shipbuilding Company, and the cause of her falling off from the efficiencies attained and performances effected on her acceptance tests was revealed. It was found that the first row of buckets in the fifth stage had been battered down very badly, as by a piece of metal projecting from a steam nozzle, or perhaps by a loose piece of metal such as a nut rolling around in the space between the buckets and the nozzle. The edge of each blade was hammered to the top of the blade next to it, almost closing the passage to the steam, and it is not at all remarkable that the turbine should have lost fifteen revolutions per minute. At the time of our advices, the rotor had not been lifted out of the case; when this is done more light may be thrown upon the cause of the trouble.

The rotor appears to have been adjusted too far aft within the casing, with the result that the revolving blades rubbed against the stationary buckets, wearing the bases and shrouds nearly an eighth of an inch. Such a brake at such a radius and at the speed at which the turbine runs must have been a very serious handicap. The buckets and blading show no signs of erosion by steam. The trouble occurred in the starboard turbine and, while it is not expected that any similar condition will be found in the port turbine, that will be opened and examined before the engine leaves the works.

Economy in Woodworking Establishments

In woodworking establishments, where the problem is to get rid of waste rather than to save fuel, and the boiler furnaces serve the part of destructors, there is little attention paid to economy in the generation and use of steam. Nevertheless, there may be more economies to be had than are apparent at first thought. The fuel charge is not the only important item in the power-plant account. The standing charges for interest, taxes, insurance and depreciation, which increase in direct proportion to the investment, often approach the fuel charge in magnitude. The use of the exhaust steam in kilns, etc., means less investment in boilers, less water to pump or buy, less scale to remove, fewer furnaces to fire and rebuild once in so often, fewer boiler tubes to clean and less expense in many other ways than in the amount of fuel used.

The barbarous method of getting rid of waste by wanton burning is being outgrown. In the first place there is a good deal less waste than there used to be. Saws cut closer scarfs and the trimmings are used up to the smallest scrap that will serve even to be glued up with other scrap to make composition board. Higher prices for coal give a greater relative value to this waste as fuel, and in woodworking centers like Minneapolis it is sold quite extensively for this purpose. While its price would not ordinarily warrant going to a great degree of refinement in an effort to save it, its cheapness and availability should not lead to the neglect of possible economies.

A source of economy analogous to the use of exhaust steam in the kilns is the use of exhaust-steam heaters. Here again there is increased boiler power, less torture to the boilers by the feeding of heated water, less scale on account of the throwing down of the impurities which are removable by heat before the water goes to the boiler, and less fuel to handle and fire, with less wear on furnace and grates, even if the fuel is worth little or nothing.

This is written with a full appreciation of the fact that many of the power plants of sawmills and woodworking establishments are models of efficiency, with equipment of the highest class; and simply to offset the still somewhat prevalent notion that cheap fuel is an argument against all effort at power-plant economy.

Are Inside-Screw Valves Unsafe?

In registering a complaint against the ruling of a boiler inspector an engineer calls attention to the fact that he was compelled to replace a new nonreturn stop valve having an inside screw by one with an outside yoke and screw, causing both delay and expense.

In making his decision, the inspector was, of course, guided by what he believed to be his duty in the matter. But to one who could not be present at the time the decision was rendered, some description of the mental process by which a valve with an inside screw was proved to be unsafe or weaker than one with an outside screw and yoke would be interesting.

Valve manufacturers stand ready to guarantee the reliability of their product whether of one style or of the other, and it is not clear why one form should be prescribed when its safety in operation has been clearly demonstrated.

In one instance, several years ago, an outside screw and yoke valve failed under peculiar circumstances, where it is highly probable that an inside screw valve with bonnet would have held.

At or near the end of an eight-inch line of steam pipe carrying one hundred pounds pressure per square inch a valve of the outside screw and yoke type was put on the end of a tee instead of a blank flange, in order more conveniently to extend the pipe line at a future time. Just before steam was turned into the line the valve was closed and the dirt, scale, red lead, flange bolts, nuts and other stuff were blown out through another valve. When the pipe was clean and the blowing valve closed, after about five minutes the yoke on the valve which had not been opened broke, allowing the valve to open wide. In this valve the body and yoke were of cast iron and the stem of bronze. Heat from the steam expanded the bronze portion of the valve more rapidly than the cast iron could accommodate itself to the tension and the yoke parted.

Examination showed that the break was in clean, sound iron and that the yoke was more than ten times as strong as was necessary to resist the steam pressure, but it failed. There may, or there may not be good reasons why one type of appliance is stronger and safer than another, but the question that would most naturally arise is: Has an inspector a right arbitrarily to condemn a piece of apparatus which may be lawfully manufactured or imported?

If the inside-screw valve is unsafe in one instance are not all similar valves unsafe?

Order

In every line of human endeavor it pays to be orderly. System based on order is the underlying principle of true progress, and upon its strict observance in matters of great or small import, largely depends the issue of success. Evidences of the truth of this assertion are all about us and nowhere are they more prevalent or more abundant than in the power field.

Suppose, for instance, that the manufacturer of an engine, or perhaps a turbine, should endeavor to construct his machine without due regard to a system carefully planned and carried out, could the result of such procedure be other than failure? And, again, when the constructive process is complete, does the observance of this principle cease at the threshold of the power-plant, leaving the engine to run at any time or for any purpose, subject to the vagaries of chance? These suppositions are, of course, nonsensical and any engineer would pronounce them so, although a glance into some engine rooms shows such disorder as to imply an entire lack of system.

In building or operating an engine it is easy to see where the law of order has play, but it is the little things that so often escape attention. It may be convenient at the moment to throw a wrench in some dark corner when the work in hand is completed, but the subsequent search when it is again needed will show the false economy of such a method. A saving of present time may be effected by letting things lie where they fall and allowing a collection of odds and ends to litter the floor, or in making repairs it is often easier to patch things up with some temporary makeshift, when there is plenty of time to do the work thoroughly and as it should be done.

In the end it will be found that a strict observance of systematic order in all things will save time and money, and if the importance of doing the little things right were only realized, the number of dirty, ill-kept and disorderly engine rooms would surely be few and far between. Orderly care in the arrangement and the position of even the smallest appointments of an engine room leads to economy in the time and energy of the operator and contributes in an appreciable degree to the life of the machinery. Be orderly and systematic in the small things and the big ones will take care of themselves.

To Revise A. S. M. E. Codes

At a recent meeting of the council of the American Society of Mechanical Engineers, the committee on revision and extension of the code for testing gas-power machinery, Charles E. Lucke, chairman; E. T. Adams, George H. Barrus, D. S. Jacobus and Arthur West, made a general report and requested that they be discharged and a new committee appointed to revise, unify and standardize all the present codes of the society on their various subjects. This committee should not be confused with the gas-power standardization committee, which is a committee within the Gas Power Section, consisting of Dr. C. E. Lucke, chairman, Arthur West, J. R. Bibbins, E. T. Adams, J. E. Andrews, H. F. Smith and Louis [illegible].

It was voted that nine members be appointed by the president for the approval of the council, a committee on power tests to revise the present testing codes of the society relating to boilers, pumping engines, locomotives, steam engines in general, internal-combustion engines and apparatus and fuels therefor, and to extend these codes so as to apply to such power-generating apparatus as the present codes do not cover, including water power, and bring these into harmony with each other and with the best practice of the day.

The committee, consisting of Messrs. [illegible] and Taylor appointed to investigate the advisability of a revision of the standard code on boiler tests, reported that in their opinion it is desirable to undertake a revision of the code in view of the progress made in the art since the standard code was adopted. The application of gas-producer power, gas-producer plants, oil-fired furnaces and other important developments makes it desirable to bring the code up to date so as to include provision for gaseous and liquid as well as solid fuels. It may be desirable, also, in the revised code to give consideration to the question of a standard method for the sampling and testing of fuels.

National Smoke Abatement Conference Proposed

Through the efforts of Prof. Charles D. Benjamin, James M. Dodge, John J. Flather, Harold W. Lewis, Morris L. Cooke and others interest has been aroused in the "smoke abatement" problem to the extent of a proposal having been made to the meetings committee of the American Society of Mechanical Engineers that the society there take cognizance of the matter by holding a national conference in connection with one of its annual or semi-annual meetings.

It is believed that a symposium of papers upon the subject, contributed by eminent authorities, could be procured, beside which the contributions might profitably be selected being as follows: "The Aesthetic Side of the Smoke Question," "Legal Aspects of the Smoke Nuisance," "What Is Smoke?" "The Chemistry of Smoke," "Causes of Smoke in Power Plants and Locomotives," "Apparatus for Preventing, Detecting and Measuring Smoke," "Successful Experiments in Smoke Abatement," "Economic Side of the Smoke Problem," "The Smoke Problem as Affected by Meteorological Conditions," "Smoke in Its Relation to Public Health," etc.

One of the chief reasons that such a conference should be of immense public good, it is believed, is because of the intimate relation between smoke abatement and the conservation of the natural resources of the country.

Who Has Seen This Missing N. A. S. E. Member?

Charles L. Brandon, a member of California Association No. 2, N. A. S. E., has been missing from his home and his friends and relatives are greatly concerned regarding his mysterious absence. Mr. Brandon was last heard of in Spokane, where he was on the lookout for a position, having just left the position of [illegible] machinist with the British Columbia Copper Company, Greenwood, B. C.

Mr. Brandon is about 35 years of age, 5 feet 10½ inches in height and weighs about 160 pounds. He has dark hair, eyes and complexion, and was usually clean shaved when last seen.

Any information concerning Mr. Brandon will be gratefully received and forwarded to his wife by Jacob Thomas, secretary, California No. 2, N. A. S. E., 214 O'Farrell street, San Francisco, Cal.

Universal Craftsmen's "Chambers Night"

The fourth annual Elmer E. Chambers Night of the Universal Craftsmen Council of Engineers, tendered to the ladies, was held at the assembly rooms of the Lexington Opera House, Thursday evening, April 29. Although the night was very stormy, the hall was well filled, and the entertainment was most enjoyable. The "bunch" elicited generous applause. Following the entertainment there was dancing. The committee of arrangements comprised W. H. Armstrong, chairman; M. J. Burke, J. E. Murray, George Quelet, James Harris, George Voet, Fred Maart. Frank Martin was floor manager, assisted by Frank Corbett, John L. Wilson, Herbert Self and Robert Lawhon.

The officers of the association are: Otto Berger, worthy chief; Fred Maart, assistant worthy chief; Fred Anthony, recording secretary; M. J. Burke, financial secretary; S. S. Henderson, warden; George Quelet, treasurer; J. Wallace, guard; William Jones, chaplain; Joseph McKeown, past chief.

Mott Haven's Housewarming

Mott Haven Association No. 47, N. A. S. E., held a housewarming Saturday evening, May 1, to celebrate its removal to the new lodge rooms in Loefler's hall, One Hundred and Forty-eighth street and Willis avenue, New York City. The "bunch" entertained enjoyably. Addresses were made by Past National Presidents, Herbert E. Stone and Joseph F. Carney. Refreshments were served.

The Combined Associations of Engineers of the Borough of Brooklyn held the second annual dinner of its delegates at Feltman's pavilion, Coney Island, on Saturday evening, April 24. An appetizing dinner was served and an excellent entertainment was given by the "bunch."

Business Items

With 3800 employees on the payroll for April, the Diamond Rubber Company, of Akron, Ohio, has under way extensions to its plant which will give employment to more than 200 additional men by fall. No new lines will be taken on by the company at present, but the increased space will be used for the extension of practically all departments, including belting, packing, hose, rubber-covered wires, cables and tires. The city of Akron has lately vacated an entire street adjoining the Diamond factories to permit of the growth of the plant, and in return the Diamond company paid the entire cost of paving the remaining portion of this street not abutting upon its property, the bill for which will be not far from $15,000.

E. H. Stevens, well known among steam power-plant and central-station men as the general superintendent of plants of the Public Service Corporation of New Jersey, has become vice-president and general manager of the Bird-Archer Company, manufacturer of boiler compounds, 90 West street, New York. During his fifteen years' experience in power-plant operation, costs and management, Mr. Stevens has had complete charge of plants aggregating several hundred thousand horsepower, and is therefore well prepared to deal with questions about feed-water treatment. The Bird-Archer Company is also to be congratulated in being able to offer to its customers the advice and help of such an experienced engineer. During the past five years he has used the company's compounds exclusively and is well posted on the results that can be secured by using boiler compounds. Mr. Stevens will have complete charge of sales and will give his personal attention to inquiries from large plants which heretofore have shown serious economy losses and high operating costs on account of scale, oil deposits and other troubles caused by bad feed water.

The improvement in the business of the Westinghouse Machine Company's shops at East Pittsburg, which has been noticeable for several months, continues in the most encouraging degree. Since the first of April quite a number of orders for steam turbines, steam engines and gas engines have been booked, and the record for the first two weeks of this month shows a considerable increase over the same period of March. With the anticipated closing of quite a number of contracts for which negotiations are now pending, the indications are that the April business will make an excellent showing. Among the contracts particularly worth mentioning which the company has lately received is an order from the City Electric Company, of San Francisco, for a 15,000-horsepower steam turbine. This will be the most powerful steam turbine installed west of the Mississippi, its power capacity being about equal to ten of the largest-size express railway locomotives. This company has already installed three Westinghouse steam turbines of a smaller size. The East Pittsburg shops are also turning out at present an order from the city of Detroit, a 5000-horsepower steam turbine, and another of the same size is going to Nichols Copper Company, of Laurel Hill, Long Island, while the Saginaw & Flint Railway Company, of Michigan, has contracted for an 1150-horsepower turbine and the Alaska Treadwell Gold Mining Company, of San Francisco, has ordered two 1000-horsepower machines of the same type.

New Equipment

The York Company, Saco, Me., is to enlarge ts power hou se.

The Scotia Worsted Company, Woonsocket, R. I., will erect a new power plant.

The Hygeia Refrigerating Company, Elmira, N. Y., will build an $80,000 addition to plant.

The citizens of La Crosse, Wis., will vote on question to build a municipal electric lighting plant.

It is said the Beacon Light Company, Chester, Penn., will spend about $125,000 on improvements at plant.

Plans have been prepared for a new power house for the University of North Dakota, Grand Forks, N. D.

The Sierra Electric Company, recently granted a franchise in Red Bluff, Cal., proposes to erect two power houses.

The Springfield (Ohio) Light, Heat and Power Company will erect a large addition to its plant on West Jefferson street.

Julius A. Gebauer, Philadelphia, Penn., is having plans prepared for a four-story factory and one-story power house.

The Eldora Electric Light Company, Eldora, Iowa, will install two 150-horsepower boilers. Albert Tresner, superintendent.

The Steelton (Penn.) Light, Heat and Power Company has decided to increase output and will install additional equipment.

The Grand Rapids-Muskegon Power Com pany, Grand Rapids, Mich., is contemplating installing a steam auxiliary plant.

The Schenectady (N. Y.) Railway Company has let contract for the construction of a new sub-station for the Saratoga division.

It is reported the Southern Lumber and Ice Company, Hattiesburg, Miss., is planning to install an electric light and power plant.

The electric light plant of the Nicholville (N. Y.) Electric Lighting Company was destroyed by fire, causing a loss of about $10,000. It will be rebuilt.

The City Council, Waycross, Ga., has under consideration the question of installing an electric-light plant to be operated in connection with the water works.

The citizens of Brewton, Ala., voted to issue additional bonds for the purpose of purchasing new machinery for the municipal electric light and power plant.

The Isthmian Canal Commission, Washington, D. C., will receive bids up to 10:30 a.m., May 24, for six boiler-feed pumps, steam and vacuum gages, etc., as per circular No. 508.

The Navy Department, Bureau of Supplies and Accounts, Washington, D. C., will open bids June 1 for furnishing and installing boiler in power house at Naval hospital, Los Animas, Colo., as per Schedule 1214.

Mechanical Equipment of the Plaza Hotel

The Power Plant of a New York Hostelry Which Cost Nearly Fourteen Millions and Is Considered the Most Magnificent in the World

BY WARREN O. ROGERS

The Plaza hotel, the most magnificent structure of its kind in the world, is located at Fifth avenue plaza, Fifty-eighth and Fifty-ninth streets, New York City. It occupies an entire block on Fifth avenue, with a frontage of 250 feet on Fifty-ninth street, and 125 feet on Fifty-eighth street. It is constructed of white marble and terra cotta, contains [illegible] rooms and represents an investment of [illegible],000, the mechanical equipment costing $1,780,000.

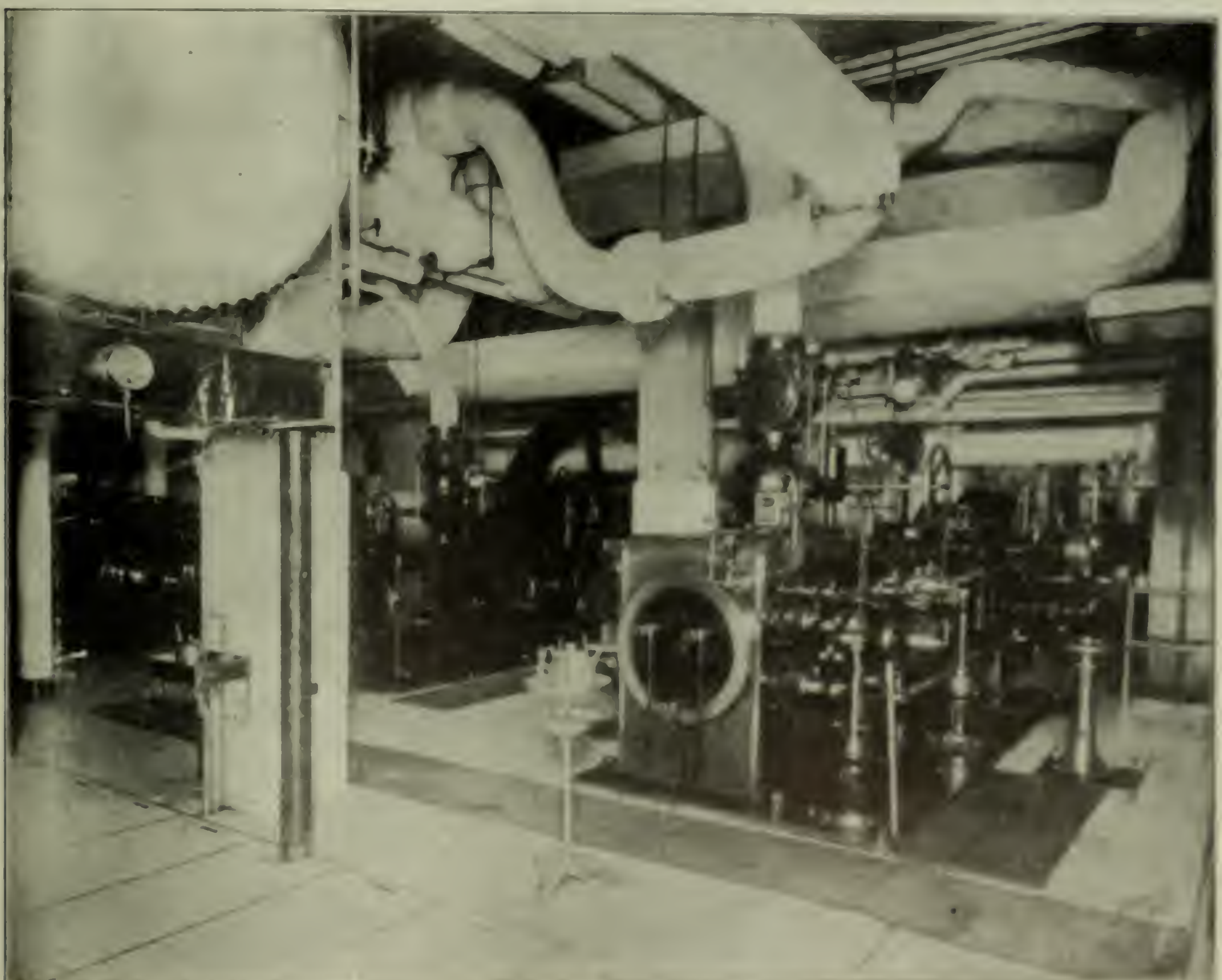


FIG. 1. A [illegible] OF THE ENGINE ROOM

Engine Room

Upon entering the engine room the visitor's attention is at once attracted by its ample proportions, occupying space practically equivalent to the floor area of the hotel. This provides abundant room for working around each machine; nothing is crowded, and the various units are arranged in an orderly manner and with considerable skill. The finish of the walls and flooring and the general appearance of the machinery add to the attractiveness of the installation. The engine room is in the subbasement and has white-enameled brick walls, while the flooring consists of white tile blocks [illegible] square.

The power equipment consists of four simple Allis-Chalmers Corliss engines, direct-connected to Westinghouse generators. Two of the engines have [illegible] cylinders, one [illegible] and one [illegible]. Besides the usual safety cams on the knock-block collars, each engine is equipped with an overspeed governor which, in case of excessive speed, cuts off the flow of steam. An automatic gravity oiling system lubricates the small [illegible] bearings. The engines are run [illegible] at an initial steam pressure of [illegible] pounds. They are painted a dark maroon, striped with gold which, together with the carefully polished bright surfaces, forms a pleasing contrast to the white floors, walls and ceiling. Figs. 1 and 2 give an idea of the arrangement of the generating units, there being two side by side at each end of the room. Fig. 3 is a plan view of the entire plant.

Refrigerating Plant

The refrigerating plant comprises two complete systems, constituting one of the most elaborate refrigerating plants in New York. It embodies a number of features not usually found in an installation of this kind. The compression and absorption systems are used, there being a 100-ton York compressor and a 100-ton York absorption machine. Two systems were adopted to insure the greatest economy during every month of the year. The absorption system is operated during the fall, winter and spring months, when the condensing water is cool and a plentiful supply of exhaust steam is available to operate the generator. The compression system is used during the summer months, when it is necessary to use live steam from the boilers, and the temperature of the condensing water is high. Either machine is capable of supplying the building with ice and refrigeration.

The compression machine, Fig. 4, is so constructed that in case either of the steam or ammonia cylinders is disabled, it can be operated by the side remaining intact. The unit consists of two vertical single-action ammonia compressors operated by a 75-horsepower cross-compound Corliss engine running noncondensing.

The condensers are of the double-pipe countercurrent type, constructed in sections, so that any section can be shut off and removed for repair without the necessity of stopping the plant. As shown in Fig. 5, the condensers for both systems are located on the grating over the refrigerating machine. The coolers are of the vertical shell type and are incased in matched lagging, the brine passing through coils of pipe in the shell.

In the absorption system the two pumps which handle the strong aqua ammonia from the absorber to the generator are of the double-acting steam-driven type, automatically governed. The generator of this system is of the horizontal type, having a vertical analyzer, the generator being so designed and containing such an amount of heating surface that it can be operated by exhaust steam at atmospheric pressure. The ammonia condensers are of the same type as those used with the compression system. They are also so arranged that by shutting suitable valves sections of the coils may be removed for repair when necessary. The ammonia coolers are of the vertical shell type of the same design as those in the compression system; the absorber is of the horizontal type and the exchanger of the vertical shell type, while the weak aqua cooler is of the double-pipe countercurrent type.

The entire refrigerating equipment consists of the brine system, the brine being pumped to the various departments of the hotel by means of four Worthington vertical brine pumps of the "Admiralty" simplex type, located in the engine room just outside the refrigerating room. There are two main brine lines, one a high-pressure and the other a low-pressure, each fed by two brine pumps. The high-pressure line consists of a three-pipe balanced system and handles all the work necessary to cool the refrigerators on all floors up to the seventeenth. Thirty refrigerator boxes are located above the ground floor, while there are 24 boxes in the basement and subbasement. The boxes are of steel, cork and glass and are practically indestructible. On the seventeenth floor is a refrigerating room for furs, etc.

In operation, the brine is cooled in the cooler and is sent up through the feed mains to the coils in the different refrigerators. The brine then passes through

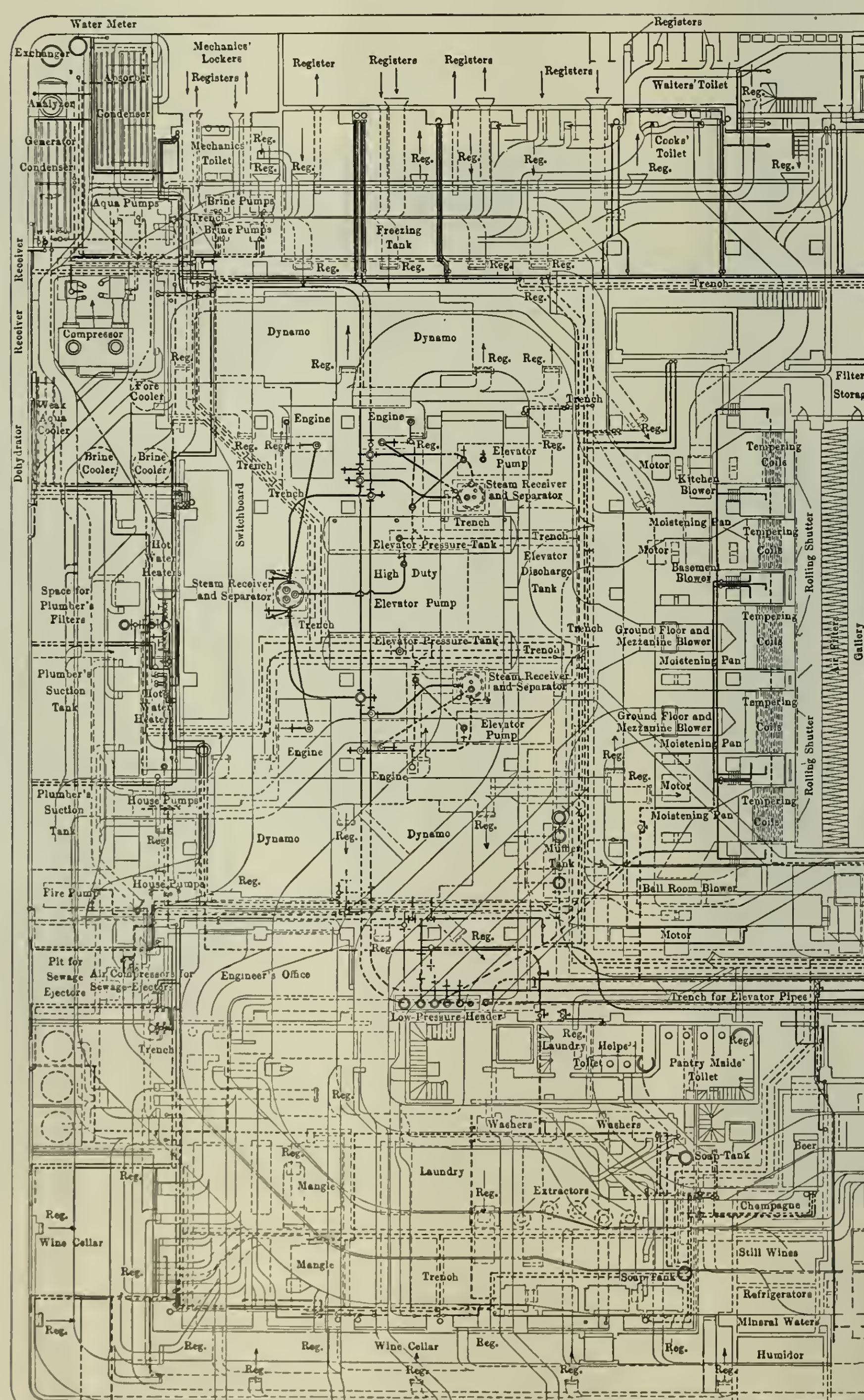


FIG. 3. PLAN VIEW OF THE ENTIRE

the return main to the reservoir tank on the seventeenth floor and is returned through the suction pipe to the pump and again circulated through its cycle.

The refrigerating boxes in the kitchen and all other places on the first floor are cooled by means of the low-pressure system, which is also used in the manufacture of ice. The suction pipe of the brine pump on this system is attached to the ice-making tanks which are located in the engine room and are shown in Fig. 6. The brine is discharged through the cooler and is then passed through the various refrigerator boxes, when it returns to the ice-making tanks.

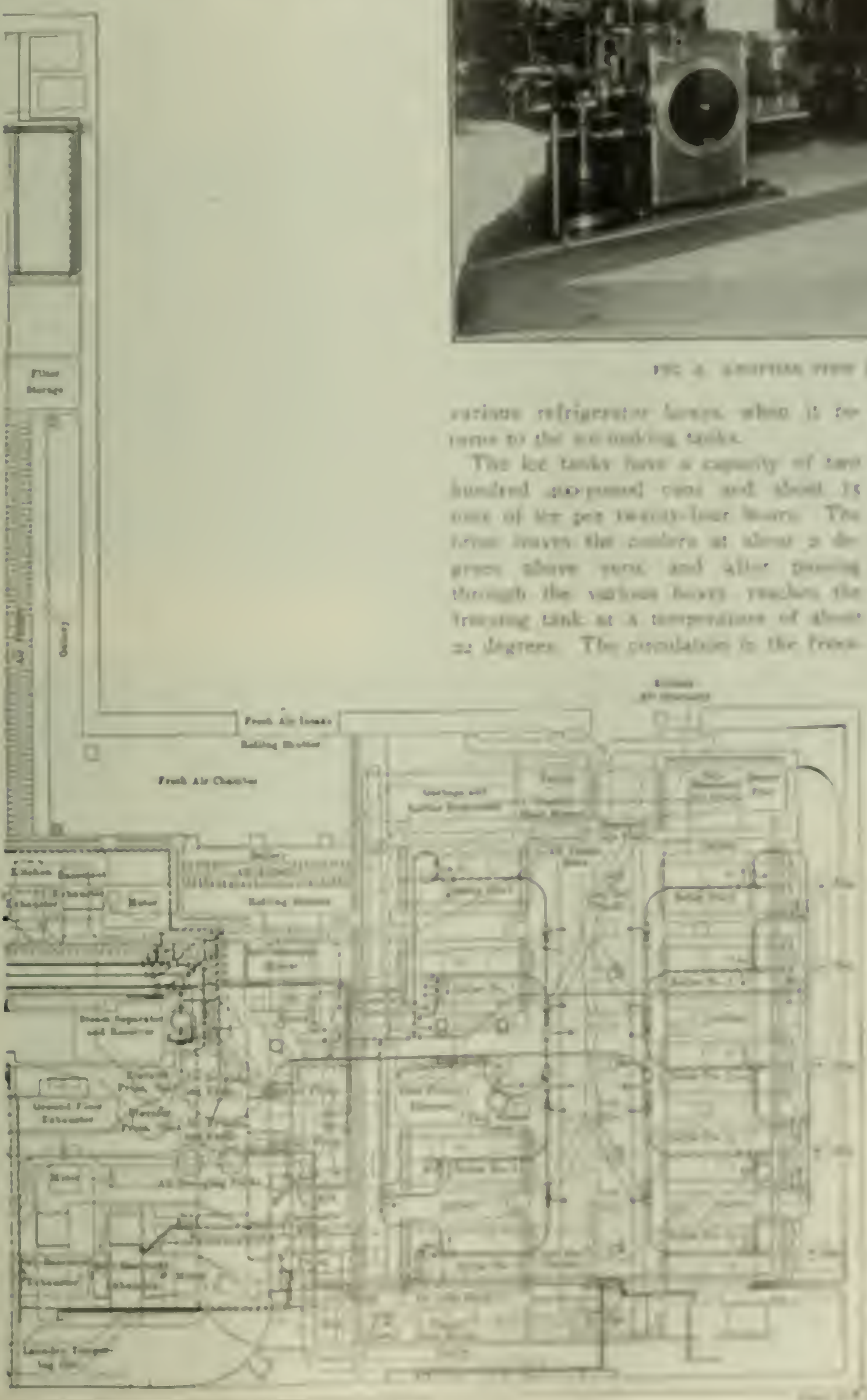
FIG. 4. ANOTHER VIEW IN THE ENGINE ROOM

The ice tanks have a capacity of two hundred 400-pound cans and about 15 tons of ice per twenty-four hours. The brine leaves the coolers at about 2 degrees above zero and after passing through the various boxes reaches the freezing tank at a temperature of about 22 degrees. The circulation in the freezing tank is accomplished by means of a vertical motor-driven agitator which keeps the brine in the tank in constant and rapid circulation. Fig. 8 shows the method of removing a can of ice by means of a hand traveling crane; also the method used in filling the cans with raw water that has been passed through a series of filtering cloths.

The entire refrigerating equipment, where ammonia is used, is placed in a room separated from the engine room by a wall partition, the only entrance being through a swing door. If an accident should occur the door may be easily shut, and a ventilating duct leading to the street opened from outside the room, thus permitting the ammonia fumes to escape and prevent them from finding their way to the hotel rooms above. The room containing the refrigerating equipment is 75 feet 8 inches long and 21 feet 9 inches wide. Both systems were built and erected by the York Manufacturing Company.

Boiler Room

A study of the plan view of the boiler power plant shows that the boilers are located adjacent to the engine room and are set in two rows facing each other with a wide working space between, as shown in Fig. 9. The nine Babcock & Wilcox water-tube boilers have a total capacity of 2700 horsepower, and supply steam not only for power but for cooking and other purposes found desirable in hotel work. The headers are made of wrought steel and are designed to carry a steam pressure of 200 pounds per square inch; the working pressure is 125 pounds



ENGINE, BOILER AND REFRIGERATING PLANT

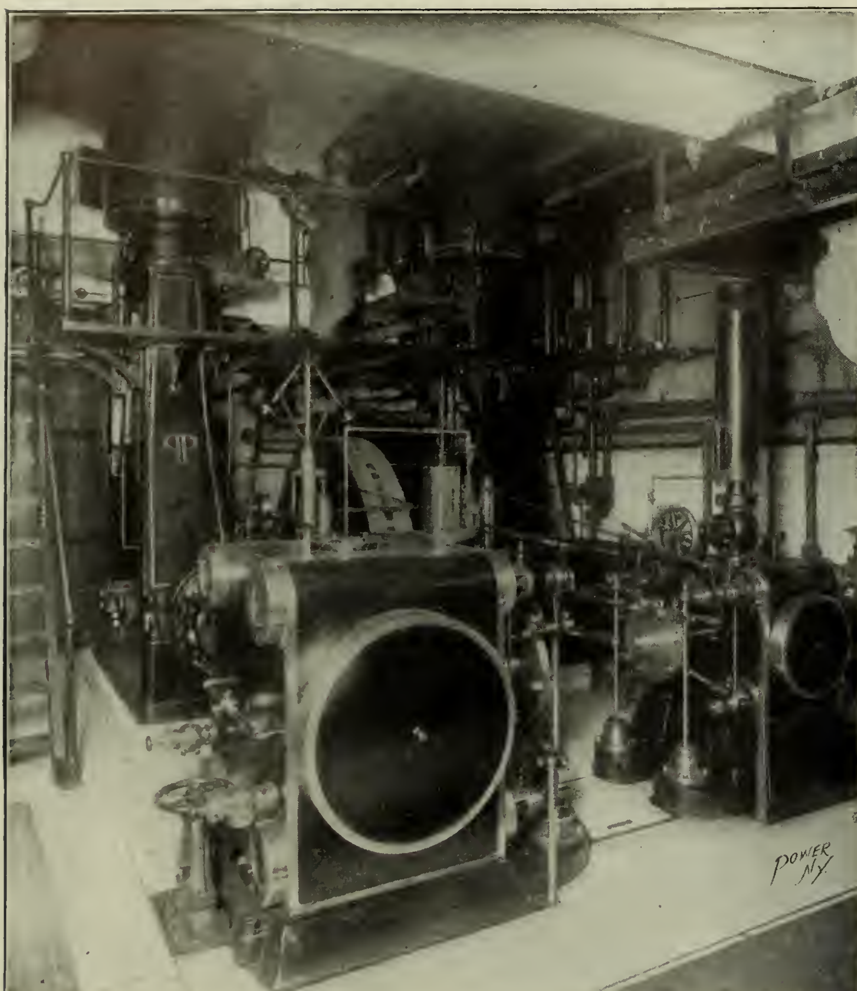


FIG. 4. THE COMPRESSION MACHINE

per square inch, however, which has been found suitable for the work required. As all boilers are not in use at the same time, sufficient opportunity is afforded for cleaning, etc.

Each boiler is fitted with a Wilkinson automatic stoker and the accompanying steam jet, two Lunkenheimer safety consolidated pop valves, and a Hubner & Mayer double-action combination stop and cutout valve, which cuts out the particular boiler it is connected to in case of accident to that boiler or piping. An unique arrangement of the boiler room is in the manner in which the firing floor separates the lower portion of the boiler room from the upper. It is made of iron gratings placed on a level with the top of the stoker hoppers. On this flooring is a narrow track over which the coal is conveyed from the coal bunkers located at one end and above the boiler room. The cars are of such design that the coal is delivered to the hopper of each stoker through a chute on the side. This is shown in Fig. 7, which also illustrates the general arrangement of the boilers.

In Fig. 8 is shown the under side of the grating floor, or the ashpit section. Here the machinery for operating the stokers is arranged; also, the steam jet, as shown. This section of the boiler room is of the same width as that above the grating floor, and is also fitted with a narrow track upon which the ash car is run. The ash and clinker are shoveled from the ashpit into the car and delivered to a Hunt steam-operated conveyer, which delivers it to the ash cart. The same conveyer is used for conveying the coal, which is dumped through a hole in the sidewalk, into a weighing hopper where it is weighed and then conveyed to an 1100-ton storage room.

Each boiler blowoff pipe is connected to a blowoff tank 4 feet in diameter and 10 feet long, made of flanged steel 3/8 inch thick; the heads have a thickness of 1/2 inch. The tank is fitted with 100 lineal

FIG. 6. PULLING AND FILLING CANS

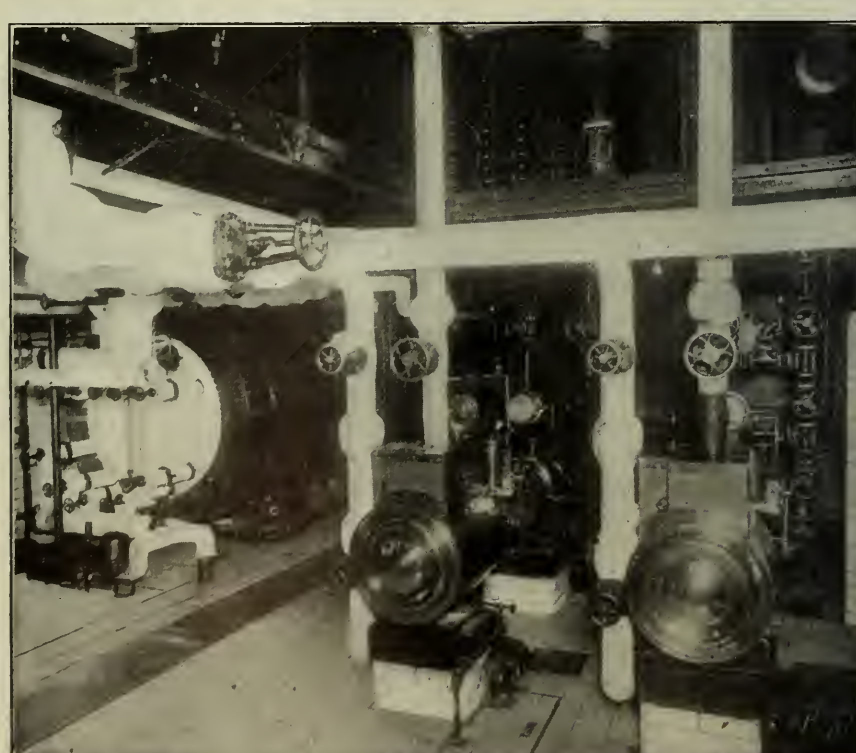


FIG. 5. THE ABSORPTION MACHINE

FIG. 8. SECTION OF BOILER ROOM UNDER FLOOR GRATING, SHOWING ASH PIT

et of 3-inch seamless brass pipe used r cooling coils.

The feed water is heated in a Goubert ed-water heater containing 600 square et of heating surface. It is 34 inches diameter and 152 inches high. There also a Goubert feed-water heater placed the 7-inch vent line, utilizing waste at from the vapor line. It is 12 inches diameter and 70 inches long and is proded with 7-inch nozzles for vapor lines d 5-inch feed inlet and outlet lines. oth heaters are designed to sustain a orking pressure of 200 pounds.

Piping

Owing to lack of head room, the 16-ch high-pressure steam header for each ttery of boilers is run along the front is a light adhesive to clear the manholes. From the headers the main steam pipes branch off and extend to the various pumps, engines and other equipment. The piping through the plant is constructed of extra-heavy and full-weight piping having gun-iron flanges and Van Stone joints. In front of the switchboard, and about central between the four engines, is a National Steam Specialty Company separator to which the engines are piped.

An 18-inch pipe conveys the exhaust steam to a receiver, from which it is distributed to 79 risers which connect with radiators through the building. Each radiator is controlled by a Johnson thermostat valve which regulates the temperature of the rooms. The returns from the heating system are taken care of by the Warren Webster system of appliances.

FIG. 10. VIEW OF SWITCHBOARD

FIG. 9. A SECTION OF THE ENGINE ROOM

One 14-inch steam separator and receiver containing 97.2 cubic feet of steam and water space is located on the main power line. One 8-inch separator and receiver containing 17 cubic feet of steam and water space is located on the auxiliary line. These separators were also made by the National Steam Specialty Company.

Pumps

Four "Admiralty" pattern Worthington boiler-feed pumps, each controlled by a Fisher governor, supply the feed water to the boilers after passing it through a Goubert feed-water heater which heats the water to a temperature of 200 degrees. In the rear of the boilers (Fig. 8) are located pumps for different services, while in the engine room are placed the pumps for hot and cold water house service. These pumps are of the

"Admiralty" compound duplex type of Worthington make.

There are two 8x12x7½x10 compound duplex steam pumps of the vertical type used for pumping out the receiver tanks and for feeding fresh water to the boilers; two 9x6x10-inch duplex steam pumps for draining the high-pressure drip tanks; two 7½x4½x10-inch duplex steam pumps used for draining the blowoff tank and low-pressure drip tank; and three 7½x5x6-inch duplex steam pumps for draining cesspools, each pump being governed by a Johnson automatic regulator, thus regulating the hight of water in the cesspools. All of these pumps are brass-lined and are of Worthington make. There is also in the pump room a 10x14x16 Knowles pump used for vacuum and feed-water heater service.

FIG. 7. FIRING FLOOR OF THE BOILER ROOM

FIG. 13. GAGE BOARD

FIG. 11. AIR COMPRESSORS

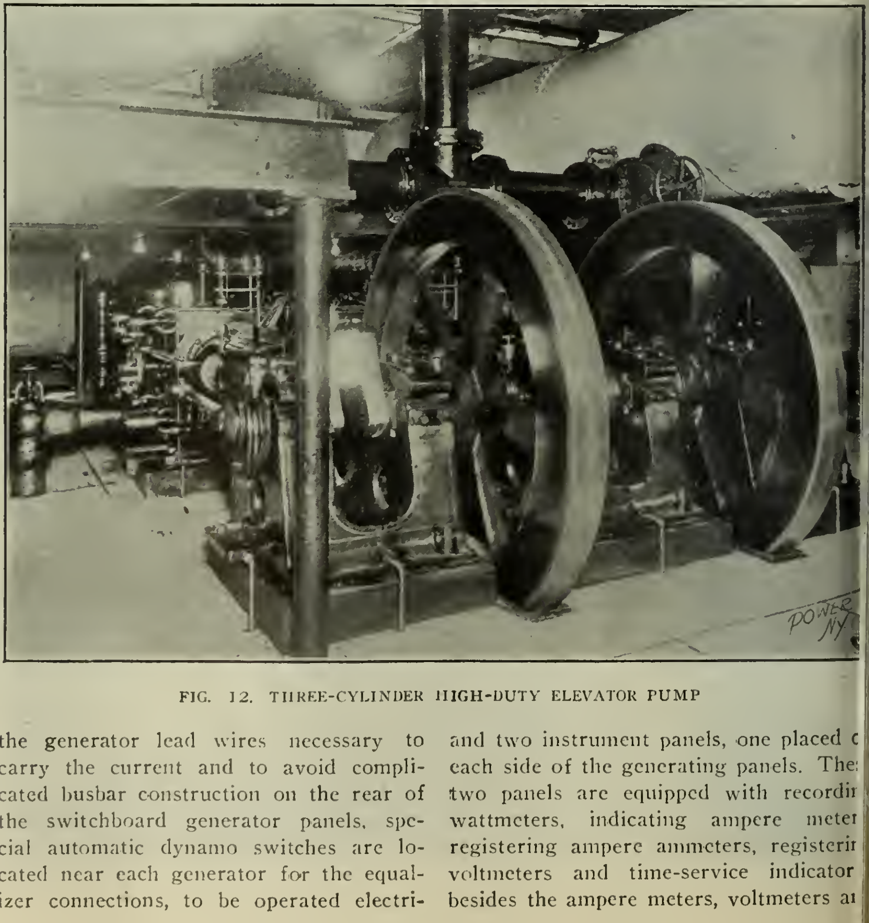


FIG. 12. THREE-CYLINDER HIGH-DUTY ELEVATOR PUMP

Electrical Equipment

The electrical equipment consists of four Westinghouse direct-current generators, one of 400, one of 300 and two of 200 kilowatts capacity. The current is generated at 120 volts, the machines being compound wound, each direct-connected to a simple Corliss engine. The speed is 90 revolutions per minute for the larger units and 100 revolutions per minute for the three smaller units. The generator circuits are extended to the switchboard by means of underground ducts. Because of the length and size of the generator lead wires necessary to carry the current and to avoid complicated busbar construction on the rear of the switchboard generator panels, special automatic dynamo switches are located near each generator for the equalizer connections, to be operated electrically from the switchboard. All of the feeders terminate near the top of the switchboard and connect to copper strips connected to the busbars and extending to the top of the board. The power feeders are connected to double-arm circuit breakers, which also answer as switches. As the switchboard is 8 feet high and 4[illegible] feet long, there is no confusion of the wiring on the back, and the different connections are arranged in a neat, compact manner.

The switchboard, Fig. 10, is made of gray Tennessee marble and is divided into 12 panels, four generating panels being in the center of the board, three feeder panels at each end of the board, each containing 26 separate circuit switches and two instrument panels, one placed o[n] each side of the generating panels. The[se] two panels are equipped with recordi[ng] wattmeters, indicating ampere mete[rs], registering ampere ammeters, registeri[ng] voltmeters and time-service indicator[s] besides the ampere meters, voltmeters a[nd]

FIG. 14. JOB TICKET

FIG. 15. ORDER TICKET

galvanometer which are mounted on the generator panels. There are 52 double-pole knife switches for controlling the lighting circuits and 26 double-arm circuit-breakers for controlling the power feeders, the latter being mounted on the feeder panel. The fuses are placed on the rear side of the switchboard. The current is used not only for the 21,000 incandescent lights in the hotel, but also to run the various motors through the building which operate the ventilating system as well as the filtered air fans.

Miscellaneous

Two mains connected with the city supply furnishes the necessary water, which is filtered through Loomis-Manning filters having a total capacity of 1,500,000 gallons per day. The drinking water is again filtered through a Hohring filter. On the eighteenth floor are storage tanks in which 75,000 gallons of water is stored for use in case of fire. The pumps in the pumping plant are so arranged that 4000 gallons of water per minute can be pumped through the fire line to the tanks.

Compressed air is used for operating a tube system designed to carry messages, etc., to various parts of the house. A vacuum-cleaning system is also installed, thus doing away with the ordinary manner of cleaning. These machines are placed in a separate room, Fig. 11. The system is operated by two steam-driven air pumps.

All of the machinery found in a well-equipped laundry is installed in the laundry connected with the hotel, all driven by electric motors. The dumbwaiters are 13 in number and are electrically operated.

There are 14 ventilating fans of the Sturtevant company's make, operated by eleven C & C motors aggregating 250 horsepower.

The Standard plunger-elevator equipment consists of 16 passenger cars and three sidewalk lifts, besides the 13 dumbwaiters already mentioned. The passenger elevators are of the hydraulic plunger type. Each car is fitted with safety devices which make it impossible for the operator to start the car until he has closed the door. The same device also prevents the door of the car from being opened while the car is between floors. The hydraulic power for these elevators is supplied by two [illegible]-inch Laidlaw-Dunn-Gordon [illegible] pumps and one three-cylinder compound flywheel-type high-duty pump made by the same company. An ingenious method of arranging the two high-pressure water tanks [illegible] connected with the elevator system is shown in Fig. 12. It will be seen that the tanks are suspended from a framework of iron beams directly over the three-cylinder engine, thus utilizing overhead room and saving that much floor space. The low-pressure tank, which carries a pressure of from 25 to 30 pounds, is located at the back end of the pump on the floor in a horizontal position.

Fig. 13 shows an attractive gage board, designed by the [illegible] Company, the gages indicating the temperatures of different [illegible], water pressure, etc.

Among other equipment is that of a [illegible] garbage cremator, the heat generated from the garbage being used for one of the boilers.

Keeping Records

A word regarding the working force and method of keeping the repair charts of this installation is of interest. There are on the average 90 men connected with the engineering force. The men in the boiler and engine rooms work in three shifts, each shift keeping [illegible] hours. This is to prevent the possibility of an accident occurring by someone neglecting [illegible] at the change of the watch [illegible]. It is less likely that an accident will occur.

FIG. 16

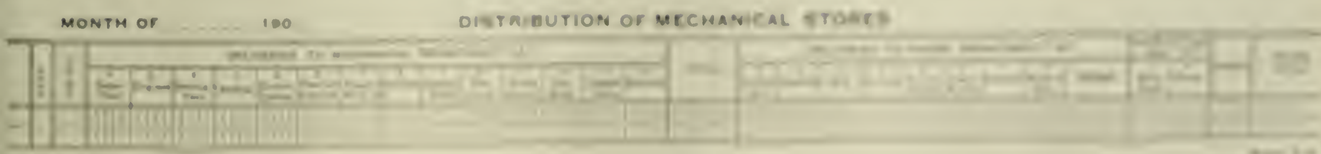


FIG. 17

The engineers' report forms were designed by the chief engineer, J. C. La Vin, and are reproduced herewith. By means of these reports it is possible to know at any time just what has been done by any workman and in what department the labor and material were used. When a man is given a piece of work to do he is given an order and job ticket similar to that shown in Figs. 14 and 15. When the tickets are properly filled in by the workman every detail regarding that particular piece of work is available, if at any time information is desired pertaining to it.

The report sheet pertaining to the distribution of labor about the mechanical and house department is shown in Fig. 16. That pertaining to the distribution of supplies for the mechanical and house department is shown in Fig. 17. By means of these report sheets the labor and material charged to each department are easily ascertained, as they are made up from the job ticket. Thus, if in looking over the report sheet of distribution of labor it is seen that boiler No. 1 had had work done on it charged to job No. 100, by referring to job ticket No. 100 the detailed report of what was done, hours consumed in doing the work and the amount and kind of material required to do it are ascertained. The report sheets on distribution of labor and mechanical stores is a tabulation of the job tickets in a condensed form.

In Figs. 18 and 19 are reproduced in reduced form the chief engineer's daily reports of the absorption and compression refrigerating plants. It will be seen that each report is most complete and that when the engineer on watch has filled in the necessary data the report enables the chief engineer to ascertain just what has been done. In Figs. 20 and 21 are shown the chief engineer's report sheets for boilers and auxiliaries, respectively.

From the foregoing it will be seen that the chief engineer is always in a position to ascertain the exact cause for any increased expense one week or month over another, as well as for one year over another.

The Curtis turbine-driven fireboats at Chicago, Ill., gave excellent account of themselves in the fire which destroyed several Chicago grain elevators on April 29. The "Graeme Stewart" promptly responded to the first alarm at 4:30 a.m., and was shortly afterward in service with full pressure on the two gun nozzles. The "Joseph Medill," although not in commission, went into action on a hurry call a few hours later with one of the gun nozzles and several hose in operation. The operation of both boats was satisfactory in every respect.

COMPRESSION REFRIGERATING PLANT. PLAZA HOTEL, N.Y.
CHIEF ENGINEERS DAILY LOG:
FOR 24 HOURS ENDING AT.................190...

PRESSURES

Time	Compressor Rev.	Compressor High Ammonia	Receiver Ammonia	Brine Cooler Ammonia	Brine Low	Brine High	Brine Return	Steam Boiler	Steam Receiver
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									

TEMPERATURES

Time	Condensers Water In	Condensers Water Out	Condensers Range	Brine High Pressure In	Brine High Pressure Out	Brine High Pressure Range	Brine Low Pressure In	Brine Low Pressure Out	Brine Low Pressure Range	Ice Tank

METER READINGS

Time	Water to Machine
	Final
	Previous
	Cubic Ft. Used

BRINE PUMPS / STRENGTH OF BRINE

Time	Low Pressure No.	Start	Stop	Rev.	High Pressure No.	Start	Stop	Rev.	Strength of Brine Time	At 60° F.
	1				1					
	2				2					

ICE MAKING

Time	Cans Pulled	Tons Harvested	Tons to Kitchen	Tons to Restaurant	Tons to Bars

TONNAGE OF MACHINE

Time	Rev. of Brine Pump × Average Range × Factor = Tons Refrigeration
	H.P. Brine × × =
	L-P " × × =
	Total Tonnage of Refrigerating Machine

Date..................
REFRIGERATING ENGINEERS ON DUTY

Time On	Time Off	Name

Remarks

Power, N.Y.

FIG. 18

ABSORPTION REFRIGERATING PLANT. PLAZA HOTEL, N.Y.
CHIEF ENGINEERS DAILY LOG.
FOR 24 HOURS ENDING AT.......................... 19.....

TEMPERATURES.

Time	Dehydrator Gas In	Dehydrator Gas Out	Absorber Weak Aqua In	Absorber Strong Aqua Out	Absorber Water In	Absorber Water Out	Exchanger Weak Aqua In	Exchanger Weak Aqua Out	Exchanger Strong Aqua In	Exchanger Strong Aqua Out	Condensers Water In	Condensers Water Out	Condensers Range	Brine High Pressure In	Out	Range	Brine Low Pressure In	Out	Range	Ice Tank
Noon																				
4 P. M.																				
8 "																				
Md. Night																				
4 A. M.																				
8 "																				
Average																				

PRESSURES

Time	Generator Ammonia	Generator Steam	Generator Exhaust Steam	Receiver Ammonia	Brine Cooler Ammonia	Absorber Ammonia	Brine Low	Brine High	Brine Return	Boiler Steam
2 A. M.										
4										
6										
8										
10										
Noon										
2 P. M.										
4										
6										
8 "										
10										
Md. Night										

METER READINGS

Time	Water to Machine		Time	Condensed Steam from Generator	
	Final			Final	
	Previous			Previous	
	Cu. Ft. Used			Cu. Ft. Used	

BRINE AND AMMONIA PUMPS

Time	Low Pressure No.	Start	Stop	Rev.	High Pressure No.	Start	Stop	Rev.	Ammonia Pumps No.	Start	Stop	Rev.
	1				1				1			
	2				2				2			

STRENGTH OF AQUA AMMONIA AND BRINE

Time	Strong Aqua Deg. Beaume	Temp't	Corrected to 60° F.	Weak Aqua Deg. Beaume	Temp't	Corrected to 60° F.	Brine At 60° F.

ICE MAKING

Time	Cans Pulled	Tons Harvested	Tons to Kitchen	Tons to Restaurant	Tons to Bars

TONNAGE OF MACHINE

Time	Rev. of Brine Pump × Average Range × Factor = Tons Refrigeration
	H.P. Brine × × =
	L-P × × =
	Total Tonnage of Refrigerating Machine

Date__________
REFRIGERATING ENGINEERS ON DUTY

Time On	Time Off	Name

Remarks

Power, N.Y.

FIG. 19

PLAZA HOTEL.
CHIEF ENGINEERS REPORT ENDING 190

B. & W. BOILERS

Coal Pounds Delivered	Coal Pounds Consumed	Cans Ashes	Average Temp. Gases	Temp. of Feed 1	Temp. of Feed 2	Temp. of Feed 3	Boiler Press.	Back Press.	Vacuum	Heating	Heating On	Heating Off	Heating Hours	Kitchen On	Kitchen Off	Kitchen Hours	Laundry On	Laundry Off	Laundry Hours	Turkish Bath On	Turkish Bath Off	Turkish Bath Hours
										Live												
										Exhaust												

Boiler No.	Time Cut In	Time Cut Out	Hours Run	Hours Banked	Hours Idle	Tubes Cleaned	Furnace Cleaned	Grates Cleaned	Back Connection Cleaned	Dust Removed	Blown Down	Inter'ly Cleaned	Grate Bars Changed
1													
2													
3													

EVAPORATION

Pounds Coal 1	Pounds Coal 2	Pounds Coal 3	Pounds Water 1	Pounds Water 2	Pounds Water 3

REMARKS

Power, N.Y.

FIG. 20

Operation of a Small Producer Gas Power Plant*

By C. W. Obert

The new Westchester market which Swift & Co., recently built in New York, at One Hundred and Fifty-second street and Brook avenue, contains an interesting producer-gas power plant for the operation of both refrigerating and electric generating machinery. The refrigerating duty at present required embraces the operation of a total cooling system containing over [illegible] feet of 2-inch pipe, which reaches a maximum of over [illegible] tons of refrigeration per 24 hours under the most severe summer weather conditions, two 65-ton refrigerating machines were installed for this service, with equipments in duplicate, owing to the great importance of continuity of refrigeration, particularly in hot weather. A maximum of nearly 90 horsepower is required for compression machines of this size and engines of 100 horsepower were selected for driving them, to provide sufficient capacity for unfavorable or overload conditions.

The electrical load, which includes the operation of several electric elevators, fluctuates ordinarily between [illegible] and [illegible] kilowatts, but occasionally reaches a maximum of over [illegible] kilowatts. For this service, duplicate 75-kilowatt generators were installed, with driving engines of 100 horsepower. This was done to secure uniformity of size and detail in all four of the driving engines.

For gas making, two producer equipments were installed. One of these is a 200-horsepower producer, intended for the supply of one refrigerating machine and one generator engine when operating at maximum capacity. The other is of 150 horsepower capacity to permit of closer adjustment of the producer capacity to the load at other times.

The plant arrangement consists of an engine room in the easterly end of the subbasement of the market building, and a producer room adjoining, the entire power equipment occupying a total space, including fuel storage, of [illegible] feet by about [illegible] feet. Headroom for the machinery and piping is afforded by the depression of the subbasement floor to a level [illegible] feet below the street, and the omission of the basement floor in this section, giving there a clear headroom of [illegible] feet. To meet the requirements of the underwriters, the producer room was separated from the engine room by a [illegible]-inch hollow-tile fire wall, forming a producer room [illegible] feet by 24 feet maximum dimensions. Under the One Hundred and Fifty-second street sidewalk there is a room [illegible] feet by [illegible] feet, containing pumps and auxiliaries for the power equipment and the building heater; and adjoining this is a room [illegible] feet by 30 feet for fuel storage; the coal is dumped into it through sidewalk coal-holes from wagons in the street.

The engines are [illegible] vertical three-cylinder units, of 100 horsepower, rated at [illegible] revolutions per minute. The two for the electrical service are direct-connected to 75-kilowatt generators and the other two through silent-chain drives to the ammonia compressors of the refrigerating equipment. They are all of the four-stroke-cycle, single-acting, inclosed type, and each has [illegible] by [illegible]-inch cylinders, designed for the above rating when operating on producer gas of not less than 125 B.t.u. per cubic foot. Throttle regulation is employed.

The gas is generated by two [illegible] suction producers. Each equipment consists of a single shell generator, a wet scrubber and a dry purifier. While the producers differ in rated capacity to permit of more accurate adjustment of their capacity to the power requirements at different seasons of the year, the scrubbers [illegible] have a maximum capacity of [illegible] horsepower, which permits the smaller producer to operate up to the maximum plant capacity of [illegible] horsepower if necessary [illegible]. The [illegible] feet and [illegible] feet [illegible] respectively, [illegible] feet in height, and their internal diameters are [illegible] feet and [illegible] feet, respectively. They are fitted with [illegible] grates for operation with anthracite. They are not fitted with attached vaporizers, but [illegible] [illegible].

THE PLAZA

Chief Engineers Report Ending 190

ELEVATORS						
Number	Time Started	Time Stopped	Hours Run	Cables Dressed	Guides Oiled	Sheaves Oiled
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						

WATER METERS			
	[illegible] St. Main	[illegible] St. Main	[illegible]
Latest Reading			
Previous Reading			
Total Cu. Feet			

GAS METERS		
	[illegible] St. Main	[illegible] St. Main
Latest Reading		
Previous Reading		
Total Cu. Feet		

WATT METERS		
	North Meter	South Meter
Latest Reading		
Previous Reading		
Total K. W.		

ELEVATOR PUMPS

No.	Started	Stopped	Hours Run	Average Pressure	Gallons Pumped
1					
2					
3					

Revolutions			
Pump Number	1	2	3
Latest Reading			
Previous Reading			
Total Rev.			

VENTILATING SYSTEM							
Motor	Started	Stopped	Hours Run	Outside Temp.	Humidity	Wind [illegible]	Wind [illegible]
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
Engine 1							
2							

HOUSE FILTER PLANT										
Number	1	2	3	4	5	6	7	8	9	10
[illegible]										
[illegible]										
[illegible]										
[illegible]										

VACUUM SWEEPING MACHINES					
No. 1			No. 2		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Tank No. 1		Tank No. 2	
[illegible]	[illegible]	[illegible]	[illegible]

LOCAL FIRE DRILL	
Time alarm sent in	Time held
Location	Glass replaced

Laundry: Number of pieces washed

Remarks

FIG. 21

*Abstract of a paper presented at the Washington meeting of the American Society of Mechanical Engineers, May 4-7, 1909.

matic attachment for regulating the amount of water vapor to conform to the power requirement and consequent rate of gasification. The wet scrubbers are vertical cylinders, each 4 feet in diameter by 15 feet high, and the dry purifiers have 4-foot shells 6 feet high.

The piping of the plant was somewhat involved by the arrangement of the engines relative to the producers and by automatic vaporizers in the exhaust connections to utilize the waste heat of the engines for the vaporization of the water. The vaporizers are located close to the engines and attached to each vaporizer is an automatic device through which air is admitted and preheated for the producers. The air is conducted to the producers from these devices by a 10-inch pipe heavily covered with magnesia insulation.

An 8-inch pipe connects the top of the generator to the bottom of the scrubber shell and each scrubber has a triplicate connection to its corresponding purifier, which is a three-part filter. From these the gas is conducted to the engines through a 5-inch main with a 3½-inch branch to each engine. The exhaust connections from the engines to the vaporizers are 5-inch pipes and from the latter, individual discharge pipes are carried up through a pipe shaft in the corner of the building to a roof outlet. This arrangement of exhaust connections is so effective in muffling the noise of the escaping gases that it cannot be heard from the adjoining street and is only barely noticeable when on the roof close to the outlets.

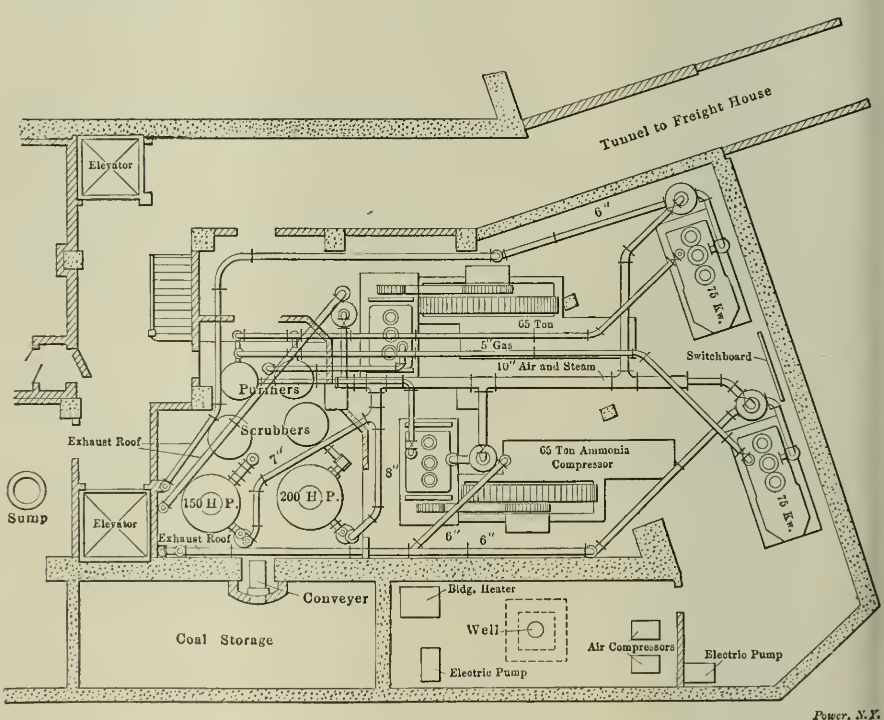
The electrical generators are 75-kilowatt General Electric direct-current 220-volt machines, each rigidly coupled to its driving engine. The distribution for both lighting and power is on the two-wire system. The electrical circuits are controlled on a three-panel switchboard which contains the usual equipment of indicating and recording instruments, field rheostats, field switches and generator and feeder switches. The building is wired separately for lighting and power circuits, and recording watt-hour meters are included in the feeder circuits. Separate busbars are provided for the power and lighting feeders, as well as a switching arrangement by which the lighting service may be supplied from a generator other than that carrying the power load, in case the fluctuations of the latter should interfere with the voltage regulation. This provision has been found unnecessary, however, as the speed regulation of the engines is satisfactory under all fluctuations of load due to elevator operation.

The refrigerating equipment is the direct ammonia-expansion system, a feature of which is the connection of all coils in the coolers in series with those in the freezers, whereby all ammonia not thoroughly evaporated in the freezer coils will be in the cooler coils (temperature, 36 degrees Fahrenheit), which permits carrying the freezer temperature at from 0 degree to +5 degrees without frosting the compressor. The compressors were built by the Hutteman & Cramer Company, and are horizontal single-cylinder double-acting machines, with 14 inches by 30-inch cylinders, each driven at 60 revolutions per minute, by a Renold silent-chain connection from its driving engine. The ammonia condenser is located on the roof of the building. The water supply for it is obtained from a well under the basement floor, and the drainage from the sprays is subsequently utilized in the scrubbers and in the engine-cylinder jackets. One of the compressor units normally handles the load alone, which leaves one equipment always in reserve.

In operation this plant has proved particularly economical, largely because of the continuous character of the service high loads to about 1 pound per horsepower-hour, but the daily average under conditions of ordinary commercial operation is usually greater.

The operating conditions during the heavy-load season are indicated roughly in the accompanying table, in which the relation of fuel consumption to load carried is shown for two weeks of similar duty. The variations in the amount of fuel charged from day to day are due chiefly to the differing conditions of the fued bed in the producer, the removal of a particularly large amount of ashes on any day necessitating a heavy fuel charge. No account is taken of cost of water used in the scrubbers and cooling jackets, as the supply is obtained from the well without cost other than that of pumping.

The fuel used is No. 1 buckwheat anthracite that has been passed over a



PLAN SHOWING LOCATION OF MACHINERY, APPARATUS AND CONNECTIONS

due to the operation of the refrigeration plant 24 hours a day, seven days a week, thereby eliminating standby losses. The average load range of the plant is ordinarily from 50 per cent. (100 horsepower) to full rated load (200 horsepower), the high- and low-load factors occurring during the summer and winter months respectively, when the refrigeration requirements are maximum and minimum. With the heavier load factor during the summer months, the fuel consumption has ranged between 3400 and 4800 pounds per 24 hours, the larger figure having been exceeded on only two days in 11 months. The consumption per brake horsepower-hour, as calculated from station fuel records and observed loads, ranged from 1.4 to 2 pounds of coal. The fuel rate has dropped during periods of continuous

⅜-inch mesh and through a 9/16-inch mesh screen, with 5 per cent. fineness, and costs $3.50 per gross ton delivered in cargo lots. It is charged only at the regular cleaning periods, at each of which from 400 to 900 pounds of coal is fed, after the fire has been cleaned down and the ashes removed from the grate. The fire is cleaned periodically twice every shift, or four times per 24 hours and requires about an hour for cleaning, on the average.

In this connection it is interesting to note the comparatively short time required to start a producer into service from the cold condition, which has been done repeatedly on short notice in about five hours; on December 12, when the 150-horsepower producer was placed in operation to relieve the larger unit, the kindling wood was lighted at 10.30 and the gas supply turned onto the engine at 2 p.m., with only about 12 inches of fire zone in the fuel bed. The reliability of a suction producer operating under a continuous and exacting service of this character is well shown by the duty of the 200-horsepower producer during the summer season of 1908. When taken out of service on December 12 this producer had been continuously in service 24 hours per day and seven days per week since April 22, a continuous run of 235 days. During that time it had received no more attention than the four cleanings and chargings per 24 hours.

The operating force for the power plant consists of a chief engineer, an assistant engineer and two producer tenders, who work in two shifts. This force is able to maintain the equipment in such satisfactory operating condition that the plant has not been shut down since it was started on February 1, 1908. In order to maintain the equipment in such condition, a thorough and comprehensive operating system has been developed which may be of interest.

The operating system involves a thorough inspection routine that keeps the force well informed as to the condition of the entire equipment and a division of duties tending to favor the maintenance work. To the day operating force is assigned the inspection and adjustments of the engines and repairs to [illegible], batteries, etc., while the night force has the work of cleaning all machinery. The regular routine of the day force in detail is as follows:

First, upon coming on duty at 7 a.m., an examination of all moving parts of the two engines in operation is made, and also of oil levels in lubricators and conditions of water jackets and ignition systems. There are always two engines in operation, one being an electrical-service engine and the other a refrigeration engine, which in the periods of heavier load in the summer time have a combined load of about 140 horsepower, of which [illegible]

7[illegible] horsepower is taken by the refrigerating system. Next the water regulation for the scrubber [illegible] and then the condition of the suction draft on the producer and also on the scrubber and purifier, there being three draft gages provided for this purpose, one connected to the gas-suction line to the engines, the second to the gas connection from the scrubber to the purifier and the third to the connection between the producer and scrubber. A [illegible] of suction of from 2 inches to 3 inches of water in these three gages indicates a proper condition of the three parts, while any unusual [illegible] in any of the connections would indicate an obstruction needing immediate attention.

Next an inspection is made of the gas generator, the temperatures of different portions of the fire being determined to ascertain the condition of the fuel bed, the existence of cracks or fissures or pockets of unburned coal. To do this a [illegible] inch iron rod is pushed into the fire [illegible]

RECORD OF LOAD AND FUEL FOR TWO HEAVY WEEKS.

	Electrical Load		Refrigerating Load, B.h.p.-Hours.	Total Load, B.h.p.-Hours.	Coal Charged, Pounds.
	Kilowatt-Hours.*	B.h.p.-Hours.†			
Sunday, July 25, 1908	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Monday, July 26	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Tuesday, July 27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Wednesday, July 28	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Thursday, July 29	410	[illegible]	[illegible]	[illegible]	[illegible]
Friday, July 30	433	[illegible]	[illegible]	[illegible]	[illegible]
Saturday, July 31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sunday, August 22, 1908	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Monday, August 23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Tuesday, August 24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Wednesday, August 25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Thursday, August 26	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Friday, August 27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Saturday, August 28	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Totals	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

*[illegible]

†[illegible]

[illegible]

charged. The coal is cleaned by screening if very fine or dirty. After charging, the operator slices across the grate so as to relieve the center of the fire and again puts water in the ashpit, this time to cool off the grate after cleaning and offset the effect of any air that may have got in during the operation. The cleaning usually occupies one hour. After giving the generator time to settle down, the ashes are withdrawn from the ashpit, an average of 1½ ash cans (about three bushels) being removed after each cleaning. During the cleaning operation the operator is always on the lookout for any change in the engine speed due to weak gas on account of opening the ash doors. Should this occur he immediately cuts the air supply to the engine. The producer is now good for six hours' operation, after which the cleaning is repeated. The refrigerating engines are operated for periods of 84 hours and then gone over. One exhaust valve is taken out of an engine each week, thoroughly cleaned, and reground, if necessary, thus insuring attention to each valve once in every three months. Igniters are cleaned weekly and the batteries and ignition system checked. The temperature of the fuel bed of the producer is taken twice a day and a gas analysis is made once a week or oftener if necessary. The average calorific value per cubic foot of gas is 134 B.t.u., based on the analysis: CO_2, 8.6 per cent.; O, 0.6 per cent.; CO, 20.2 per cent.; H, 18.5 per cent. and N, 52.1 per cent.

The "Mauretania," on the trip which ended at Liverpool on April 20, made 200 miles toward the end of the voyage in 6 hours 10 minutes, or at the rate of 29 knots an hour, a feat never before accomplished by an ocean liner.

Some Properties of Steam*

By Prof. R. C. H. Heck

The purpose of this paper is to present some recent experimental results as to two of the fundamental thermodynamic properties of water and steam, and to make certain comparisons between these determinations and the older values used in our steam tables. The two properties considered are the relation between pressure and temperature of saturated steam, and the specific heat of water.

The Pressure-temperature Relation

This relation is, from the point of view of experimental determination, the simplest of the properties of steam, and with accurate instruments and adequate skill can be very precisely measured. For this reason, the results obtained by various experimenters differ by relatively small amounts, and in discussing them we take up a question in the realm of scientific accuracy rather than one concerning effectively correct values for ordinary technical use. For certain purposes, however, it is most important that this relation be truly and accurately known.

In *Annalen der Physik*, 1907, Volume 22, pages 609 to 630, is published a paper by F. Henning on "The Saturation Pressure of Steam," in which are gathered together all the determinations that have been made on this relation, from Magnus and Regnault down to that time. These are compared by means of curves, which show, to a large scale, their departures from an assumed standard of reference. This standard is the formula of Thiesen:

$$(t + 273) \log \frac{p}{760} \; 5.409\,(t - 100) - 0.508 \times 10^{-8}\left[(365 - t)^4 - 265^4\right],$$

where t is Centigrade temperature and p is pressure in millimeters of mercury. From the comparison and discussion the conclusion was reached that up to 100 degrees Centigrade this formula is to be accepted, while above 100 degrees the determinations of Regnault are best—not as set forth by his formula, but as worked over by Henning, from a selection of his more reliable observations.

A new and very accurate determination by Holborn and Henning, over the range from 50 degrees to 200 degrees Centigrade, is fully described in *Annalen der Physik*, 1908, Volume 26, pages 833 to 883, in a paper on "The Platinum Thermometer and the Saturation Pressure of Steam," while in *Zeitschrift des Vereins deutscher Ingenieure*, February 20, 1909, is given a brief presentation and comparison of results. Exceedingly close agreement is shown between these new observations, the recomputed Regnault values, and the work of Knoblauch, Linde, and Klebe (see Table 3 in *Zeitschrift* article). The final result is a table giving p for every degree from 0 degree to 205 degrees Centigrade, which follows Thiesen's formula up to 50 degrees, and embodies the author's work from that point.

This table is here reproduced in Table 1, but with pressure converted to pounds per square inch and interpolated for every degree Fahrenheit from 32 degrees to 402 degrees, or to just past 250 pounds absolute. Later the writer hopes to extend this table, carrying forward the line of the Holborn-Henning determination in comparison with the observations of Regnault and others. This can be done even

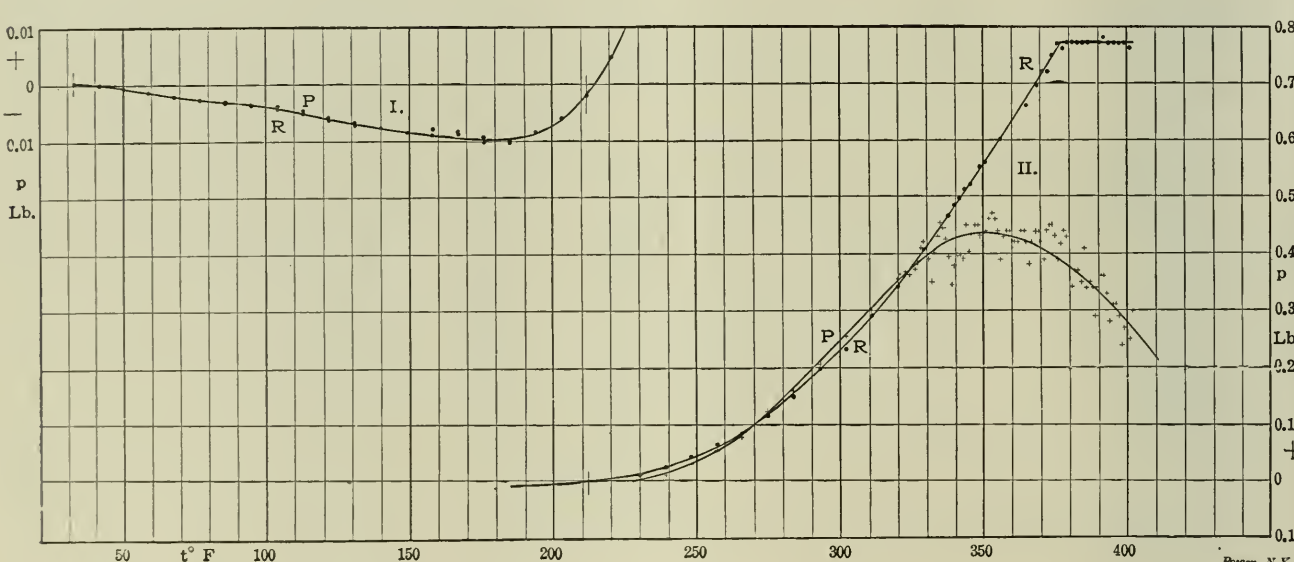


FIG. 1. COMPARISON OF PRESSURE-TEMPERATURE DETERMINATIONS

*Paper presented at the spring meeting of the American Society of Mechanical Engineers, Washington, D. C., May 4-7, 1909.

up to a pressure of 1000 pounds with sufficient accuracy for all practical purposes.

In the work of conversion and interpolation, it was necessary to carry the numbers to a higher degree of apparent accuracy, or to use more significant figures, than any experimental precision would call for. Without a mathematical formula, a function of this sort can be carried forward only by carefully smoothing out the differences until those of the second order follow a continuous rate of change. In this operation, the first differences were brought to a sufficient degree of smoothness to furnish effectively accurate values of the rate of change of p with t; and this differential coefficient, $\frac{dp}{dt}$ is also given in Table 1. It may be considered absolutely correct (as a derivative) within four or five units in the last place, while as between successive values the closeness is much better. This is less precise than might be desired, but it is accurate enough for use in calculating specific volume, since the thermal data there involved are not of any greater degree of reliability.

In Fig. 1 is given a comparison between the pressures in Table 1 and some hitherto generally used values. The base is temperature Fahrenheit, the ordinate the difference between the other value of p and that in Table 1. Curve 1, for the range up to 225 degrees Fahrenheit, is drawn to the large scale at the left, and shows how Regnault's formula drops below the new determination. The curves at 2 have the ordinate scale at the right, only one-tenth as large as that for 1. The letter R marks the "standard" Regnault rates, here plotted from the table in Rankine's "Thermodynamics," which happened to be the most convenient in its manner of expression; note the abrupt change at about 380 degrees Fahrenheit. Curve P shows Peabody's values, which are based on Regnault, but with revised computations, and depart quite decidedly from the older table above 225 degrees. The scattering of the points above that temperature is due to the coarseness of numerical expression, Peabody giving but one decimal place for the higher pressures. The curve is simply sketched through this band of points.

Holborn and Henning do not attempt to devise a formula, but base their table on a method of graphical interpolation. It will be noted that curve 1 shows a faint waviness, indicating some departure from perfect mathematical smoothness; but the extreme smallness of the irregularities is really a proof of the skill with which the original interpolation was made.

The Specific Heat of Water

In Fig. 2 are plotted several important curves for the specific heat of water—the true or instantaneous, not the mean value. Curve R shows Regnault's formula, which in Fahrenheit units is

$$s = 1 + 0.0000222\,(t - 32) + 0.000000278\,(t - 32)^2.$$

This curve differs radically from the newer and true determinations of the specific heat over the lower part of the range as shown by the other curves.

Curve B represents the experiments of H. T. Barnes and associates; these are described briefly in *Proceedings Royal Society*, 1909, Volume 82, fully in *Phil. Trans. Roy. Soc.*, 1902, Volume A 199, while in *Physical Review*, 1902, Volume XV, there is a description of the determination on supercooled water, which was carried to minus 5 degrees Centigrade, and the tabulated values for the whole range up to 95 degrees Centigrade. The body of this work was done by a continuous method, water flowing through a small tube and absorbing heat which was electrically supplied and measured; for the range below freezing a method of mixing was found necessary.

Curve P, which begins at 140 degrees Fahrenheit, shows the values used by Peabody above this temperature; below it he accepts the work of Barnes. Peabody's line—it is almost straight—is based on Regnault's experiments; but it hardly seems reasonable to make s thus an almost straight-line function of t.

Curve D shows the very important experiments of Dieterici, described in *Annalen der Physik*, 1905, Volume 16. In these a small body of water, pure and free from air, was sealed in a tube of quartz. This little cartridge was heated to a certain desired temperature, then dropped into a Bunsen ice calorimeter, where the heat given off in its cooling to 0 degree Centigrade is measured. The highest temperature reached was about 300 degrees Centigrade. The drawback to this method is the relatively large heat capacity of the quartz tube, which has to be very carefully determined. From 100 degrees Fahrenheit upward Dieterici finds that his results conform very well to a parabolic equation like that of Regnault, which for Fahrenheit units has the constants

$$s = 0.99827 - 0.0000576\,(t - 32) + 0.00000064\,(t - 32)^2$$

Below 100 degrees Fahrenheit, calculation from graphical interpolation is preferable to calculation by formula. A numerical comparison of the several curves is given in Table 2.

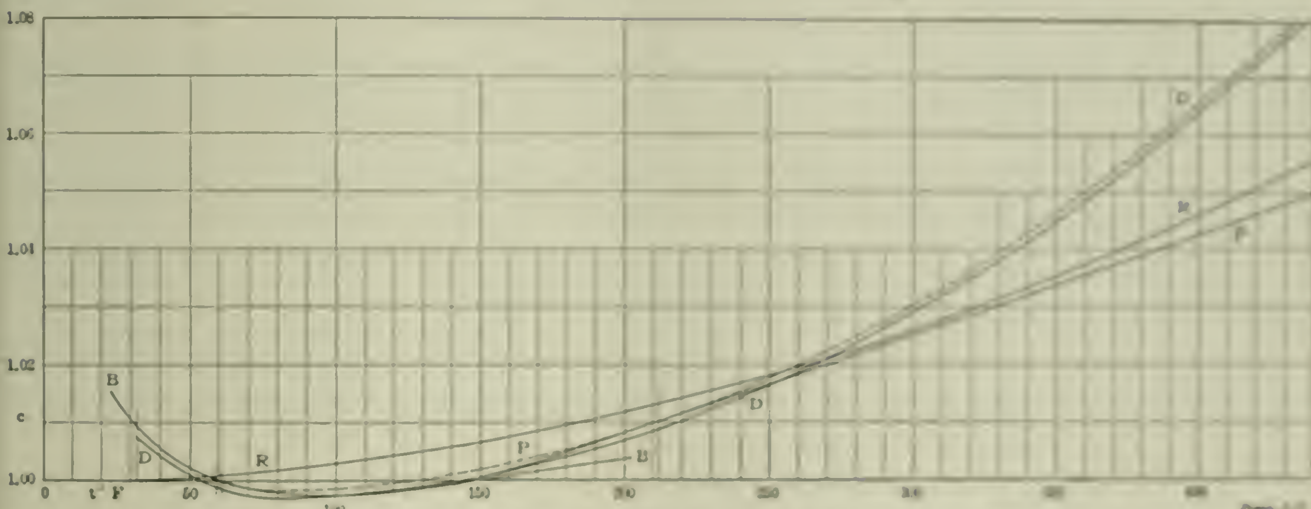


FIG. 2. THE SPECIFIC HEAT OF WATER; VALUES MEASURED OR USED BY REGNAULT, BARNES, PEABODY AND DIETERICI

[illegible] Heat Units

Before discussing these data, something must be said as to the unit of heat measurement. Regnault intended to use the heat capacity of water at 15 degrees Centigrade as the heat unit—in other words, the 15-degree calorie—but it was not until after his time that the first accurate set of measures of the specific heat over the lower range of ordinary temperatures was either clearly perceived or accurately measured. Barnes' values are based on unity at 16 degrees Centigrade, and, it will be noted that the *B* curve on Fig. 2 crosses the base line at just about 16 degrees Centigrade (the two short vertical cross-lines near 60 degrees Fahrenheit are at 15 degrees and 16 degrees Centigrade). The now generally used numerical values of the mechanical equivalent of heat, 427 meter kilograms or 778 foot-pounds are based on a heat unit at 15 degrees Centigrade or 59 degrees Fahrenheit.

Dieterici's results are expressed in the mean calorie, which is one one-hundredth of the heat required to raise 1 kilogram of water from 0 degree to 100 degrees Centigrade; and his specific heat values check up to an average of unity over this range. Graphically, on Fig. 2, his curve cuts the 15-degree Centigrade ordinate at 0.0012

TABLE 1. THE PRESSURE-TEMPERATURE RELATION.

t	p	dp/dt	t	p	dp/dt	t	p	dp/dt	t	p	dp/dt
...	...	...	76	0.4433	0.01467	121	1.7362	0.04815	166	5.459	0.1277
32	0.0886	0.003575	77	0.4582	0.01510	122	1.7849	0.0493	167	5.588	0.1302
33	0.0922	0.00371	78	0.4735	0.01554	123	1.8348	0.0505	168	5.719	0.1327
34	0.0960	0.003845	79	0.4893	0.01600	124	1.8859	0.0517	169	5.853	0.1353
35	0.0999	0.003985	80	0.5055	0.01646	125	1.9382	0.05295	170	5.990	0.1380
36	0.1039	0.00413	81	0.5222	0.01694	126	1.9918	0.0542	171	6.129	0.1407
37	0.1081	0.00428	82	0.5394	0.01742	127	2.0466	0.05545	172	6.271	0.1434
38	0.1125	0.00443	83	0.5570	0.01792	128	2.1027	0.05675	173	6.416	0.1462
39	0.1170	0.004585	84	0.5752	0.01844	129	2.1601	0.0581	174	6.564	0.1490
40	0.1217	0.004745	85	0.5939	0.01898	130	2.2189	0.05945	175	6.714	0.1519
41	0.1265	0.00491	86	0.6132	0.01952	131	2.2790	0.0608	176	6.868	0.1548
42	0.1315	0.005075	87	0.6330	0.02008	132	2.3405	0.06215	177	7.024	0.1577
43	0.1367	0.00525	88	0.6533	0.02065	133	2.4033	0.06355	178	7.183	0.1607
44	0.1420	0.00543	89	0.6743	0.02123	134	2.4675	0.06495	179	7.345	0.1637
45	0.1475	0.00561	90	0.6958	0.02182	135	2.5332	0.06645	180	7.511	0.1068
46	0.1532	0.00580	91	0.7179	0.02243	136	2.6004	0.0680	181	7.679	0.1699
47	0.1591	0.00600	92	0.7406	0.02305	137	2.6692	0.0696	182	7.850	0.1730
48	0.1652	0.00620	93	0.7640	0.02368	138	2.7396	0.0712	183	8.025	0.1762
49	0.1715	0.00641	94	0.7880	0.02432	139	2.8116	0.0728	184	8.203	0.1794
50	0.1780	0.00663	95	0.8127	0.02498	140	2.8851	0.0744	185	8.384	0.1827
51	0.1847	0.00685	96	0.8380	0.02566	141	2.9603	0.0760	186	8.568	0.1860
52	0.1917	0.00708	97	0.8640	0.02635	142	3.0371	0.0776	187	8.756	0.1894
53	0.1989	0.00731	98	0.8907	0.02705	143	3.1155	0.0793	188	8.947	0.1929
54	0.2063	0.00754	99	0.9181	0.02776	144	3.1956	0.0810	189	9.142	0.1964
55	0.2104	0.00778	100	0.9462	0.02849	145	3.2775	0.0828	190	9.340	0.1999
56	0.2219	0.00803	101	0.9751	0.02923	146	3.3612	0.0846	191	9.542	0.2035
57	0.2301	0.00829	102	1.0047	0.02999	147	3.4467	0.0864	192	9.747	0.2072
58	0.2385	0.00856	103	1.0350	0.03077	148	3.5341	0.0883	193	9.956	0.2109
59	0.2472	0.00883	104	1.0662	0.01357	149	3.6233	0.0902	194	10.169	0.2147
60	0.2561	0.00911	105	1.0982	0.03240	150	3.7141	0.0921	195	10.385	0.2185
61	0.2653	0.00939	106	1.1310	0.03325	151	3.808	0.0940	196	10.606	0.2224
62	0.2749	0.00968	107	1.1647	0.0341	152	3.903	0.0960	197	10.830	0.2263
63	0.2847	0.00998	108	1.1992	0.0350	153	4.000	0.0980	198	11.058	0.2303
64	0.2948	0.01029	109	1.2347	0.0359	154	4.099	0.1001	199	11.291	0.2343
65	0.3053	0.01061	110	1.2711	0.03685	155	4.200	0.1022	200	11.527	0.2384
66	0.3161	0.01094	111	1.3084	0.03775	156	4.303	0.1043	201	11.767	0.2425
67	0.3272	0.01127	112	1.3466	0.0387	157	4.408	0.1064	202	12.013	0.2467
68	0.3386	0.01161	113	1.3858	0.0397	158	4.516	0.1086	203	12.261	0.2509
69	0.3504	0.01196	114	1.4260	0.0407	159	4.625	0.1108	204	12.514	0.2552
70	0.3625	0.01232	115	1.4671	0.0417	160	4.737	0.1131	205	12.771	0.2595
71	0.3750	0.01269	116	1.5093	0.0427	161	4.852	0.1154	206	13.033	0.2639
72	0.3879	0.01307	117	1.5525	0.04375	162	4.968	0.1178	207	13.299	0.2683
73	0.4012	0.01345	118	1.5968	0.0448	163	5.087	0.1202	208	13.569	0.2728
74	0.4148	0.01384	119	1.6421	0.0459	164	5.209	0.1227	209	13.845	0.2783
75	0.4289	0.01425	120	1.6886	0.0470	165	5.332	0.1252	102	14.124	0.2819

TABLE 1 (continued).

t	p	dp/dt	t	p	dp/dt	t	p	dp/dt	t	p	dp/dt
211	14.408	0.2866	256	33.085	0.5677	301	67.99	1.015	346	127.67	1.675
212	14.697	0.2914	257	33.657	0.5758	302	69.01	1.0271	347	129.35	1.693
213	14.991	0.2962	258	34.236	0.5840	303	70.05	1.0395	348	131.05	1.711
214	15.290	0.3011	259	34.824	0.5922	304	71.09	1.052	349	132.77	1.729
215	15.594	0.3061	260	35.420	0.6005	305	72.15	1.065	350	134.51	1.746

TABLE 1 (continued).

t	p	dp/dt	t	p	dp/dt	t	p	dp/dt	t	p	dp/dt
216	15.902	0.3111	261	36.025	0.6088	306	73.22	1.0775	351	136.26	1.764
217	16.215	0.3162	262	36.638	0.6172	307	74.31	1.090	352	138.04	1.782
218	16.534	0.3214	263	37.259	0.6256	308	75.40	1.103	353	139.83	1.800
219	16.858	0.3266	264	37.888	0.6341	309	76.51	1.116	354	141.64	1.818
220	17.187	0.3319	265	38.526	0.6426	310	77.64	1.129	355	143.46	1.836
221	17.521	0.3372	266	39.173	0.6513	311	78.77	1.142	356	145.31	1.855
222	17.860	0.3426	267	39.828	0.6600	312	79.92	1.155	357	147.17	1.874
223	18.205	0.3480	268	40.492	0.6688	313	81.08	1.169	358	149.06	1.893
224	18.556	0.3535	269	41.165	0.6777	314	82.26	1.182	359	150.96	1.912
225	18.913	0.3591	270	41.848	0.6868	315	83.44	1.195	360	152.88	1.931
226	19.275	0.3648	271	42.54	0.6960	316	84.65	1.209	361	154.82	1.951
227	19.643	0.3705	272	43.24	0.7052	317	85.86	1.223	362	156.78	1.970
228	20.017	0.3763	273	43.95	0.7145	318	87.09	1.237	363	158.76	1.990
229	20.396	0.3821	274	44.67	0.7239	319	88.34	1.251	364	160.76	2.010
230	20.781	0.3880	275	45.40	0.7334	320	89.60	1.265	365	162.78	2.029
231	21.172	0.3940	276	46.14	0.7430	321	90.87	1.280	366	164.82	2.049
232	21.568	0.4000	277	46.88	0.7527	322	92.16	1.295	367	166.88	2.069
233	21.970	0.4061	278	47.64	0.7625	323	93.46	1.309	368	168.96	2.089
234	22.379	0.4123	279	48.41	0.7725	324	94.78	1.324	369	171.06	2.108
235	22.794	0.4185	280	49.19	0.7826	325	96.17	1.339	370	173.18	2.128
236	23.216	0.4248	281	49.98	0.7926	326	97.45	1.354	371	175.31	2.148
237	23.644	0.4312	282	50.77	0.8028	327	98.81	1.369	372	177.47	2.168
238	24.079	0.4377	283	51.58	0.8131	328	100.19	1.384	373	179.65	2.189
239	24.520	0.4442	284	52.40	0.8235	329	101.58	1.400	374	181.85	2.210
240	24.967	0.4508	285	53.23	0.8340	330	102.99	1.415	375	184.07	2.231
241	25.421	0.4575	286	54.07	0.8446	331	104.41	1.430	376	186.31	2.252
242	25.882	0.4643	287	54.92	0.8553	332	105.85	1.445	377	188.58	2.274
243	26.350	0.4711	288	55.78	0.8661	333	107.30	1.461	378	190.86	2.296
244	26.825	0.4780	289	56.65	0.8770	334	108.77	1.477	379	193.17	2.318
245	27.307	0.4850	290	57.53	0.8880	335	110.26	1.493	380	195.50	2.341
246	27.795	0.4920	291	58.42	0.8991	336	111.76	1.509	381	197.86	2.364
247	28.290	0.4991	292	59.33	0.9103	337	113.27	1.525	382	200.23	2.387
248	28.793	0.5063	293	60.25	0.9216	338	114.81	1.542	383	202.63	2.410
249	29.303	0.5136	294	61.17	0.9330	339	116.36	1.558	364	205.05	2.433
250	29.820	0.5210	295	62.11	0.9445	340	117.92	1.574	385	207.49	2.456
251	30.345	0.5285	296	63.06	0.9561	341	119.50	1.591	386	209.96	2.479
252	30.877	0.5361	297	64.03	0.9678	342	121.10	1.607	387	212.45	2.502
253	31.417	0.5438	298	65.00	0.9796	343	122.72	1.624	388	214.96	2.525
254	31.965	0.5517	299	65.98	0.9915	344	124.35	1.641	389	217.50	2.548
255	32.521	0.5596	300	66.98	1.0035	345	126.00	1.658	390	220.06	2.571

TABLE 1 (continued).

t	p	dp/dt	t	p	dp/dt	t	p	dp/dt	t	p	dp/dt
391	222.64	2.594	401	249.75	2.832						
392	225.24	2.617	402	252.60	2.857						
393	227.87	2.641									
394	230.52	2.664									
395	233.20	2.687									
396	235.90	2.711									
397	238.62	2.735									
398	241.37	2.759									
399	244.14	2.783									
400	246.93	2.807									

TABLE 2. THE SPECIFIC HEAT OF WATER.

Temperature. Cent.	Temperature. Fahr.	Regnault.	Dieterici.	Barnes.	Peabody.
−5	23	....	....	1.0158	....
0	32	1.00000	1.0075	1.0094	....
+5	41	....	1.0037	1.00530	....
10	50	1.00049	1.0008	1.00230	....
15	59	....	0.9987	1.00030	....
20	68	1.00116	0.9974	0.99895	....
25	77	....	0.9970	0.99806	....
30	86	1.00201	0.9971	0.99759	....
35	95	....	0.9972	0.99735	....
40	104	1.00304	0.9974	0.99735	....
50	122	1.00425	0.9983	0.99800	....
60	140	1.00564	0.9995	0.99910	0.99940
70	158	1.00721	1.0012	1.00035	1.00150
80	176	1.00896	1.0032	1.00166	1.00415
90	194	1.01089	1.0057	1.00305	1.00705
100	212	1.01300	1.0086	(1.0044)	1.01010
120	248	1.01776	1.0157	....	1.01620
140	284	1.02324	1.0244	....	1.02230
160	320	1.02944	1.0348	....	1.02850
180	356	1.03636	1.0468	....	1.03475
200	392	1.04400	1.0605	....	1.04100
220	428	1.05236	1.0758	....	1.04760
240	464	(1.06144)	1.0928	....	....
260	500	(1.07124)	1.1115	....	....
280	536	(1.08176)	1.1318	....	....
300	572	(1.09300)	1.1538	....	....

Regnault: from the formula given. Above 200 deg. Cent. his formula is an extrapolation.
Dieterici: from table in original publication, computed by formula from 40 deg. Cent. upward.
Barnes: from *Physical Review*, with last value extrapolated.
Peabody: from Steam and Entropy Tables, p. 10.
Dieterici: values in mean calories (heat units), others in 15 deg. Cent. units.

below the unity base line. In a special experiment, with electrical measurement analogous to that used by Barnes, he made the mechanical equivalent of the mean calorie bear to our standard Rowland value for the 15-degree calorie the ratio of the numbers 419.25 to 418.8, or 1.0011 to 1. Disregarding some uncertainties which may exist in the minds of physicists as to the finality of this determination, it seems reasonable, for engineering purposes, to use this 0.0011 or 0.11 per cent. correction in order to change from one system of units to the other.

The amount of attention here paid to this small point is justified by the importance given to it through the introduction of the mean calorie to the society in the recent paper on "The Total Heat of Saturated Steam," by Dr H. N. Davis. Personally, I think we had better transform heat values to this unit by means of the ratio just offered, rather than change our mechanical equivalent of heat from 778 to 778.9.

Now the specific heat is the ratio of a certain absolute quantity of heat to an assumed unit quantity. If we use a larger unit, the ratio will be smaller, and vice versa. Assuming that the mean calorie is 1.0011 of the 15-degree calorie, we change Dieterici's values to the 15-degree unit if we increase them by 0.11 per cent. This would raise his curve to the dotted position on Fig. 2, and change his formula to

$$c = 0.99938 - 0.0000576\,6\,(t - 32) + 0.000000407\,(t - 32)^2$$

SPECIFIC HEAT OF WATER — CONCLUSION

It is pretty safe to say that the Holborn-Henning results for pressure and temperature, set forth in Table 1, are final, and that this relation is now known surely and accurately enough for all purposes of practical science. But in regard to the specific heat of water we are yet confronted by one of the annoying uncertainties which have so long surrounded many parts of that subject. Dieterici claims an experimental accuracy ranging from 0.1 per cent. at low ranges to 0.5 per cent. at high ranges of temperature; but his method is open to the objection that two heat capacities have to be measured and their difference used.

In spite of some small doubt as to the accuracy of Dieterici's results, and a faint suspicion that his curve may rise too rapidly, I am of the opinion that his determination is to be accepted instead of Regnault's. Further, the idea of an increasing rate of increase in c, as expressed by a second-degree equation, seems to be far more reasonable than that of a nearly constant rate of increase.

It is hardly probable that the heat capacity of water will ever be so accurately determined that the heat for the external work of expanding the water will be more than a small fraction of the probable error in heat measurement.

The Specific Volume of Saturated Steam*

By Prof. C. H. Peabody

For many years the specific volume of saturated steam has been computed from the thermodynamic equation

$$s = \frac{r}{A\,T} \cdot \frac{1}{\frac{d\,p}{d\,t}} + \sigma,$$

in which the quantities have the following significance:

s = Specific volume, for example the volume in cubic meters of one kilogram.

r = Heat of vaporization in calories.

T = Absolute temperature obtained by adding 273 to the temperature by the Centigrade thermometer.

$\frac{d\,p}{d\,t}$ = Differential coefficient of the pressure with regard to the temperature, the pressure being in kilograms per square meter.

σ = Specific volume of water ([illegible] cubic meter per kilogram).

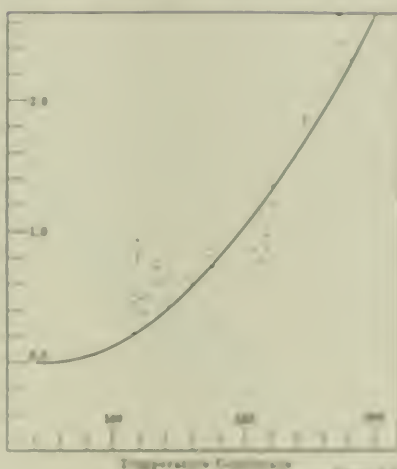


FIG. 1

For this paper French units are used because the original data are given in them and comparison with experimental values is convenient.

All the quantities entering into this equation are now determined with a certainty and precision that must be considered satisfactory for engineering purposes and a comparison with experimental determinations of the specific volume shows an exceptionally good concordance.

To make the exposition of this statement clear it is necessary to review the experimental data and to state the precision that can properly be attributed to them.

The mechanical equivalent of heat as determined by Rowland[1] may be taken as 427 meter-kilograms (778 foot-pounds) at 15 degrees Centigrade, which corresponds nearly with 62 degrees Fahrenheit. There have been some recent investigations which on the whole confirm this result, though there is some indication that it is a little small. The uncertainty may be one in a thousand or one in two thousand.

Callendar[2] gives for the absolute temperature of freezing point 273.1 degrees Centigrade, with a probable error of one in two thousand.

For the range of temperature from 30 degrees to 200 degrees Henning[3] gives the equation

$$r = 94.210\,(365 - t)^{0.31249}$$

in calories at 15 degrees Centigrade. In English units the equation may be written

$$r = 141.124\,(689 - t)^{0.31249}$$

Experiments by Dieterici,[4] Griffiths[5] and A. C. Smith[6] confirm his results and extend the equation to freezing point. The probable error of this equation is one in one thousand.

In his paper, "The Total Heat of Saturated Steam," read at the annual meeting, 1908, Dr Harvey N. Davis gives for the total heat of steam from 212 degrees to 400 degrees Fahrenheit

$$H = H_{212} + 0.3745\,(t - 212) - 0.00055\,(t - 212)^2$$

Transformed into French units this may be written

$$H = 638.8 + 0.3745\,(t - 100) - 0.00099\,(t - 100)^2,$$

provided that the constant term be taken as the sum of Henning's value for r at 100 degrees Centigrade and the heat of the liquid be taken as 100.0, according to a consideration to be taken up later in this paper. To conform with the conditions already assumed, this equation should give the total heat in calories at 15 degrees Centigrade, while Dr Davis used for his calorie $\frac{1}{180}$ of the heat required to raise one kilogram of water from freezing to boiling point. The difference amounts to [illegible], as indicated by the heat of the liquid just mentioned ([illegible]). Now the total heats at 100 degrees and 200 degrees Centigrade are [illegible] and [illegible], and their difference is [illegible] calories so that the total effect is less than [illegible] of a calorie.

As for the heat of the liquid we have the three following sources of information:

*Paper presented at the annual meeting of the American Society of Mechanical Engineers, Washington, D. C., May 4-7, 1909.

[1] Proc. Am. Acad., Vol. 15, [illegible]
[2] Phil. Trans., [illegible]
[3] Annalen der Physik, [illegible]
[4] Annalen der Physik, [illegible]
[5] Phil. Trans., [illegible]
[6] Physical Review, [illegible]

(*a*) Barnes'[7] determinations of the specific heat of water from 0 degree to 95 degrees Centigrade.

(*b*) Dieterici's[8] determinations of the same property from freezing point to very high temperatures.

(*c*) Regnault's[9] determinations of the heat of the liquid.

Barnes' experiments were made by an electrical method for which great relative precision is claimed, and they showed a good concordance with Rowland's work on the mechanical equivalent, which in reality was an investigation also of the specific heat. Dieterici's investigation consisted essentially in heating water in a quartz tube, which was then transferred to the ice calorimeter. His results appear to be systematically larger than Barnes'; at 95 degrees Centigrade, the discrepancy is $\frac{4}{10}$ of 1 per cent.

In 1907 the author endeavored to join Regnault's values for the heat of the liquid to those deduced from Barnes' values of the specific heat. Now Regnault's experiments consisted in running hot water into a calorimeter partly filled with cold water and noting the rise of temperature in the calorimeter. There were 40 tests in all, scattered irregularly from about 100 degrees to 190 degrees Centigrade for the temperature of the hot water; there were in a way three groups of tests, one near 110 degrees, one near 160 degrees, and the third near 190 degrees Centigrade.

The average rise of temperature in the calorimeter for the first group was not far from 9 degrees Centigrade, which item appears to account for the considerable irregularity of results at that place. The experiments with the highest temperatures had nearly twice that rise of temperature in the calorimeter and about half the dispersion of results.

In order to use Regnault's results his values for the heat of the liquid were recomputed, allowing for the true specific heat of the water in the calorimeter, and then a diagram was plotted as shown by Fig. 1, in which the abscissas are temperatures and the ordinates are values of $q - t$.

This allows of the use of a large vertical scale which much accentuates the apparent scattering of points. A curve was then drawn to join a curve from 0 degree to 100 degrees Centigrade, from Barnes' results for the specific heat of water. This curve passes near the highest group of points, above the middle group and below the lowest group.

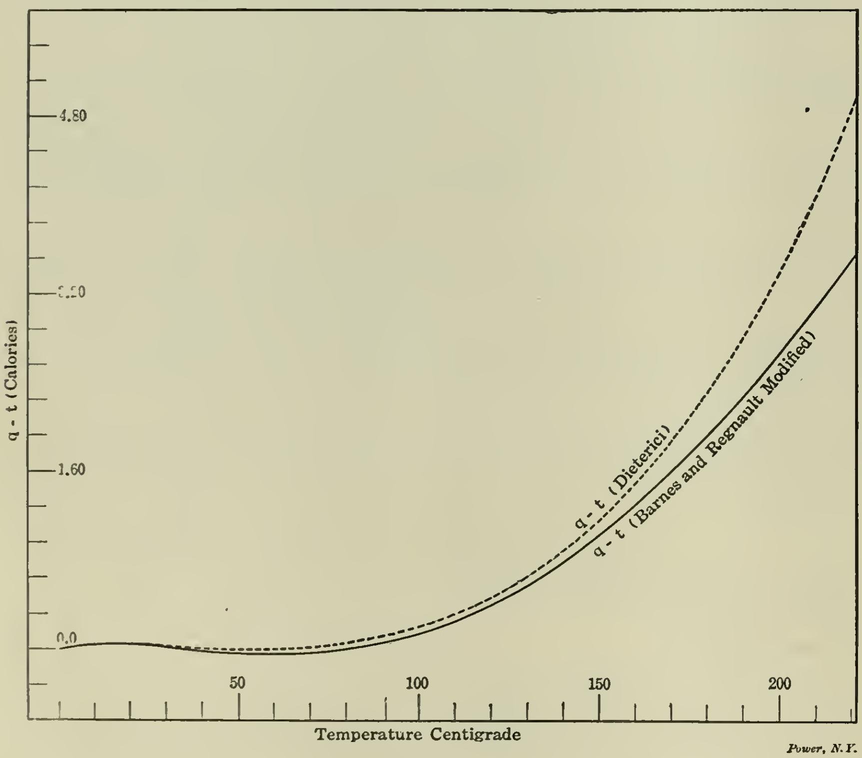


FIG. 2

It should be said that Barnes' results were first transformed to allow for the use of 62 degrees Fahrenheit for the standard temperature, instead of 20 degrees, which he had taken in his report; also that his values were slightly increased at temperatures approaching 100 degrees so as to avoid a break in the curve. The last had the effect of increasing the heat of the liquid at 100 degrees by one one-thousandth.

Finally a table of specific heats was drawn off for temperatures from 0 degree to 220 degrees Centigrade, which served as the basis of a graphical integration for the value of $q - t$. Fig. 2 gives the curve representing the final value of this quantity and also a curve representing values that would be obtained if Dieterici's values for the specific heat were excepted.

The author is of the opinion that the full curve in Fig. 2 shows very nearly the true value of the property under consideration, and he has used it to determine heats of the liquid.

The maximum deviation of a single point from the curve in Fig. 1 is 0.8 of a calorie, which amounts to ¾ of 1 per cent. of the heat of the liquid at that point. If we could consider that an error of 0.02 degree might be attributed to the temperatures in the calorimeter it would account for one-third of that deviation. But to take the most pessimistic view of the situation and charge an error of 0.8 of a calorie against the method, we may still consider that for temperatures above boiling point the heat of the liquid is always associated with the heat of vaporization, and that their sum is more than 630 calories, so that the deviation in this light amounts to ⅛ of 1 per cent.

A more just view is clearly to take the deviation of the worst group of points. This occurs at 117 degrees and is about 0.3 of a calorie, that is, 0.25 per cent. of the heat of the liquid. The most favorable view is to consider that the upper end of the curve is well fixed by Regnault's experiments, which were then under the most favorable conditions, and that the lower end is tied to Barnes' values, which have all desired precision. This matter is discussed with some detail because the original experimental results needed to be entirely recast for the present purpose.

But while important from some aspects, the quantities with which we are dealing are not affected by uncertainties that concern our main investigation, i.e., the specific volume of saturated steam, for the maximum variation between the author's value for the heat of the liquid, and a value determined from Dieterici's investigation, amounts to 0.8 of a calorie at 200 degrees Centigrade. This is only ⅛ of 1 per cent. of the total heat at that place. However, we need for our specific volume the heat of vaporization, and the discrepancy then becomes ⅕ of 1 per cent.

Recent determinations of the pressure of saturated steam have been made by Holborn and Henning,[10] with all the resources of modern physical methods including the platinum thermometer. They claim a precision of 0.01 degree in the determination of temperature and that their results reduced to the thermometric scale have a probable error of not more than 0.02 degree at 200 degrees Centigrade. Their own experiments cover the range of temperature from 50 degrees to 200 degrees Centigrade (122 degrees to 392 de-

[7] *Phys. Review*, Vol. 15, p. 71, 1902.
[8] *Annalen der Physik*, Vol. 16, p. 593, 1905.
[9] *Memoirs de l'Institut de France*, Vol. 26.

[10] *Annalen der Physik*, Vol. 26, p. 383, 1908.

NOTE—Since these results may not be easily accessible, it may be of interest to say that they have been transferred directly to Table 3, of the author's "Steam and Entropy Tables," edition of 1909.

grees Fahrenheit), and they have extrapolated results to 205 degrees Centigrade. Below 30 degrees they have made use of experiments by Thiesen and Scheel to extend results to freezing points, these experiments were not made with the same degree of precision as those by Holborn and Henning.

In order to extend calculations to 220 degrees Centigrade, as has been the habit in computing steam tables, the author made use of a diagram shown by Fig. 3, in which the abscissas are temperatures Centigrade and the ordinates are differences between Holborn and Henning's value and pressures computed by the following equation:

$$\log p = 5.457570 - 0.4120021\,(9.997411296 - 10)^{t-[illegible]} + (7.74168 - 10)\,(9.997411296 - 10)^{t-[illegible]},$$

which was chosen as a matter of convenience and because it gave a curve which crossed the axis near 220 degrees Centigrade when produced. It is thought that the extrapolated values are not much in error, though there is no means of determining this question. Fortunately this part of the range of temperature, as well as that below 30 degrees Centigrade, is not so important to engineers.

The degree of precision attained by Holborn and Henning in the determination of the pressure of saturated steam is far beyond any direct technical requirement, since pressures are seldom determined closer than one tenth of a pound; it is, however, requisite, if the differential coefficient $\frac{dp}{dt}$ is to be determined with certainty and accuracy.

Since their results are presented in a table without attempting to represent it by an equation, it becomes necessary to replace $\frac{dp}{dt}$ by $\frac{\Delta p}{\Delta t}$, which can be most readily obtained as follows: For a given temperature, for example 100 degrees, we may compute the ratio by taking two adjacent temperatures, such as 98 degrees and 102 degrees, finding the difference of pressure, which is to be divided by the difference of temperature; and the result is to be multiplied by 13.5959 [illegible] that is the pressure of one millimeter of mercury on one square meter. This result is

$$\frac{\Delta p}{\Delta t} = 13.5959\,\frac{815.9 - 707.[illegible]}{4} = [illegible]$$

A number of elements entered into the determination to use this method and to take an interval of 4 degrees. If the relation of the pressure to the temperature could be represented by a second-degree curve, that is, if such a curve were a parabola with its axis parallel to the axis

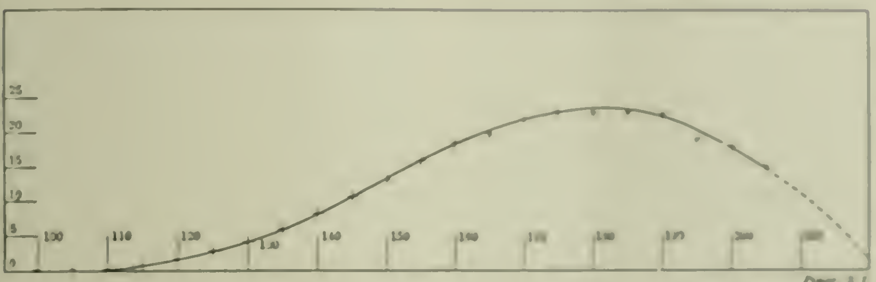


FIG. 3

of pressure, the ratio $\frac{\Delta p}{\Delta t}$ for any interval would be precisely equal to $\frac{dp}{dt}$. A table of values that could be represented by such a curve would have constant second differences; by second differences are meant the results obtained by taking (a) the differences of successive tabular values, and (b) the differences of these differences. An examination of the second differences of Holborn and Henning's values showed great regularity between 50 degrees and 100 degrees, i.e., for their own determinations. The second differences increased slowly; for intervals of 4 degrees the increase was imperceptible, for 6-degree intervals the increase was barely perceptible, but for 10-degree intervals it was very apparent.

Now the possible precision of reading the hight of a column of mercury, including allowance for variations of density, is better than the determination of temperature; consequently the probable error may be considered to be that attributed to the determination of temperature, namely [illegible] degree; consequently the probable error of a single determination of the ratio $\frac{\Delta p}{\Delta t}$ [illegible]. To diminish the effect of [illegible] errors this ratio was computed for each degree of temperature and the regularity of the results thus obtained was tested by taking first and second differences. Where the second differences showed irregularity, the values of the ratio were changed to the extent of [illegible] in order to improve the regularity of the second differences. This process is equivalent to drawing a smooth or fair curve to present physical properties determined by observation.

Having values of the ratio $\frac{\Delta p}{\Delta t}$ for each degree of temperature the specific volumes were computed by the thermodynamic equation in the first paragraph. They were in turn tested for regularity by taking first and second differences, and again the values were changed when necessary to the extent of [illegible] to improve the regularity of the second differences. The combined effect of both changes is estimated not to exceed [illegible] in any case and the author believes that the probable error of the final determinations of the specific volumes is not greater than that assumed for the range of [illegible] degrees to 200 degrees Centigrade.

It may further be said that having computed the values of [illegible] at each fifth degree and plotted the results on a large diagram, no individual values were found to vary from a fair curve more than [illegible].

Fortunately there are extant experiments on the specific volume of saturated steam by Knoblauch, Linde and Klebe,[3] made with such a degree of precision as to give a satisfactory check on the computations made by the method described. These experiments consisted in measuring the temperature and pressure of superheated steam at constant volume, and the results were so treated as to give the volume at saturation by a straight-line extrapolation, with great accuracy. The experimenters give the following equation to represent the properties of both superheated and saturated steam:

$$[illegible]$$

COMPARISON OF EXPERIMENTAL AND COMPUTED VALUES OF THE SPECIFIC VOLUME OF SATURATED STEAM.

Temperature.	Volume, Cubic Meters.			Temperature.	Volume, Cubic Meters.		
	Experimental.	Computed.	Per Cent Deviation.		Experimental.	Computed.	Per Cent Deviation.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[3] [illegible]

$B = 47.10$; $a = 0.000002$; $C = 0.031$; $D = 0.0052$,

volumes being in cubic meters per kilogram. pressures in kilograms per square meter. and the absolute temperature being on the Centigrade scale.

For English units the equation may be written

$$p\,u = 85.85\ T - p\ (1 + 0.00000976\ p)$$

$$\left[\frac{150{,}300{,}000}{T^3} - 0.0833\right],$$

the volumes being in cubic feet, the pressures in pounds per square foot and the temperatures in degrees Fahrenheit.

Knoblauch claims for this equation a mean probable error of $\frac{1}{500}$, though admitting individual discrepancies of twice that amount. This equation applied to the computation of specific volumes of saturated steam shows a good concordance with results, computed by the thermodynamic equation, the greatest discrepancy being $\frac{1}{300}$ at 165 degrees Centigrade (329 degrees Fahrenheit).

Not satisfied with this apparent concordance, which after all was with an empirical equation which on examination showed somewhat larger variation from individual experimental values at saturation, the author had a diagram drawn of the 32 values of the specific volume reported by the experimenters. The diagram was drawn to a very large scale, using temperatures for abscissas and logarithms of volumes for ordinates, and a fair curve was drawn by aid of a stiff spline. From readings on this curve the volumes were determined at 5-degree intervals, and are set down in the accompanying table together with valves computed by the thermodynamic equation.

The greatest deviation of values in this table is 0.2 per cent., which is precisely the probable error assigned by the experimenters for their work. It may therefore be concluded that between the limits of temperature in this table and probably from 30 degrees to 200 degrees Centigrade (86 degrees to 392 degrees Fahrenheit), the probable error of computations by aid of the thermodynamic equation is not in excess of $\frac{1}{500}$.

This conclusion carries with it the attribution of at least the same degree of precision to all the properties entering into the thermodynamic equation. A little consideration will show that this conclusion covers all the properties given in steam tables, including the entropy. As an apparent exception we have the heat of the liquid at high temperatures which may be uncertain to the extent of ¼ of 1 per cent. of itself, but as that quantity is then associated with the heat of vaporization the influence of such an error will be of no consequence in computations.

It may therefore be expected that steam tables based on the present information will have permanence.

Increasing the Weight of Governor Balls

By A. J. Dixon

To the question, "How would a Corliss engine be affected if weight were added to the governor balls?" the following answer was made by an applicant for an engineer's license: "The balls would continue to revolve in the same plane for the same speed, and consequently the increased weight could have no effect on the speed of the engine." It is clear that the kind of governor referred to was the purely ideal revolving pendulum, involving only centrifugal force and gravity, and not taking into account the frictional and other resistances that the practical, everyday working governor has to contend with. Of course, if the governor had no work to do, no resistance to overcome, or if the energy necessary to drive it at a certain speed should always remain the same, irrespective of the weight of the balls, the applicant's answer would have been correct; for, since the two controlling influences in the action of the revolving pendulum or flyball governor are centrifugal force and gravity, the added weight would simply intensify these forces an equal amount—the balls would tend to fall lower by reason of the added weight, but they would likewise have a greater tendency to fly outward by reason of their greater mass, and the net result would be that they would remain in the same plane.

In order to accomplish regulation in actual practice, the speed of the governor must vary within certain limits, and obviously, the narrower these limits the closer the regulation. It is not feasible to regulate closer than within about 2 per cent. of a mean or average speed. This is partly owing to the frictional resistances to be overcome, but chiefly to the resistance due to the inertia of the moving parts of the governor. For example, suppose the engine is cutting off at a certain point for a certain load, and the load suddenly drops off. For a brief moment the valves will continue to cut off at the same point as before, slightly accelerating the speed of the engine, but directly the inertia of the driving mechanism and moving parts of the governor will be overcome, together with the incidental frictional resistance, the speed of the governor will increase, the balls will rise to a slightly higher plane, and cutoff will occur earlier in the stroke of the piston. This will be the succession of events only in the case of a properly designed governor, where the weight of the balls, which is naturally the principal factor in the retarding influences just noted, and the power of the driving mechanism are so adjusted to each other that the resistances can be compensated for by the aforesaid 2 per cent. increase in speed.

Since the inertia of a body is directly proportional to its mass, it is clearly evident that if the mass of the governor balls were increased without at the same time re-proportioning the other essential parts of the governor and its driving gear to correspond, the mechanism could not act as quickly in response to the accelerated speed of the crank shaft as before, on account of the increase in resistance due to the greater inertia and greater friction; consequently, the engine would continue to gather speed until a velocity would be attained sufficient to overcome the additional retarding influence. Then, this velocity of the crank shaft would probably be so great, that when the governor belt would finally take hold and impart a proportionate speed to the governor spindle, the moving parts would acquire a momentum that would carry the balls above the proper plane for regulation under the altered condition of load, with the result that the valves would cut off earlier than they should, the engine would slow down only to be speeded up again after a few revolutions, and the final outcome of the whole performance would be a badly racing engine.

The natural inference to be drawn from the preceding remarks is, that the less weight put into the governor balls, the closer the attainable regulation. But this is so only up to a certain point beyond which it is impossible to go. This limit is fixed by the amount of energy necessary to operate the releasing gear; that is, to overcome the frictional resistance between the hook plates and steel blocks with which they engage. It is quite evident that the energy necessary to do this work is present in the mass of the revolving parts of the governor, and consequently, if the balls were deficient in weight, the hooks could not be forced to disengage or slide off the studs, without a more or less serious displacement of the knockoff cams and consequently of the whole governing mechanism.

A press despatch states that Secretary Ballinger of the Interior Department has instructed the director of the Geological Survey to make an investigation of power sites under the public domain outside of national forests which are not included in withdrawals for reclamation purposes with a view to securing at the next session of Congress legislation to control and regulate their disposition.

The Great Falls Power Company, of which P. M. Gillatt, engineer of the H. M. Byllesby Company, Chicago, is one of the principal movers, is now taking contracts and proposes to supply sixty-three towns and cities in Manitoba with electrical energy.

Increasing the CO_2 Content of Flue Gases

Investigation of Combustion Conditions under Ten Boilers (8400 Horsepower) Using Bituminous Slack Saved $6500 per Year

BY A. J. BOARDMAN

The plant consists of eighteen 400-horsepower and four 300-horsepower Babcock & Wilcox water-tube boilers, with Roney stokers. The diagram of the boiler room is shown in Fig. 1. The four batteries on the north steel stack include four 400-horsepower boilers and four 300-horsepower boilers, which are the oldest boilers in the house. On the south stack are four 400-horsepower boilers, and there are ten 400-horsepower boilers on the brick stack, which is more than the stack was designed for. The last boiler is approximately 148 feet from the stack. With future extensions to the house an additional stack will be built to equalize the draft.

FIG. 1. PLAN OF BOILER ROOM

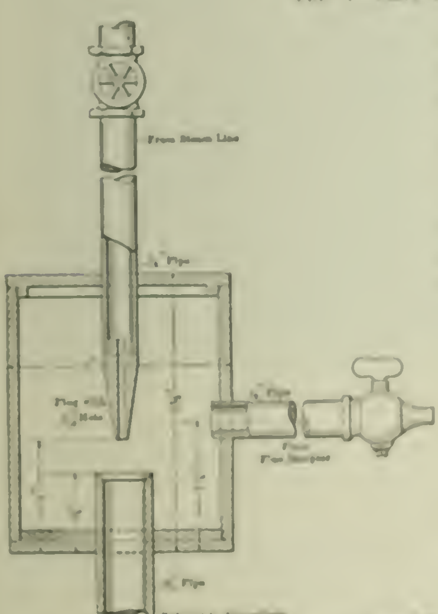


FIG. 2. CONSTRUCTION OF ASPIRATOR

The idea that prompted this investigation was to find out to what extent it was possible to regulate the boilers in order to secure the highest CO_2 at the stack and at the same time get the required capacity out of the boilers. It was deemed advisable to attempt both to regulate the boilers singly and as a whole by analysis of the stack gases. This would give a relative value of the CO_2 after allowing for the infiltration of air through leaks in the breeching.

So far most of the claims of the manufacturers of CO_2 recording instruments have been based on hard coal which gives the best possible conditions for complete combustion. An average analysis of the coal used in this plant, which is [illegible] county, Indiana, slack, is as follows:

	Per cent.
Moisture	[illegible]
Volatile matter	[illegible]
Fixed carbon	[illegible]
Ash	[illegible]
Total	[illegible]

A number of tests made have shown that the CO_2 record gives accurate information regarding the efficiency of a boiler. For a boiler that works at the highest theoretical efficiency the CO_2 record would be constant at about 20, that is, all the oxygen of the air would combine with carbon to form CO_2. In practice such results are seldom obtained, excepting for momentary jumps up to 16, 17 or 18 per cent., which are for very short periods and may be considered abnormal. When a condition exists in the grate for any length of time to give a CO_2 value of 17 or 18 per cent., the boiler capacity will probably decrease. It might be stated that the boiler in the plant under consideration which gave the highest average CO_2, 14 per cent., had the least amount of draft. A test on the same boiler showed a capacity of 87 per cent. under approximately the same conditions.

In the present case, using bituminous slack, when the CO_2 rose as high as 15 per cent. for a short time, the fire became heavy and the capacity of the boiler was seriously interfered with.

It is common knowledge that there seems to be an excess of air owing to a lack of knowledge of the existing conditions in the grate. The result is that the best efficiency in practice corresponds to about 70 per cent. of the theoretical and will generally be lower, depending upon the kind and quality of coal, amount of [illegible] grate, furnace, etc. With the coal used in this plant under the conditions described the average CO_2 [illegible] at the stack should be about [illegible] per cent. [illegible] the highest attainable practical efficiency would give approximately [illegible] per cent. of CO_2 with [illegible] average of about [illegible] per cent.

FIG. 3. ARRANGEMENT [illegible]

Apparatus Used and Preliminary Testing

The apparatus used were an Orsat-Muencke flue-gas analyzer, an Ellison draft gage and a 1000-degree thermometer. The draft was taken over the fire and at the bottom of the soot blowoff holes in the side of the boiler instead of the standard place in front of the damper. There was a difference of 0.02 inch between the damper and the bottom soot holes, but since the readings were only relative this deviation could make no appreciable difference.

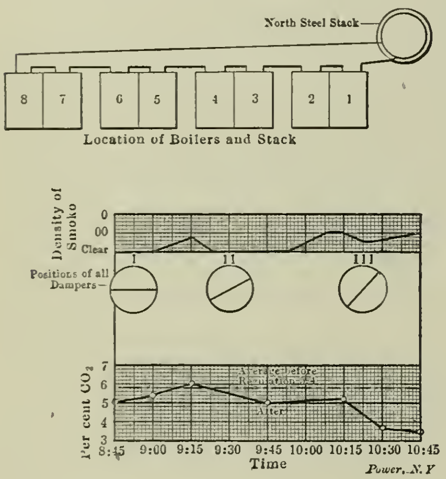


FIG. 4. OBSERVATIONS ON NORTH STEEL STACK

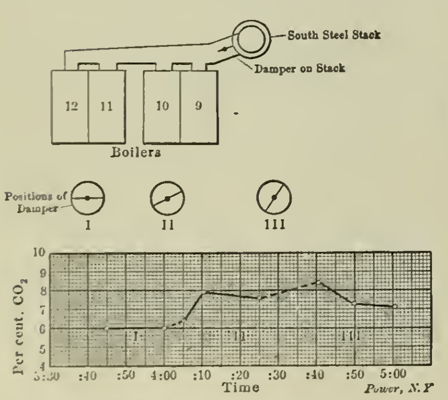


FIG. 5. REGULATION ON SOUTH STEEL STACK

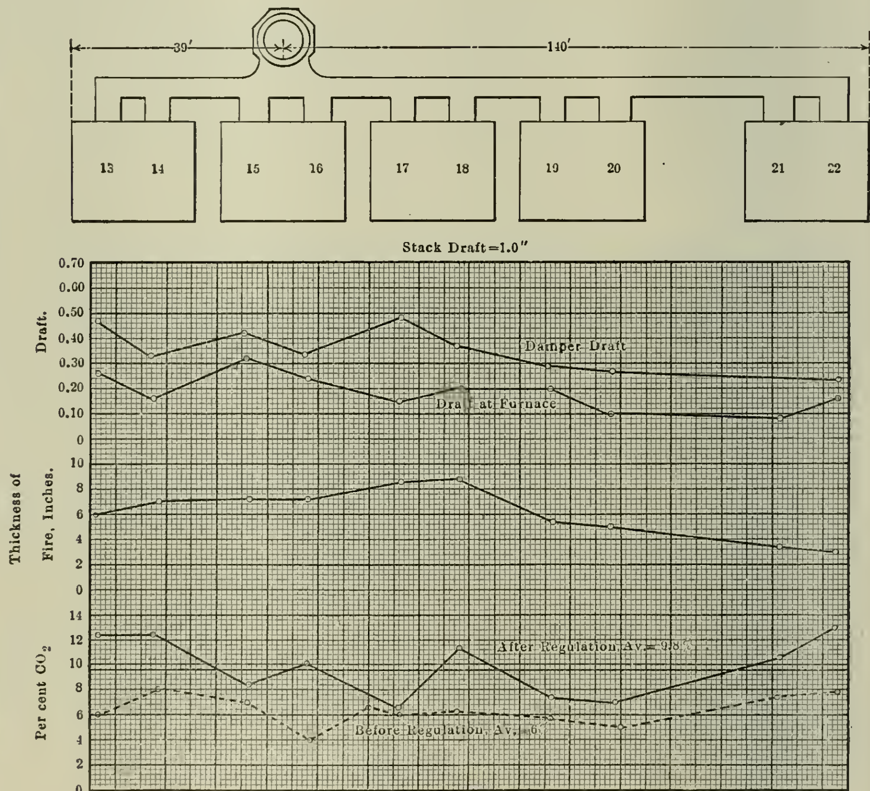


FIG. 6. PRELIMINARY TEST OF BOILERS ON BRICK STACK

The flue-gas samples were taken at the same place. At the brick stack, where it was necessary to draw the samples down into the boiler room, a distance of 40 feet, a steam aspirator, Fig. 2, made out of piping, was used, and in addition a cotton soot filter, on account of the suction that was exerted in drawing down the gas. The samples were then taken from a tin sampling can, as shown in Fig. 3.

Trials were made on several of the boilers to get extreme and average results before attempting to regulate any bank of boilers. The CO_2 varied from 3.5 to 16.6 per cent., the average being near 6 per cent. The highest CO_2 record, 16.6 per cent., was obtained on boiler No. 22, which had the least draft, 0.26 inch, in front of the damper. This extremely high reading was probably due to momentary conditions and may be regarded as abnormal.

A series of observations were taken on the north steel stack, including a smoke chart*, and CO_2 analysis. It was noted that as the load increased the smoke became more dense and the CO_2 decreased. This is explained by the fact that as the boilers were being forced an excess of air was required which increased the density of the smoke and also decreased the CO_2 content of the flue gases. The next day an attempt was made to increase the CO_2 by adjusting the conditions at the fires, that is, with the excess of air shown by the CO_2 record, either shut off the draft or carry a heavier fire, as the most economical draft is not a dilution coefficient of one, but the least amount of air it is possible to get along with.

Infiltration of Air through Breeching

With the dampers wide open the CO_2 was about 5.4 per cent. As the dampers were gradually shut off the CO_2 decreased at the stack. This showed that the breeching was full of leaks. By closing all the dampers a little, more air was pulled through the leaks. Further closing of the dampers decreased the CO_2 to 3.5 per cent., which conclusively proved this to be true. (See Fig. 4.)

On the majority of the boilers in question the baffling was in poor condition. Experiments on the defective boilers showed that it was impossible to raise the CO_2 to any appreciable extent. This is due to the fact that after the air is drawn through the fire, if there is not a thorough mixing of the free oxygen of the air with the unburnt volatile matter of the coal to produce complete combustion, the gases then pass out of the flue at a very high temperature, which lowers the efficiency of the heating surface. Owing to the high temperature and slagging action of the gases, it is difficult and expensive to keep the baffling over the bridgewall in good shape, and the result is that some boilers have about one-half the effective heating surface of others.

The results obtained on the south steel stack, serving four boilers of 1600-horsepower capacity, were somewhat better. Allowing for the infiltration of air in the breeching, the average was raised from 6 to about 8 per cent. (See Fig. 5.) This represents a saving of 9 per cent. of the heat lost up the flue. High temperature readings showing poor baffling on boiler No. 11 interfered with better results. A different method was followed with the boilers on the brick stack. Flue-gas analyses were made for the greater part of one day to ascertain the average CO_2, Figs. 6 and 7. It was thought desirable to attempt individual regulation on each

*The chart used is similar to the Ringelman chart with the exception that the densities are designated as clear, 00, 0, 1, 2 and 3, instead of 0, 1, 2, 3, 4 and 5.

boiler to find the best conditions for each boiler, draft, thickness of fire, etc., then try to approximate the conditions before running a test with the boilers on that stack. As the work proceeded the necessity of a recording device became more apparent. It was easy enough to take

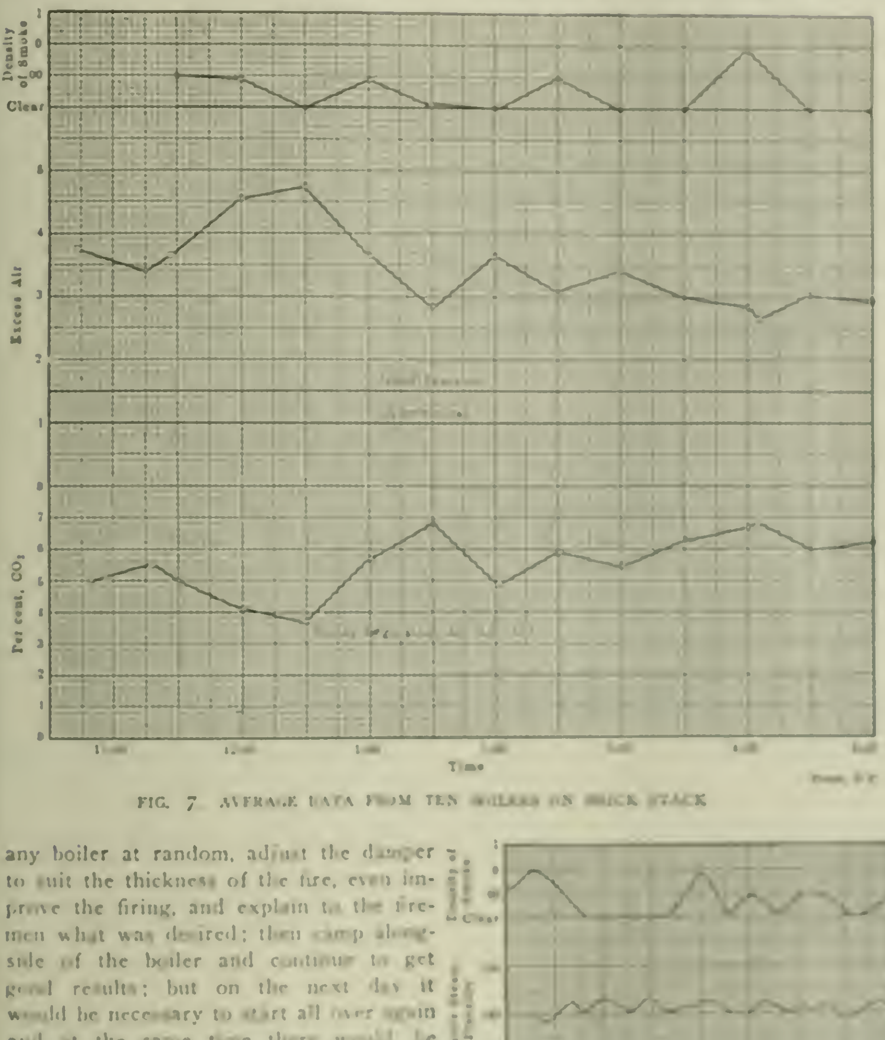


FIG. 7. AVERAGE DATA FROM TEN BOILERS ON BRICK STACK

any boiler at random, adjust the damper to suit the thickness of the fire, even improve the firing, and explain to the firemen what was desired; then camp alongside of the boiler and continue to get good results; but on the next day it would be necessary to start all over again and at the same time there would be twenty-one other boilers, each wasting heat up the stack. There was nothing that could be told the firemen that would be of any permanent value in firing.

Effect of Damper Regulation

Experiments were then made on all ten boilers connected to the brick stack with special reference to damper regulation. The series of observations extended over one day. Although the experiments on the separate boilers and stacks had given an idea of what might be expected, it still remained to prove out a few of the theories that had been advanced by the previous tests.

The graphical logs, Fig. 8, show, first, that the maximum attainable CO_2 with the coal used is in the neighborhood of 10 per cent.

Second, that the increase in CO_2 corresponding with the decrease in draft showed a decrease in steam pressure and boiler capacity.

This checks up with the results of the steaming tests at St. Louis, i.e., if the oxygen is decreased simultaneously with the rise of CO_2 content, the completeness of combustion* decreases.

Third, that the density of smoke increased with the raising of the CO_2. This

FIG. 8. [illegible]

is explained by the fact that by decreasing the air supply with the thickness of fire constant, it became necessary to make frequent use of the slice bar, which resulted in an increase in the density of the smoke.

About 3 o'clock in the afternoon the load had started to peak and it became necessary to open up the dampers to get capacity out of the boilers.

In the following data Column 1 gives average results before regulation and Column 2 average results after regulation.

	1	2
Flue gas temperature	[illegible]	[illegible]
Boiler room temperature	[illegible]	[illegible]
CO_2 per cent., volume	[illegible]	[illegible]
$CO_2 + O$, per cent., volume	[illegible]	[illegible]
Free oxygen	[illegible]	[illegible]
CO, per cent., volume	Trace	[illegible]
Nitrogen by difference	[illegible]	[illegible]
Dilution coefficient	[illegible]	[illegible]
Wt. air per lb. carbon	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
Per cent. heat lost to flue	[illegible]	[illegible]
Volume of air per lb. carbon	[illegible]	[illegible]
Efficiency, per cent.	[illegible]	[illegible]

Saving in heat lost [illegible] per cent. by raising CO_2 from an average of 5.8 up to 7.3 per cent.

Assuming 20 pounds of coal per square foot of grate surface per hour, and ten boilers, each with [illegible] square feet of grate surface, or a total of [illegible] square feet.

[illegible] pounds coal per hour.

[illegible] pounds coal per eight hours.

[illegible] tons.

[illegible]

[illegible]

Total saving for 24 hours [illegible]

Saving for one year [illegible]

This last result, which is the total saving on ten boilers, shows that it would pay to keep a man to take charge of the boiler room, with the sole purpose in view of increasing the CO_2.

*[illegible]

Carbon Burned to CO_2: Nitrogen 79.

Gas Analysis Combustible Burned to 100% Carbon.	Excess Air.	Gas Analysis Combustible Burned to 100% Carbon.	Excess Air.
$CO_2 = 21$, $N = 79$	1.00	$CO_2 = 10$, $O = 11$	2.10
$CO_2 = 20$, $O = 1$	1.05	$CO_2 = 9$, $O = 12$	2.23
$CO_2 = 19$, $O = 2$	1.10	$CO_2 = 8$, $O = 13$	2.62
$CO_2 = 18$, $O = 3$	1.17	$CO_2 = 7$, $O = 14$	3.00
$CO_2 = 17$, $O = 4$	1.23	$CO_2 = 6$, $O = 15$	3.50
$CO_2 = 16$, $O = 5$	1.31	$CO_2 = 5$, $O = 16$	4.20
$CO_2 = 15$, $O = 6$	1.40	$CO_2 = 4$, $O = 17$	5.25
$CO_2 = 14$, $O = 7$	1.50	$CO_2 = 3$, $O = 18$	7.00
$CO_2 = 13$, $O = 8$	1.61	$CO_2 = 2$, $O = 19$	10.50
$CO_2 = 12$, $O = 9$	1.75	$CO_2 = 1$, $O = 20$	21.00
$CO_2 = 11$, $O = 10$	1.91		

This table is correct for the values given. It is impossible to compute a table that will show the heat loss for any case, owing to the number of varying factors that influence the result.

A Peculiar Accident

On the afternoon of Saturday, March 20, Peter H. Bullock, chief engineer of the Concord Reformatory, Concord Junction, Mass., was passing through the engine room on his way to his office and paused near the cylinder of a 20x48 Harris-Corliss engine. As he glanced from the valve gear to the governor, by the hight of which he saw that the load was light, there came the sound of water slapping in the cylinder. Signaling his assistant to go to the boiler room, he partially closed the throttle, slowing the speed of the engine, when almost immediately there came the pound of solid water in the cylinder.

Mr. Bullock immediately closed the throttle and, as the engine continued to pound hard as it slowed down, unhooked the motion plate, hoping to stop the engine more quickly. At the third stroke following, as the crank was passing the forward center, the side of the throttle valve burst, steam and hot water striking him in the face and on the upper part of the body and throwing him to the floor. Bruised and scalded, and with eyes and mouth closed, Mr. Bullock crawled as rapidly as possible toward a window seventy feet away, running into the flywheel of a high-speed engine *en route*, which bruised him more. But in less than thirty seconds from the time he placed his hand on the throttle lever he was safe outside the building.

In this plant steam is generated in three vertical boilers, with induced draft controlled by a Foster fan-regulating valve, and in two horizontal tubular boilers with natural draft. At the time of the accident shavings and waste lumber were being burned under one of the horizontal boilers and, as the fire was burning fiercely, it is thought that the Foster valve in the fan-engine steam pipe practically stopped the fan engine and water was carried over into the steam main from the horizontal boiler. From the horizontal boiler the steam pipe passes across the boiler room and, making a right-angle turn, leads along the side wall which separates the engine room from the boiler room. At the end of this pipe steam for the engine is taken from the bottom, compelling all water in the pipe to flow to the engine.

It would seem that after the throttle, which was of the sliding-cover lever-operated type, was closed water collected in the pipe and as the water in the cylinder was rapidly forced upward through the steam chest, lifting the steam valve of the engine and the valve in the throttle from their seats, when the water from the cylinder met the column of water in the pipe above the throttle, the pressure required to start this column was greater than the body of the throttle would stand.

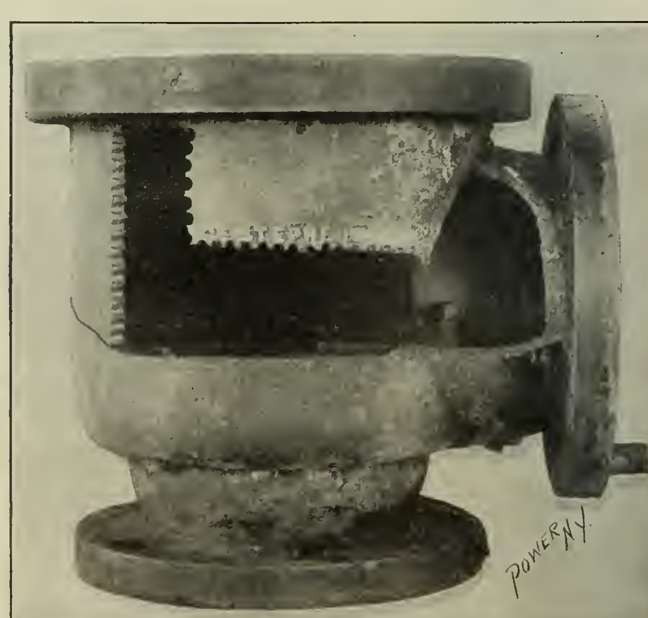
It is assumed that the break in the valve was caused by water from the cylinder of the engine rather than by that from the boiler, because at no time was there any sound that would indicate what is known as water hammer in the steam pipe. A piece of the casting was blown out and could not be found.

Test pieces were cut from the body of the valve casting and sent to the mechanical laboratory of the Massachusetts Institute of Technology, where they were found to have a tensile strength of more than 20,000 pounds per square inch.

Critical examination of the fracture showed that possibly a crack about six inches long existed in the iron for a long time, as most of the way around the edge it looked bright and clean, while for the rest of the circumference it appeared dull, as though oil had seeped into a very small crack and carbonized.

At one place the thickness of the metal in the shell was reduced to about 1/4 inch, but calculation shows that even at the reduced thickness a sound valve casting would be safe for a working pressure of more than 200 pounds per square inch. It is probable that the body of the valve had become weakened, or it would not have failed in time to save the engine from a serious wreck. Inside the largest

VIEW OF VALVE BODY, SHOWING FRACTURE



SHOWING PORTIONS CUT FOR TEST PIECES

diameter of the valve body was 9½ inches, with a thickness of 7/16 inch, except where reduced by the spot-facing tool to about 5/16 inch at a single point.

After steam had been shut out of the pipe and the excitement had somewhat subsided, it was observed that the water in the horizontal tubular boiler was a little lower than normal, showing that it was not unlikely that it had at no time been unusually high, but had primed during the fierce firing just preceding the accident.

Mr. Bullock has been chief engineer at this plant for nearly thirty years and this was his first accident of any kind in which anyone was hurt.

The engine has been in constant operation about sixteen years and has never before had a dose of water.

Practical Points in Electric Crane Work

By R. H. Fenkhausen

A certain make of radial arm crane controller was for the first few years of its manufacture equipped with the type of brush holder shown in Fig. 1. A holder of this type was mounted on each end of the controller arm but insulated from it. The path of the current was from brush to brush in each holder and fiber buttons F were used to insulate the springs at one end and thus prevent the passage of current from destroying their temper.

As no pigtails were employed to carry current to the brushes, and they could not be easily attached, the current was forced to travel from brush to holder and thence to the other brush. The brushes were necessarily loose in the holders to allow them free play, which resulted in heavy arcing that soon destroyed brushes, springs and, eventually, the holders themselves.

There being some seventy-five of these holders in the plant under my charge, the maintenance charges were very high and the shutdowns of cranes numerous, so that it became necessary to design a better brush holder. The result is shown in Fig. 2. In the new holder it will be evident, the brush holder has no part in the carrying of current. All current is carried by the brass plate X and the holders proper could be made of any convenient material. It was, of course, easier to convert the old holders to the new, simply by cutting off the bridges D, Fig. 1. The change described increased the life of the brushes over fifty times and entirely stopped crane shutdowns due to this cause.

As many hundreds of these holders (estimated at 2000) were placed on the market before the makers changed the design, it is hoped that this description of the simple alteration will aid some readers of Power into whose hands the old brush holders have gone.

Many cranes are equipped with a limit switch to prevent overtravel of the hook, and most of these are operated by a weighted arm traveling on a rod [illegible] from the end of the drum shaft. This limit switch is [illegible] [illegible], but careless operators [illegible] [illegible] to stop the hook [illegible] and [illegible] disturb the setting of the weight A, Fig. 3, in order to save themselves the trouble of resetting the switch. As several [illegible] had [illegible] a [illegible] [illegible] alteration of the [illegible] [illegible] the [illegible] as follows: A plate B, Fig. 3, was attached to the frame of the crane under the weight A. Studs E E were tapped into the weight, holes having been drilled through their heads, and a lead wire was passed through the said heads and around the bar B, as shown, and the ends sealed with a lead seal closed with a sealing tool having the initials of the company engraved on the face. The cap screws F and G were also sealed to prevent tampering.

When a hook overtravels the seal must be broken, and as the crane inspector is the only one having access to the sealing tool, every case of overtravel is recorded against the operator.

This plan is also useful to prevent unauthorized alteration of the setting of circuit-breakers, relays, etc.

FIG. 1

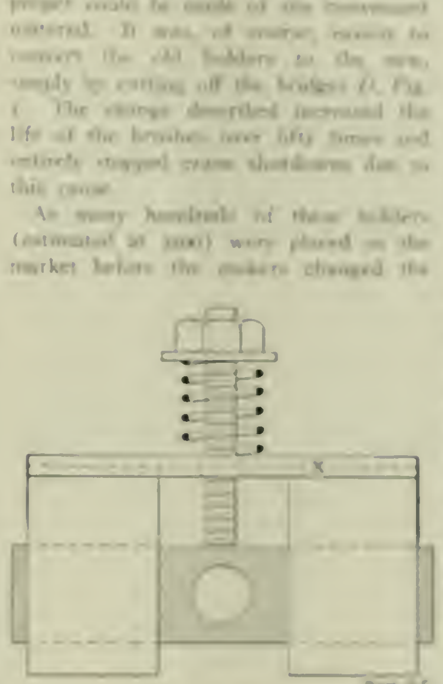


FIG. 2

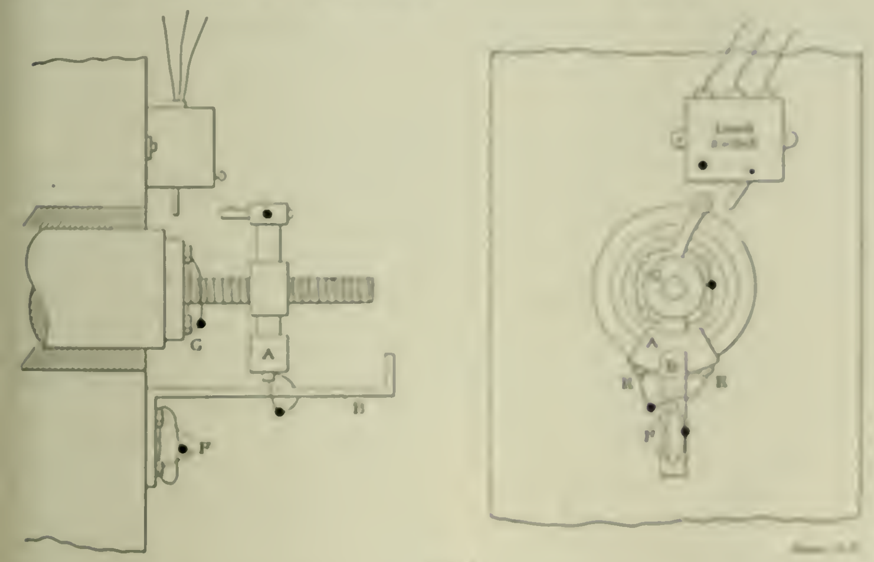


FIG. 3

New Boat Shows High Efficiency

One of the new White Star liners, the "Laurentic," which was built in Belfast, Ireland, for the Canadian trade, made a remarkably good showing in her trial [illegible]. The coal consumption per indicated horsepower-hour was as low as 1.1 pounds and only 11 pounds of water per indicated horsepower-hour was used. The engine equipment consists of two four-cylinder triple-expansion engines working on the outboard screws, and one low-pressure Parsons turbine connected to the midship screw, the combined power of the [illegible] being [illegible] horsepower. A boiler pressure of 200 pounds per square inch is carried. The steam supply [illegible] [illegible] to the reciprocating engines and expands to a pressure of from 12 to 13 pounds absolute per square inch. When the low-pressure cylinders of the engines [illegible] [illegible] given to the turbine on the center shaft for the [illegible] [illegible] [illegible] and [illegible] the turbine is [illegible] [illegible] the steam is fed directly from the engines to the main condensers. During the trial the engine-turbine [illegible] [illegible] about [illegible] [illegible] [illegible] more than was expected, and [illegible] [illegible] the [illegible] [illegible] a guaranteed speed of 17.

Practical Letters from Practical Men

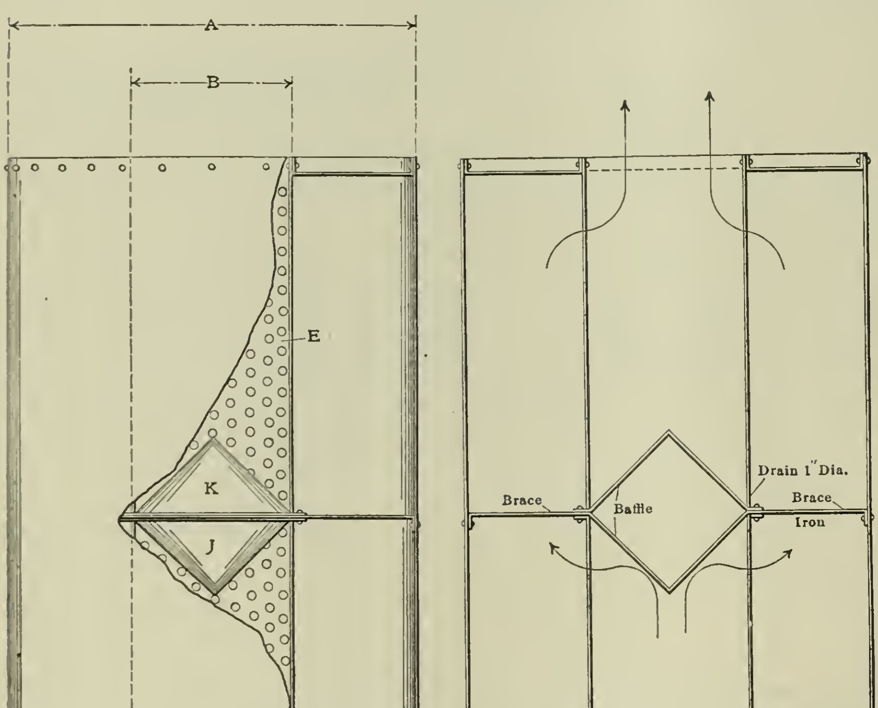
Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Homemade Exhaust Head

The accompanying sketch is of an exhaust head. It is very simple and inexpensive and so efficient that it has been adopted by the company with which I am connected. We have used them on exhausts on from 2- to 16-inch pipes, with entire satisfaction.

The head is made of galvanized iron with riveted and soldered joints, making it water-tight. It consists of two cylinders *A* and *B*, *B* being only a continuation of the exhaust pipe which is divided into two sections by the conical baffles *J* and *K*, the upper section *E*, being perforated the entire length, while the lower section is perforated down to the point *D*. The remaining part *H* forms a catchbasin for the water and oils separated from the steam. The perforations are staggered and vary in direct proportion to the area of the exhaust pipe. The outer cylinder *A* forms a condensing chamber around *B*. This is stiffened in the center of the large heads by a light brace. At the bottom is a flange into which is screwed the return pipe. The large internal area of this chamber overcomes any possible chance of back pressure on the engine, while giving the best conditions for the expansion, condensation and separation of the water and oil.



A HOMEMADE EXHAUST HEAD

I have also used the device with success as a muffler on a high-speed engine.

H. M. Nicholls.

Chicago, Ill.

Arrangement of Air Pump and Heater in a Mine Plant

On beginning my work in my present plant I found two slide-valve engines installed to run the mill, one a 13x16, the other an 18x24. These engines can be run simple, both at one time or separately, with or without vacuum; or, by changing two valves, they can be run compound with or without vacuum. I usually have 120 pounds of steam pressure.

The air pump and jet condenser are located 40 feet from the low-pressure cylinder of the mill engine, which has an 8-inch exhaust pipe. This is rather small for that distance and reduces the vacuum a little. I averaged 17 inches of vacuum, at the condenser, which is not so bad for an altitude of 7200 feet. A perfect vacuum at this altitude being about 22¾ inches, 17 inches is equal to about 24 inches at sea level.

In order to get a vacuum on the mill engines when the compressor was not running, I connected the air pump to the mill by means of a shaft, having a crank on the end connected to an arm on the rockshaft of the air pump. By slipping off the connecting rod from the rocker arm on the air pump, and the pin on the compressor, adjusting this arm for the mill connection, the mill drives the air pump at 50 revolutions, very satisfactorily.

We have a pond, about 100 feet square, 350 feet from the condenser, and draw the condensing water from it, through a 5-inch pipe, directly by the air pump, which makes a lift of 15 feet besides the friction in the pipe. This pipe runs under the mill through a tunnel which conveys the warm water back to the pond for cooling, discharging at the farther end.

As the water from the mine is bad for the boilers, I made a surface condenser to furnish condensed water for them, connecting the condenser to the air pump and drawing the water from the pond with a common steam vacuum pump. This pump circulates the water over the condenser tubes, the hot water dropping back into the same canal, and returns to the pond to be cooled. I get the same vacuum with the surface condenser that I do with the jet condenser. This reduces the power required to operate the air pump almost to nothing, and puts the power it requires when running the jet condensing onto this circulating pump. But I make use of all the heat in the exhaust of this pump to raise the temperature of the feed water, which water comes from the surface condenser at about 120 degrees temperature, by running the exhaust to the heater.

The heater has no outlet for the exhaust steam and other inlets, except a ¾-inch pipe at each end to drain out the water of condensation. These pipes are connected to one leading to the hotwell. In addition to the exhaust steam of the circulating pump entering the heater, the trap which drains the receiver and reheater (which are one) between the high- and low-pressure cylinders of the compressors also discharges its water into the heater. On account of the variable temperature of the feed water entering the heater, there is a fluctuating back pressure on the exhaust of the circulating pump, but this does not interfere to any disagreeable extent with the regularity of the pump.

This same heater is connected to the receiver of the mill engines by a 1-inch pipe having a valve. When the mill is running there is more water to be heated (which water comes from the same feed pump) and consequently requires more heat. This is obtained from the receiver of the compound mill engines, which receiver has an average pressure of about 25 pounds, and the heater is always exposed to this pressure. The 1-inch pipe is so located that it takes all the water of condensation from the receiver. No steam from any other source enters the heater except that mentioned.

I introduce the feed water at the top and deliver it to the boilers from the bottom, as the water going out at the bottom leaves the oil at the top of the heater, which is blown out at intervals from the top. I am making a settling tank, however, to further the extraction of the oil, and shall locate this tank to catch the water as it falls from the air pump and let the feed pump take it from the tank, thus making less deposit of oil in the heater.

L. D. [illegible]

Los Angeles, Cal.

Compression

Are we not inclined to railroad this question of compression with so much theory that the most is lost sight of? Few will dispute that it is good engineering to entrap sufficient exhaust steam ahead of the advancing piston to absorb the inertia of the moving parts to such a degree that the crank will pass the centers as quietly as possible and, incidentally, warm up the cylinder walls and reëvaporate what condensation may be present rather than to have these useful functions performed by the incoming live steam.

Calculating the right amount of compression for each case may be shorn of a lot of perplexity if we are content to deal with the question in the abstract. If a reciprocating engine is operated at its normal load, speed, initial and back pressures, with the crank-pin box loosened up for the occasion, that setting of the valve or valves with regard to exhaust closure that enables the crank to pass the centers with the least jar settles the question of compression for that set of conditions, does it not?

With the four-valve, double-eccentric type of engine, valve setting is a simple operation, but when dealing with the single-valve engine, either throttling or automatic, difficulties are sometimes met with that afford an opportunity for a little mental exercise.

Inasmuch as equal lead, cutoff and exhaust opening and closure cannot be attained in a single-valve engine, that is, equal as between the two ends of the cylinder, a middle ground must be sought that will give the best net results.

To illustrate, attention is called to Fig. 1, showing the results of setting a slide valve by the eye. The cutoff is fairly equal, but the exhaust release on both ends is poor and the admission at the left is distinctly bad, and the engine knocked badly on that end. Fig. 2 shows the lead compensation, which carried the crank over the centers beautifully, with the box loosened up, and while the cutoff is unequal to a marked degree the exhaust opening leaves little to be desired.

FIG. 1

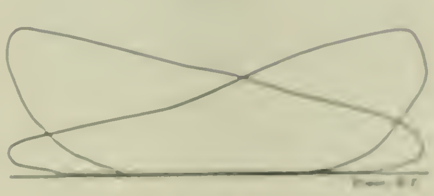


FIG. 2

It is obvious that unequal cutoff has a tendency to make the governor less [illegible], but with a fair-sized balance wheel this difficulty is more apparent than real. In handling single-valve automatic engines under ordinary conditions it is pretty safe to [illegible] and attention to keeping the valve in its proper place with reference to eccentric or valve-stem length; that is, when taking up wear, take it up equally on both sides.

There are occasions, however, when testing the governor when on the shaft, by means of an offset key, enables an engine to cope with unusual conditions that the designer had no opportunity to figure on.

In one case, an abnormally high load caused such early exhaust closure that the slack in the moving parts was taken up with a slam before the crank passed the centers. We had no way of adding to the load nor lowering the steam pressure, on account of other units, so we cut off enough inside of exhaust lap to enable the engine to run quietly under existing conditions.

In another case a single-valve automatic engine was overloaded to such extent that the high terminal pressure obliterated the effect of what little compression was realized from late exhaust closure. Long, [illegible] the reciprocating parts of this engine approaching the centers "all steamed out," only to be brought up with a steam-hammer jar when the steam valve opened.

The engine cylinder was about 12x24-inch; ⅛ inch was added to the inside lap and the knock disappeared.

A novel theory, so far, was carried out. Instead of trying to bring the face of the added pieces flush with the working face of the valve, no attempt was made to do so, with the idea that a steam-tight joint would be useless until an appreciable pressure had been raised in the cylinder, by which time the valve would have time to get over onto the old part that was already steam-tight; in other words, the added pieces acted only as obstructions or chokes. While there was not enough difference in the pressure to make it very [illegible], the scheme worked and saved a lot of useless timing.

E. G. TILDEN.

Downers Grove, Ill.

Pump Valves

In the March 23 number, page [illegible], D. T. [illegible] says he cannot see why springs are required on the valves of a boiler-feed pump. While I should not care to do without springs, I do think we often apply more pressure than is necessary.

In the plant of which I have charge, there is a duplex steam pump for feeding the boiler, taking water from an open heater, which could not very well be placed so high above the pump as it should have been. However, we had no trouble so that with a few springs [illegible] when the pump began to [illegible] the results we [illegible] it was not getting water [illegible] enough to fill the cylinder. It would run nicely up to a certain speed, also after stopping the engine, when the water in the heater would begin to get cooler.

Thinking that the spring might be set tighter on the end giving trouble, I opened up the valve chamber, but could not detect any difference. I decided to ease up on all the springs on the suction deck, although I did not consider them too tight, but on starting up again I found that my trouble was over.

THOMAS WHELPTON.

Rosthern, Can.

Puzzling Transformer Action

The trouble with a series circuit operated from a constant-current transformer, recently reported by E. L. Mason, is quite unusual. It is difficult to make positive statements in the absence of statistical data of the apparatus, but I believe the accompanying diagrams and reasoning constitute a plausible explanation.

In Fig. 1 (drawn from memory) is shown the apparatus; the constant-current transformer at the left, the boosting transformer in the center, and the terminals of the lamp circuit (with the

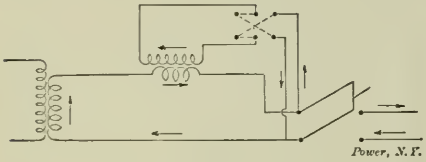


FIG. 1

switch shown open for clearness) at the right. Arrows have been added to show the direction of current in the several parts of the circuit during the half cycle in which the current plows upward through the constant-current transformer secondary.

The arrow heads show that both transformer secondaries carry more current than the lamp circuit, which is said to take 3.5 amperes. If we assume in the absence of any definite data that the voltage is about 2000, then the booster transformer has a 2000-volt primary and a 100-volt secondary. With the connections as given, the transformer primary absorbs power from the circuit, which is returned by the secondary, increasing the voltage (this is the normal conditions of boosting). When everything is balanced the product of volts boost times current in the (booster transformer) secondary is approximately the same as that of the volts and amperes in the primary. This arrangement, Mr. Mason says, operated satisfactorily.

Let us now throw over the reversing switch on the booster transformer. We shall then have the connections shown in Fig. 2. We may note here that the constant-current transformer is more powerful than the booster, so that the directions of the currents are the same, except between the booster primary and the main circuit. We now have the booster transformer primary operating in parallel with the constant-current transformer to furnish current to the lamp circuit. When balance is again obtained, the functions of the booster primary and secondary have been interchanged and the power absorbed by the secondary, which is equal to the current times the volts drop, reappears in the primary and is delivered to the lamps. The product of volts and amperes in both

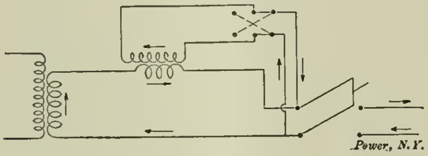


FIG. 2

circuits of the (booster) transformer is again nearly the same.

There is one important difference in the current relations in Fig. 1 and 2, which we must now take into account. In Fig. 1 the constant-current transformer carries the sum of the lamp and the booster-transformer currents; in Fig. 2, the difference. The excess of current in one case over the other is about twice the booster-transformer current, as the current will not be exactly the same in both connections. When the current in the (constant-current) transformer secondary decreases, there is a prompt change of position of the secondary coil, because this is exactly the condition which the transformer is designed to handle. The voltage rises so as to increase the current in the circuit.

We must not forget, however, that both transformers are in parallel, so that they have the same voltage at their terminals. This requirement regulates the drop through the booster-transformer secondary. The final condition of equilibrium will be increased voltage and more current to the lamp circuit, provided these

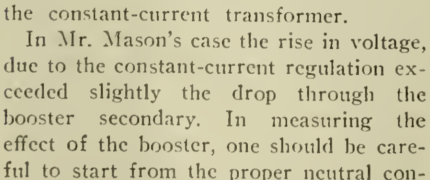


FIG. 3

are within the limitations of movement of the constant-current transformer.

In Mr. Mason's case the rise in voltage, due to the constant-current regulation exceeded slightly the drop through the booster secondary. In measuring the effect of the booster, one should be careful to start from the proper neutral condition, which is with open-circuited primary and short-circuited secondary (of the booster transformer). If the secondary is not short-circuited when the primary is open, it acts as a choking coil and causes a considerable voltage drop.

In order to realize the purpose of this booster, it will be necessary to block the secondary of the constant-current transformer, which converts it into a constant potential transformer. If the connections are then changed as in Fig. 3, the booster transformer will either boost or buck, as desired, but the constant-current regulation will be lost.

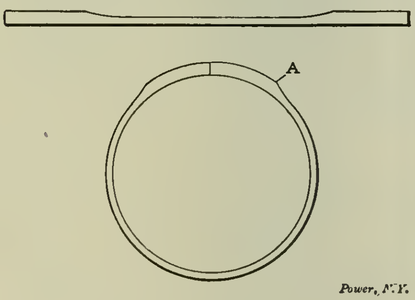
Local conditions must be peculiar to require such unusual connections. As a general thing, sufficient adjustment is obtainable in a constant-current transformer by changing the amount of counterbalancing weights to take care of any probable requirement.

SELBY HAAR.

Schenectady, N. Y.

Joints for a Boiler

According to the best practice a triple-riveted butt joint has a theoretical efficiency of about 85 per cent. of the sheet. Whether the efficiency of the joint is that high under actual working conditions is



SUGGESTION FOR BOILER PLATE

an open question. Conceding that it is, and that the efficiency of a double-riveted butt joint is about 82 per cent. of the strength of the sheet, to get the increased efficiency of about 4 per cent. an additional row of rivets is necessary; the slight increase in width of the covering plate required is not worth considering, as far as increased cost is concerned.

Is there any reason why boiler plates cannot be made as shown in the accompanying sketch, and in that way compensate for the reduction in the section of the plate due to the rivet holes?

A plate so rolled would allow a riveted joint to be made exceeding in strength the body of the plate.

It might be a little difficult to bend the plate just at the point where the full compensation begins, as shown at *A*.

There may be a reason for not using the style of plate I suggest, as the grain or fiber of the plate caused by rolling would run the wrong way. I have been unable to learn the strength of steel plates "with" and "across" the grain. I find that iron plates show 6 per cent. more strength with the grain. When I say iron plates I refer to the very best grade of boiler plates.

A. H. HALE.

Denver, Colo.

Limitations of a Pump Lift

Replying to Frank L. Walls' letter in a recent issue, I differ with him regarding the statement that the limitations of a pump are a 27-foot raise, as I have several times raised water 30 feet and one time even as high as 31½ feet.

In this latter instance there was a shaft 42 feet deep at which depth were two tunnels, each 200 feet long. Their purpose was to get at the different artesian wells to cut them off at that depth, also for a header to connect up a nine and a half million 500-foot lift Dow pump, the pump to be set in a pit 42 feet below the surface on a level with the flow of the wells.

I put a duplex pump so that the cylinders were just above the water level and started up. Everything worked nicely until I got the water down 29 feet, when the pump refused to lift water. The only trouble we had was with the packing in the pump cylinders, which had to be renewed every two weeks or so.

W. Ellerbrock

Honolulu, Hawaii

A Siphon Discussion

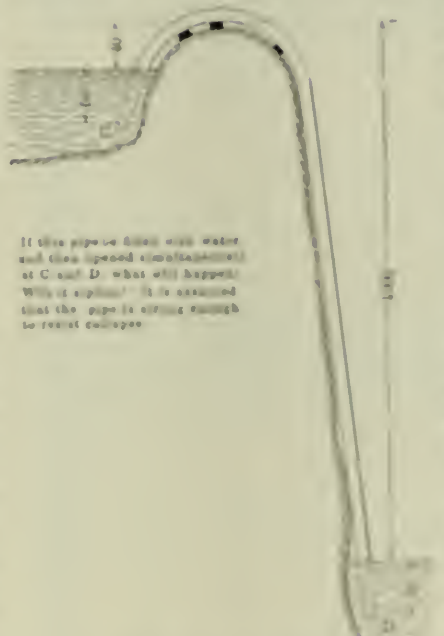
The chief engineer and a packing salesman were smoking in the fire room and chatting about the weather, politics and machine diseases, when the salesman, fishing in his pocket, produced a piece of paper with a sketch similar to the one shown herewith. Handing it to the chief, he said: "Here is something that the engineer down at the rubber works put up to me this morning. I wasn't quite sure about it and want you to post me. He wanted to know if it would siphon."

"It certainly would not," replied the chief, after looking over the sketch, "because the atmospheric pressure at sea level will not support a column of water more than 34 feet high, and consequently the water would not flow over the neck of the siphon."

"I told him that," said the salesman, "but he then asked me what would actually happen when the water was released at both ends of the pipe, and that put me 'up a tree.' I told him I was sure that the water would flow out of both branches of the siphon until it reached a point in each about 34 feet above the surface of the water in the respective reservoirs, and he then wanted to know what would take the place of the water. That was too deep for me, but I am curious to know just what would happen."

The chief looked at the sketch again and pondered deeply. "Well," he said, "there is something queer about that after all. That 1000 feet of water trying to go down the pipe would certainly give an almost perfect vacuum in the neck of the siphon;" and he pondered some more. Finally, after applying a fresh match to one of the salesman's deceptive-looking cigars, he said: "I think I have it. You see, water will boil in a perfect vacuum at any temperature down to 32 degrees Fahrenheit, so the neck of the siphon would become filled with vapor, rising from within the liquid in both its branches. This would reduce your vacuum and the water would begin to drop down the tubes, continuing until a point was reached where the vacuum would not be sufficient to cause ebullition (or boiling), when it would remain stationary."

The salesman was still scratching his head when the inquisitive mind of "Jimmy," the oiler, who had been standing by taking in the whole conversation, began to see trouble ahead, and he stepped up to the chief saying: "Now, I don't want to 'butt in' and am only looking for information (Jimmy always was a curious kid). If what you say is true, about water boiling in a vacuum, how is it that we can hold such a good one in our condenser?"



WILL THE PIPE SIPHON?

"That's right, Kid. If you don't know, find out," replied the chief. "I'll explain it for you, but the best way is to consider such things is to 'dope' them out for yourself. According to the steam tables, water will boil at 32 degrees Fahrenheit in a vacuum of 0.089 of a pound, absolute pressure, which is a prohibitive vacuum to maintain for a condenser. You have at times some [illegible] a 28½ inch [illegible] inches, which is as much as you get as a steady thing. This would give an absolute pressure of about [illegible] pounds per square inch and a boiling point of nearly 126 degrees Fahrenheit.

"Now the water in the condenser [illegible] cooling water having a constant circulation. If such a thing should happen it would mean a great deal more work for your dry-vacuum pump."

This ended the discussion, and the salesman, after handing the chief another of his "El Ropo" cigars, wended his weary way, while "Jimmy" went back to his engine, thinking of the long years ahead of him before he could master the knowledge the business seemed to need.

E. V. [illegible]

Poughkeepsie, N. Y.

Double Eccentrics

The Wheelock-Corliss engine at the Poughkeepsie (N. Y.) Heat, Light and Power Company's plant, reference to which is made on page 613 of the March 30 number, was the first engine the Wheelock company equipped with the two-eccentric idea, and that part of it was made under my direction. This was ten years later than my first use of them.

W. E. Crane

Brookdale, N. Y.

Economy of Different Speed Engines

In the issue of March 30, page 600, William E. [illegible] seeks by use of a chart to show the economy of an 8x10 engine over one 8x8. There is an old saying that figures don't lie, but I don't know about that chart.

I will not go into lengthy details, but assume [illegible] that figures lie, and if he cares to go into it he can [illegible]. I assume that these engines make the same number of revolutions per minute. We will say, for sake of illustration, that the piston rods are the same diameter, 1½ inches in round figures. The 8x10 engine cutting off at one-third stroke on its [illegible] uses 223 cubic inches of steam at each complete revolution. The 8x8 engine cutting off at [illegible] stroke, or [illegible] inches, uses [illegible] cubic inches of steam at each complete revolution. According to [illegible] there is a difference of [illegible] cubic inches of space to be filled with steam at each revolution in favor of the 8x8 engine. Assume that these engines are running 250 revolutions per minute, which, according to my figures, would make [illegible] cubic inches per minute in favor of the 8x8 engine. What this would amount to in pounds of steam per day, I have not figured. In [illegible] of the economy we find that it takes [illegible] of [illegible] to run engine [illegible] and [illegible] make the [illegible] of [illegible]. If these two engines are what I am [illegible], I should be pleased to have him [illegible].

[illegible]

[illegible], Mass.

Steam Engine Experiment

At the artisan school we have been doing a cranky thing in steam-engine business that may be good, and surely will astonish the steam-engine engineers. We have at the school a center-crank shaft-governed 6x12 engine which is three or four times too large for the job. On cold days we have to have a lot more steam to heat the building than we need for power, but on warm days we are not getting our power economically. We had slowed down the engine as much as we could and have it govern, and it occurred to me to try this experiment: We shifted the valve so as to have it take steam only at one end of the cylinder when running light, but at both ends when starting.

The only thing now was to see that the governor ball could go out far enough to cut off the working end and not allow the engine to run away when running light. The thing is working all right, and the boy says he does not have to shovel as much coal. One experiment does not prove much, and maybe this will inspire someone else to try it.

My notion was that by so doing we would cut the initial condensation and clearance, two main sources of loss, in the middle; and against that the excess of work in punching the exhaust steam out of the idle end of the cylinder. The first thought was to stop off the crank-end part, but if we did that, leaving the engine the same, water passing the piston might accumulate and cause a smashup; or, if we took out the packing, or opened the pet cock, we would have no compression to stop the noise at that end of the engine.

When circumstances justify repeating this experiment it would seem to be worth while. Our coal bill at the end of the month will prove results, as so far the weather has been about the same. The coal is uniform, and the same boy is fireman.

John E. Sweet.

Syracuse, N. Y.

A Power Plant Layout

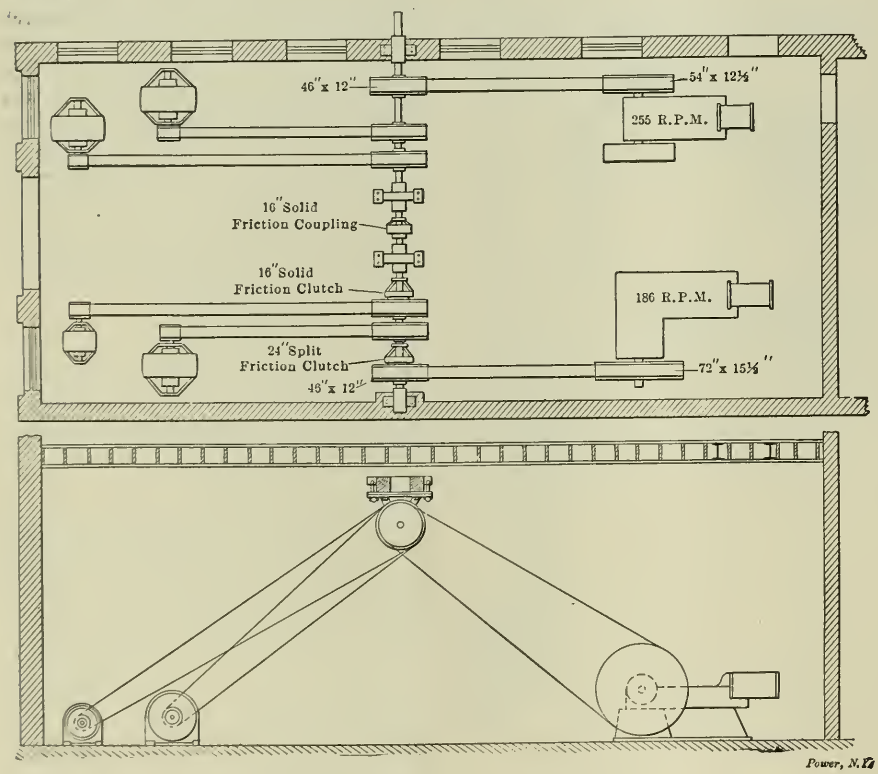
The accompanying illustration shows the layout of the engine room of a factory. There are two engines, one of 85 horsepower, running at 255 revolutions per minute, the other of 50 horsepower, running at 186 revolutions per minute. Both are belted to the same jack shaft, running at 300 revolutions per minute. The 50-horsepower engine may be thrown in or out by means of a friction clutch.

The 85-horsepower engine is sufficient to run the factory during the forepart of the day, but in the evening, when the heavy load comes up, the engine will not pull the load, and the 50-horsepower engine is thrown in by means of the friction clutch. The combination of the two engines seems to take care of the load all right.

Which engine carries the load, or does each take its portion?

C. L. Wilson.

Louisville, Ky.



LAYOUT OF FACTORY ENGINE ROOM

Gas Burns in Smoke Flue

One of the boilers in my boiler room persists in burning gas in the front connection and in the stack. It is a horizontal tubular boiler, 20 inches long and 60 inches in diameter with 4-inch tubes.

I have examined it carefully, and seen that the tubes were properly cleaned, the combustion chamber emptied, and all holes in the brickwork stopped, still the trouble persists, and requires the opening of the fire doors to stop it. This occurs mostly on quiet days when the draft is poor. It has done this ever since I have been here and, I am told, ever since it was installed. Others, of a different make but same type, working alongside, cause no trouble.

I have had my men try light and heavy firing, but nothing seems to improve the condition. Any suggestions as to remedying the trouble will be appreciated.

E. A. Adams.

Lujane, Colo.

Keying Flywheels

H. Wiegand gives some very good points concerning the keying of flywheels on shafts, in his letter which appears on page 608, of the March 30 issue. It is essential that a wheel should fit the shaft so that not the slightest lost motion or, rather, looseness, exists. If the wheel is loose, no arrangement of keys will make it entirely satisfactory, if the operating conditions are severe.

The object of a key is to prevent the wheel from turning on the shaft, not for the purpose of making it fit the shaft. If a wheel properly fits the shaft, the key need not fit tightly, top and bottom, but should fit snugly sidewise, and simply "fill the hole," top and bottom; thus, no strain is given the wheel as referred to by Mr. Wiegand, yet it will be perfectly secure and will never turn, nor will there ever be any tendency for the key to work out.

Driving in a key that is fitted top and bottom only, simply being a sliding fit sidewise, would tend to ease the part of the bore of the wheel near the keyway, from the shaft, and so destroy what was at first a good fit. Many a propeller wheel have I worked upon where after the wheel had been fitted on the taper shaft, the key was fitted to drive nearly all the way—tight sidewise—until it just "filled the hole," top and bottom, without putting any undue stress upon the hub of the wheel. The key could not get out, even though it should ever get loose, which if properly fitted is not possible to happen.

Charles J. Mason.

Scranton, Penn.

Probable Cause of Air Compressor Explosions

In a recent issue Mr. Richards took exception to the suggestion that leaky discharge valves may cause very hot air to be discharged from the compressor, the argument being that the re-expansion of the air leaking back will cause it to be cooled again.

In practice it has been found that free expansion of air does not cause the air to be cooled anywhere near the theoretical temperature, or the temperature obtained when this expansion takes place in a working cylinder. A leaky valve would not be like a specially designed nozzle, by any means. There would be considerable friction which would have quite an influence upon the temperature of the leaking air. Perhaps Mr. Richards has noticed a small pipe will get hot when cold air is blown through it at a very high rate.

As to 5 per cent. being a large amount of leakage, that would depend upon the type of compressor. I think 5 per cent. would be easily exceeded when a valve or two "go bad." I have heard of cases where the leakage was enough to be noticeable in the amount of opening which the suction valves were operating with.

F. W. HOLLMANN.

Baltimore, Md.

Improve the Diagrams

In answer to Linden A. Cole, I would say that the admission lines in the high-pressure diagram are good, yet if the crank end took steam a little earlier, it may rid the diagrams of the round corners. The expansion line in each case is fair, but the exhaust valve is slow in opening. The expansion line of the head-end diagram indicates leakage of steam through the admission valve; the cutoff is also unequal, the head end doing the more work.

In the low-pressure diagrams the steam lines are poor, as the piston travels some distance before full pressure is shown. The cutoff here is also unequal, the crank end doing most work. The steam valves probably leak, as shown by the expansion lines. The exhaust valve in the crank end starts to close before the head-end valve, but less compression is shown, which is probably due to a leak.

The boiler pressure is 150 pounds and the scale of spring for the high-pressure is 80, yet the steam line is only 1 1/4 inches above the atmospheric line, denoting a pressure in the cylinder of 100 pounds. What became of the other 50 pounds? Scaling the diagram, we have about 10 pounds back pressure, but how about the receiver pressure of 15 pounds? Is the steam throttled or passed through a reducing valve between the boiler and engine?

E. G. HARRIS.

Burlington, Ia.

Two Commutator Devices

The accompanying sketches are of two appliances that I have used quite a while and found very useful. In Fig. 1 is shown a commutator clamp. It is very often necessary to take out the end rings of a commutator on account of internal grounds, and by having a clamp that will hold the segments firmly and perfectly

FIG. 1

round, it becomes an easy matter and also saves turning up in a lathe. I have tried numerous kinds, but the trouble with them led me to make the one herein described. It is made of 2x1/4-inch steel, with a 1/2-inch screw. The drawing clearly shows the adjustable fastening. The bending is around rivets on one side of each fastening, which can be moved by removing the two cotters. The clamp is made loose or taut by screwing the bolt in the nut.

A sandpaper holder for commutators is shown in Fig. 2. The sandpaper is made fast on top by a clamp and screw. The two face blocks are pivoted and adjust

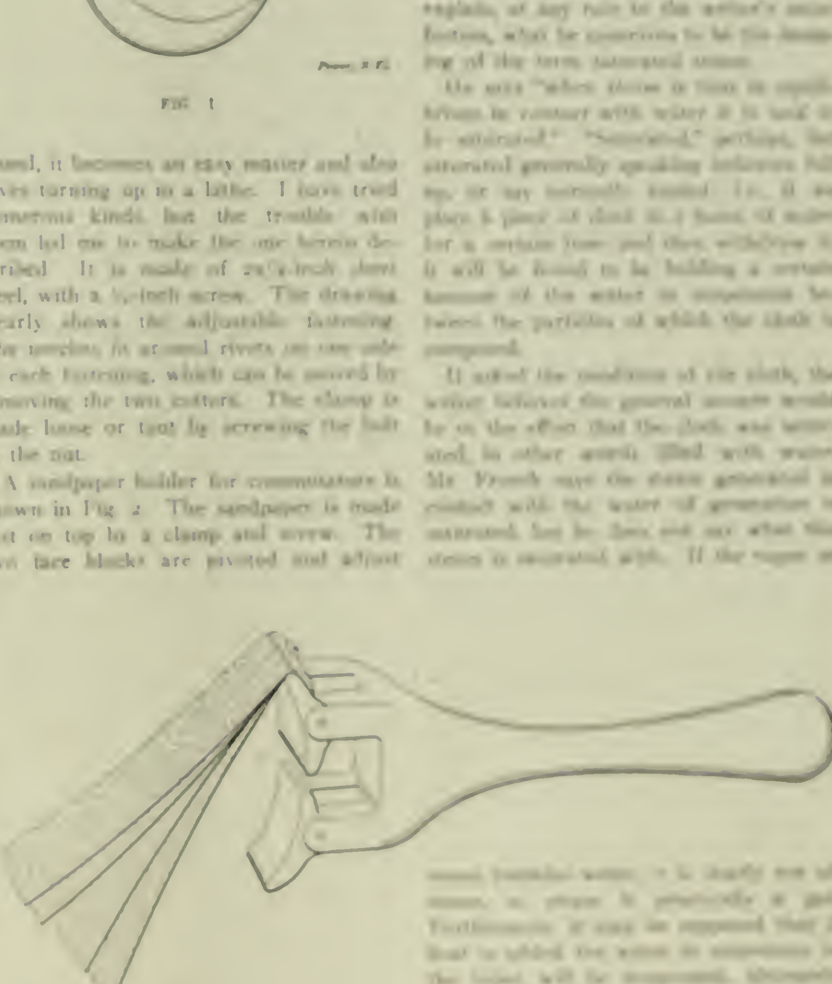


FIG. 2

themselves to the commutator, and will fit any size of commutator. If it has been [illegible] the heavy block will go in between the brushholders. It always keeps the commutator level and smooth, and is absolutely indispensable around an electrical shop. The one I have been using has [illegible]-inch face blocks.

W. T. CRAWFORD.

St. Louis, Mo.

Hygrometry

In the issue of February [illegible], page [illegible], J. French, in a not very gentle manner, gets after the writer's contribution in January. Mr. French's suggestion has referred to a handbook dealing with steam problems, written by a well known authority, and strangely enough, perhaps, finds his views confirmed by at any rate one authority.

The book referred to is "Condensers," written by F. M. Low, and the confirmation mentioned is found at the top of page 18. The writer is fully aware of the rather general definition given in the majority of steam handbooks, but at the same time would suggest that this, as also Mr. French's attempt, is somewhat ambiguous. Even now, Mr. French does not explain, at any rate to the writer's satisfaction, what he conceives to be the meaning of the term saturated steam.

He says "when steam is [illegible] in equilibrium in contact with water it is said to be saturated." "Saturated," perhaps, but saturated generally speaking indicates full up, or say naturally loaded. I.e., if we place a piece of cloth in a basin of water for a certain time and then withdraw it, it will be found to be holding a certain amount of the water in suspension between the particles of which the cloth is composed.

If asked the condition of the cloth, the writer believes the general answer would be to the effect that the cloth was saturated, in other words filled with water. Mr. French says the steam generated in contact with the water of generation is saturated, but he does not say what this steam is saturated with. If the vapor or

[illegible] water, it is clearly not all steam, as proper, is practically a gas. Furthermore, it may be supposed that if heat is added, the water in suspension in the vapor will be evaporated, ultimately giving us all steam, which the writer believes Mr. French would call "dry and saturated steam."

Once again, be it noted, the expression "saturated steam" still appears, although all moisture has disappeared, but no indication is given as to what the steam or vapor is saturated with. Still further, if we allowed all the water in the boiler to be evaporated, we would obtain a boiler full of steam or vapor, and as there is now no water in contact with the steam it would be of interest to learn what kind of steam Mr. French would call it. The latter condition approaches somewhat to that existing in a steam pipe remote from a boiler, generally *superheated steam*, inasmuch as we may suppose the radiation losses sufficiently great to cause the steam to lose all its vapor, or extra heat, above that normal to saturated steam of a given pressure, and then we have the condition as suggested by the writer of steam just saturated with heat units. Any further loss of heat would mean that the steam would not be saturated with heat and that it would contain less heat than the quantity as given in the steam table for any given pressure. Moisture would then appear, but the steam would not be saturated with water or moisture until a much greater heat loss was made, so what is it saturated with?

The writer is quite aware that this is not, strictly speaking, a practical point, but is really a theoretical one, and therefore most important that it be thoroughly understood.

W. Vincent Treeby.

London, England.

Making Improvements in a Small Power Plant

A certain power plant consisted of a 100-horsepower horizontal tubular boiler, a feed pump, a closed feed-water heater and a 50-horsepower high-speed engine for driving a dynamo for electric lighting and a line shaft for power.

In the dyehouse proper were eleven wooden tanks, 10 feet long, 4 feet wide and 4 feet deep, each filled with about 1000 gallons of water, heated by live steam. There were also two dyehouses containing coils of 1-inch iron pipe, using live steam at 80 pounds boiler pressure.

Exhaust steam could not be used directly in the tanks, on account of the cylinder oil which it contained, the slightest amount of which would spoil the dyestuffs. Neither could a steam coil be put in the bottom, as the steam had to boil the water thoroughly to dissolve the dyes and chemicals used. The best plan seemed to be to heat the water before putting it in the tanks. The feed-water heater was too small to supply both the boiler and tanks with hot water. Two of the eleven tanks were seldom used, however, so they were raised about 10 feet above the others, on suitable supports and coils of pipe set in one of them in a horizontal position. After making connection with the exhaust line, after leaving the feed-water heater, exhaust steam was turned into the coils and the water was quickly brought to a high temperature. A valve and float regulated the cold-water inlet.

The tanks were connected so that when the first, in which the cold water entered, was about two-thirds full, it overflowed into the second, from which a connection was made about 1 foot from the bottom for filling the dye tanks. The object in connecting the tanks this way was to keep one always filled with boiling water, and kept boiling by a steam coil placed in the bottom, while the other was filling with cold water. After these changes were made it was necessary only to use live steam for from 5 to 10 minutes to boil the dyes, instead of from 3¼ to 1¼ hours, as before, and not only was the live steam saved, but also the time, which in a day's run amounted to considerable.

The next thing to get at was the dyehouse, where there was an enormous waste of steam. Instead of connecting the coils to a good steam trap, and returning the condensation to the boiler, a 1-inch valve was screwed on the end of the coils, and as this valve was usually kept about one-half open, an enormous amount of steam and water was continuously blown out and wasted. I had noticed that when the water was used freely, the temperature often went down to 150 degrees, and even lower, and more live steam had to be used, while at other times the temperature was usually about 200 degrees.

Another steam coil was put into the second or storage tank, laid flat about 6 inches from the bottom, and the steam and water from the dyehouse coils passed through it, and after passing through a steam trap the water was discharged into the cold-water tank supplying the boiler-feed pump. After putting in this coil the temperature of the water in the storage tank was always from 210 to 212 degrees. When the tanks were working at their capacity there was no sign of any exhaust steam escaping, only a continuous stream of water running from the drain pipe to the sewer.

To force the exhaust through the coils a back-pressure valve was made and weighted to about two pounds. This valve was about the simplest thing imaginable, and consisted merely of a round piece of cast iron, about ¼ inch thick, and large enough to cover the exhaust pipe. It was covered on the bottom with a piece of sheet lead riveted on to form a seat on the end of the exhaust pipe, which was filed off flat and even. The valve was hinged to an iron clamp around the pipe, and a small chain running down to the engine room with a weight attached. On the hinged side, the iron clamp was turned upward so that when the exhaust steam opened it wide open it could not fall completely back, but rested against this upward projection, and could always be closed again from below.

Before these changes were made the amount of coal used per week was 12 tons, and after the change eight tons, or a difference of four tons per week, which at $2 per ton, the price at that time, made a saving of $8 per week, just one-half the engineer's salary.

Although this saving may seem small, it must not be forgotten that this was a very small plant. The total cost of making these changes including pipe, valves, fittings and labor, was $100. In three months it had paid for itself, and the saving in one year was $416.

A. J. Shad.

Cincinnati, O.

Trouble with a Dynamo

If Mr. Baker will take a piece of clean cloth, wipe his commutator, and rub a wax candle on the commutator two or three times a day it may help him to overcome his trouble with sparking.

William F. Taylor.

Frankfort, Penn.

Knock in the Engine

In a recent number, Mr. Bryan tells of a pound in his engine. I should say that the pounding was caused by water in the cylinder. I suggest that if he has no steam trap in his header line he put one in. Also give his engine time thoroughly to work the water out of the cylinder.

H. R. Williams.

Chanute, Kan.

Will the Load on the Bolts Change?

I should like to ask Mr. Fischer who, in the May 4 number submits an answer to Mr. Glick's cylinder-head bolt problem in the issue of March 30, page 609, how a bolt can be extended without an increase of the tension in it. What stretches the bolt except an increase of tension? And if the bolt stretches enough to relieve the pressure on the cylinder flange or the gasket a given amount, is it not only by the imposition of an equivalent force producing tension and consequently stretch in the bolt?

Julian Ralph.

Easton, Penn.

Centrifugal Pumps

In the March 16 number there was another article on centrifugal pumps, by George B. Pearce. He does not seem to have decided one way or the other, as to whether the pump requires more or less power with the discharge valve closed.

I am operating three 12-inch motor-driven centrifugal pumps, which will lift water 20 feet after they are primed. If I close the discharge valve the motor requires only 30 amperes, while with the discharge valve wide open 45 amperes is required, a third more than when it is closed. We operate the pump with the discharge valve closed so as to give 40 amperes on the motor, which furnishes all the water we require for the condenser under any load.

J. G. Dunnington.

South Oil City, Penn.

Some Useful Lessons of Limewater

A Test for Water; Importance of Marsh Gas as Related to the Chemistry of Carbon; Table of Carbon Compounds; What Carbon Monoxide Is

BY CHARLES S PALMER

We will go right on with the study of carbon and its compounds; but right here I will mention a test for water which will be very convenient to know and to use. Get an ounce or two of common "blue vitriol," or sulphate of copper ($CuSO_4 + 5H_2O$). You will note that the formula is C-u-SO_4, plus five molecules of water. By the way, "Cu" is the chemical abbreviation for the Latin word *cuprum* for copper. This water, which is always found in blue vitriol, seems to be a part of the crystallized form, for the blue crystals always take up five molecules of water for one molecule of the copper sulphate they contain. If you powder an ounce or so of this blue vitriol and then put it in a saucer and heat it, stirring it now and then, it will lose most of this water at a temperature a little above 212 degrees Fahrenheit, that is, on the common thermometer. On the Centigrade scale, which is used by nearly all working chemists, this temperature, that is, the temperature of boiling water, is 100 degrees Centigrade.

Now, if you heat the powdered blue vitriol, carefully, a little above this temperature, it will lose most of the water and will change from a bluish powder to a light gray, almost white. This is "anhydrous," that is water free, or almost so, for it still contains a little water. Do not heat it too high, for, if you do, the white anhydrous copper sulphate will decompose still farther and will be useless for the test for water. Now take a knife-pointful of the white or grayish anhydrous copper sulphate and lay it in a clean saucer, afterward touching it with a drop of water, when it will at once become blue. Of course, you can see that when water is added to the anhydrous copper sulphate it takes up the water again which it lost on heating, and passes back to the hydrous or blue form of copper sulphate, that is blue vitriol; and so this adding of a mere trace of water to the white anhydrous copper sulphate, whereby it becomes blue, makes a very delicate test for the common substance, water.

This anhydrous copper sulphate can be used for testing not only large quantities of water, but also, if one is careful, for the merest trace. Thus, we mentioned in one of the previous lessons that the steamy layer formed at the bottom of the inside of a lamp chimney when the lamp is first lighted and when the lamp chimney is cold is water, and this can be proved by taking the lamp chimney off the lighted lamp while the chimney is still cold and dusting a little of the white anhydrous copper sulphate upon the steamy layer on the inside lower part of the chimney, when one can get a faint but distinct bluish or greenish-blue tint due to the presence of water. Your common sense will teach you how to use this test in dozens of cases as we go on; and it will be very handy to test the appearance of water as it presents itself now and then, without depending alone on the statement that it is water. You want to be sure and get this *blue* vitriol or sulphate of copper; do not confound it with *green* vitriol, the sulphate of iron, nor with *white* vitriol, the sulphate of zinc.

The Importance of Marsh Gas

The next point in the chemistry of carbon which we will consider is the importance of methane or marsh gas. This is the most important hydrocarbon of all the many hundreds of compounds of carbon and hydrogen. Theoretically in all cases, and practically in many cases, the other hydrocarbons can be obtained, directly or indirectly, from marsh gas. Therefore, if one can obtain marsh gas he can go, by various chemical changes, to any of the other compounds of carbon. Now this is a very remarkable fact: it means that if one can obtain marsh gas, he is practically in command of the whole chemistry of carbon; if one can obtain marsh gas, he has practically at his command all the compounds of carbon, and that means most of the thousands of compounds in organic chemistry. It is interesting to know that this substance, marsh gas, is found not only in natural gas and gas from wood, but it can also be made artificially from purely inorganic sources. Among the many interesting compounds which the late French chemist, the great Moissan, produced by means of the electric furnace is a carbide of aluminum, Al_4C_3. This aluminum carbide is a gray or dark-brown powder, and is decomposed with water, giving off marsh gas, and leaving behind aluminum hydroxide, according to the equation:

Aluminum carbide		Water		Aluminum Hydroxide		Marsh gas
Al_4C_3	+	$12H_2O$	=	$4Al(OH)_3$	+	$3CH_4$

It is not necessary for you to memorize this equation, but it will be a good thing for you to remember that marsh gas can be obtained by the action of water on aluminum carbide, a product of the electric furnace.

Now, the point at which we are aiming is this: Marsh gas is fundamental to and typical of the organic compounds; and the organic compounds are found very commonly in the living tissues of plants and animals. Consequently, some have argued—perhaps rather hastily—that if marsh gas and the organic compounds can be made artificially from inorganic sources, living organisms, like plants and animals, can be made artificially from inorganic compounds without the go-between of any living egg or living tissue to help the process. This may be true, but you must bear in mind that it is no proof that chemists could make living plants or animals just because they can make methane and many other thousands of organic compounds from inorganic sources.

Chemical action is one thing, and the life process (which makes plants and animals, although it uses chemical action) may be quite a different thing. My own opinion is that the life process uses chemical action and is largely controlled by it, and yet the life process is something entirely distinct from and, in a large sense, superior to chemical action. But this is only my opinion, and the opinions of others who may differ from me in this respect are certainly worthy of consideration. The trouble is that at the present time we have little knowledge of the real nature of chemical affinity, and still less of the nature of the life process as found in living plants and animals, and it is really rather premature for anyone to have a very strong opinion on either side of this much-discussed subject. Indeed, it is much safer to hold all such questions in your mind in what is called "suspended judgment." Then, whenever these questions do come up, one ought to remember that marsh gas itself, and from this many thousands of organic compounds which are found in connection with living plants and animals, can be made artificially from inorganic sources; but notice that though we have made the substances we have not, at least, [illegible] made the living process. This also is one of the things over which you may like to ponder now and then.

The Carbon Compounds

Just here I want to ask your attention

for a few minutes while we study together the accompanying remarkable table of some carbon compounds. It will look to you at first like a long, stupid and blind affair; but if you will note a few things about it—I should not think of asking you to memorize it—it will give you some very clear notions regarding the simple relations between hundreds and thousands of compounds. Thus, you will notice that, in the first column of this table are given the hydrocarbons of the marsh-gas series; and you will notice that the constant difference between any hydrocarbon and the next higher is measured by two atoms of hydrogen and one atom of carbon, or "CH_2"; that is, starting with methane, CH_4, if you add "CH_2" you will get the next higher hydrocarbon, C_2H_6, or ethane; and so on. Now the next column of the table gives the first oxidized form of the hydrocarbon, that is, the "alcohol"; and so corresponding to methane we have methyl alcohol; and corresponding to ethane we have ethyl alcohol; and so on. You will also note that between any two of these alcohols we have the same numerical difference, "CH_2," that is, one atom of carbon and two atoms of hydrogen, that we had between any two of the hydrocarbons. Thus, if you add this constant difference, "CH_2" to methyl alcohol, CH_3OH, you get the next higher alcohol, ethyl alcohol, which has the formula, C_2H_5OH; and so on through the list.

Reduced.	TABLE OF SOME CARBON COMPOUNDS.		Oxidized	
Paraffin Hydrocarbons.	Alcohols.	Aldehydes.	Acids.	
Methane, CH_4.	Methyl Alcohol, CH_3OH.	$H\,CHO$.	Formic.	$H\,CO_2H$.
Ethane, C_2H_6.	Ethyl Alcohol, C_2H_5OH.	CH_3CHO.	Acetic.	CH_3CO_2H.
Propane, C_3H_8.	Propyl Alcohol, C_3H_7OH.	C_2H_5CHO.	Propionic.	$C_2H_5CO_2H$.
Butane, C_4H_{10}.	Butyl Alcohol, C_4H_9OH.	C_3H_7CHO.	Butyric.	$C_3H_7CO_2H$.
Pentane, C_5H_{12}	Pentyl or Amyl Alcohol, $C_5H_{11}OH$.	C_4H_9CHO.	Valeric.	$C_4H_9CO_2H$.
Hexane, C_6H_{14}.	Hexyl Alcohol, $C_6H_{13}OH$.	$C_5H_{11}CHO$.	Hexoic.	$C_5H_{11}CO_2H$.
And so on.	And so on.		And so on.	

Now, be patient a few moments because the rest of the table will clear itself up just as easily as this part has done. You will note that the next column of the table, representing the next oxidation stage from the alcohols, is the "aldehydes" (put the accent on the first syllable thus, *al*-de-hydes). You will note that although each hydrocarbon and each alcohol has its corresponding aldehyde, yet these aldehydes are named in anticipation of the compounds of the fourth column, or the acids. You will also note that between any two of the aldehydes, there is this same numerical difference, "CH_2," which we found in the hydrocarbon and alcohol columns. Thus, corresponding to methyl alcohol we find formic aldehyde; and corresponding to ethyl alcohol we find acetic aldehyde; and so on. The fourth, and last column, of this table represents the corresponding acids, and between the formulas of any two successive acids you will note there is this same numerical difference, "CH_2."

Reviewing briefly the last paragraph, we find in order from reduced extreme to oxidized extreme (that is, as far as this oxidation goes) the hydrocarbon, the alcohol, the aldehyde and the acid.

It is not my intention to frighten you by loading this table on your memory; but merely to call your attention to the wonderful simplicity in the apparent complexity of the table; and also to the wonderful completeness of the table. If there were any simpler way by which I could give you a notion of the wonderful variety and completeness of the carbon compounds, I would gladly do it; but a little attention to this table will not hurt one, especially as we want to use the substance of this table in explaining the chemistry of many compounds of carbon.

In the first place, a little close attention and a little close thinking are good for all of us, because they help to make "gray matter;" and in the next place, when we try to explain the chemistry of such things as wood, paper, cotton fiber, starch, dextrine, sugar, etc., it will be very helpful to know that all of these things just mentioned are very close cousins to one another, and that they are all only so many complicated alcohols, and in some cases aldehydes (or ketones—pronounced key-tones—which are closely related to the aldehydes).

One can read of hard times or of good times, but these remarks do not mean much unless one himself has seen and lived through some hard times and some good times. One can talk flippantly of working 10 or 12 hours a day, or of walking 40 or 50 miles in a day; but one does not really appreciate what that means unless he has himself done some of these things. So when we read that, of all the elements, carbon is vastly superior in the number, the variety, the completeness and the simplicity of these compounds and these series of compounds—if one reads all this without studying a little over such a simple table as that just given, of the hydrocarbons with their alcohols, aldehydes and acids—he cannot understand easily just what is meant; but with the help of this series of hydrocarbons, with their alcohols, aldehydes and acids, one can get a clear mental picture of something of what is meant by this.

Of course, each of these hydrocarbons, or alcohols, or aldehydes, or acids, is a definite substance; each of these may be a gas, or it may be a volatile liquid; it may be a heavier nonvolatile liquid, or it may be a solid; but each compound, represented by each formula, represents a distinct substance, worthy of study and attention; and all of these substances have had much attention from chemists.

Among the higher compounds in this table there are several varieties, caused apparently by the fact that the atoms, as they increase in number, can arrange themselves in different ways; and the one fact which seems to come out is that among the higher compounds, the backbone of the molecule is made up of a chain of the carbon atoms, and these chains may be straight or branching, and so on. Take the column of acids, for instance. Every acid can form a salt with every base; and so, if lime is a base, then lime can neutralize formic acid, making calcium formate; and, similarly, lime can neutralize acetic acid, forming calcium acetate; likewise, calcium proprionate from pripionic, calcium butyrate from butyric acid (the acid characteristic of butter) and valeric acid, forming calcium valerate; and so on. Furthermore, if sodium, potassium, ammonium (NH_4 the hypothetical but really make-believe imitation of sodium and potassium found in ammonia compounds), if iron, zinc, copper, lead, barium, strontium, silver, aluminum, magnesium, etc., if these metals all make basic compounds, then any one of them can neutralize any one of the acids mentioned in the table, forming the appropriate salts; and there you have an illustration, both of the wonderful richness of the chemistry of carbon, and also of the danger in this richness.

But we will not get lost in this table; simply, we will use the table as an illustration of the marvelous completeness of the oxidation products of the alcohols, aldehydes and acids going out from each hydrocarbon. I am afraid that some of the readers will want to skip this table and this chapter; but do not do that; treat it honestly and fairly, and take comfort from the fact that no other element can put up such a number and variety of compounds as carbon does. I do not hold myself responsible for the chemistry of carbon; Mother Nature made it, and she gives you and me the chance to study it. If a few hard things come up now and then, it may be worth our while to tackle each one in order and do the best that we can with each subject as it comes along.

There is one other point here that I want to mention and that is the way in which some of the formulas are written. Look at the formula for formic acid, $H\dot{C}O_2H$. Now, there are two hydrogens in formic acid, and they are entirely different from each other. One atom of hydrogen is open and active; if we should treat formic acid with zinc you could drive off this hydrogen and collect it, just as you did the hydrogen that you got from hydrochloric acid and zinc, or sulphuric acid and zinc. But the other hydrogen in formic acid is of a different kind from that which can be driven off by zinc. This other hydrogen is hidden away behind the carbon and shows little affinity; consequently, it is a kind of latent or "paraffin" hydrogen. This subject cannot be discussed fully at this time, but this fact is enough to show that in the study of these compounds of carbon there are many new and peculiar points arising which do not come up in the study of the other elements.

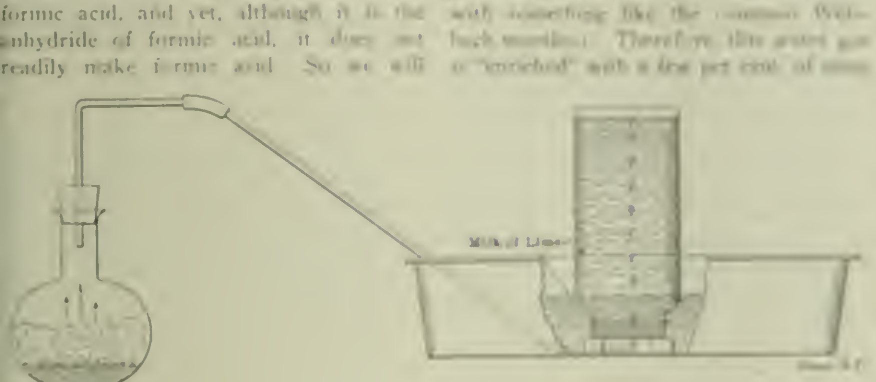
Carbon Monoxide

The next substance to study is carbon monoxide. You want to go back and read the last paper and note where carbon monoxide lies in the table of carbon compounds given in that lesson. You will see that it lies between carbon on the one hand and carbon dioxide on the other, and you will see that it is also related to formic acid in the same way that carbon dioxide is related to carbonic acid. This carbon monoxide can be obtained from formic acid, and yet, although it is the anhydride of formic acid, it does not readily make formic acid. So we will drop the theoretical relation of carbon monoxide to formic acid and will study it simply as itself. It has been mentioned already that this carbon monoxide is found in common city gas, "water gas" so-called, because it is obtained by blowing water in the form of steam on glowing coal, according to the reaction:

$$\text{Coal} + \text{Water} = \text{Hydrogen} + \text{Carbon Monoxide}$$
$$C + H_2O = H_2 + CO$$

If you go through the modern gas plant where this water gas is made, you will see a furnace filled with coal, usually hard coal, which is blown up hot by a blast of air. The gas formed during this process of getting the coal hot is waste gas, consisting largely of carbon dioxide, and is thrown off into the air. When the coal is blown hot, the air blast is shut off, the steam blast is turned on and the action of the steam on the glowing coal results in producing a mixture consisting mostly of hydrogen and carbon monoxide. But in two or three minutes this action begins to chill the coals, the steam is then shut off and the air blast is turned on again until the coal is again hot, when the steam is turned on to make water gas consisting mainly of carbon monoxide and hydrogen, and so on. Of course, this old process of making water gas is a very wasteful process on the one hand, and yet a very cheap process on the other; there are modifications and improvements of this which you will find in some modern gas plants; but, on the whole, the preceding description will apply fairly well to the processes used in many, perhaps most, of the city plants.

Now, this process of making city gas, or water gas, from steam and hot coal, results in a mixture running perhaps 45 per cent., perhaps 40 per cent., of both hydrogen and carbon monoxide. The mixture makes a very hot gas, but one which burns with an almost colorless flame. Therefore, it does not make a good illuminating gas when burned alone (unless it is used with something like the common Welsbach mantles). Therefore, this water gas is "enriched" with a few per cent. of some



MAKING CARBON MONOXIDE

hydrocarbon which will give it illuminating properties. There is one important fact which you want to note about this water gas and that is that carbon monoxide is a very poisonous gas to breathe. The old-fashioned coal gas contained only 5 or 10 per cent. of this carbon monoxide; but the modern city gas, consisting mainly as it does, of enriched water gas, will usually contain from 20 to 40 per cent. of carbon monoxide. Consequently, as compared to the old-fashioned city gas, with its 5 or 10 per cent. of carbon monoxide, was not nearly as dangerous as is at present and a small leak in the modern city water gas.

An exposure of 10 to 20 minutes to the modern water gas, especially in a small closed room, is liable to prove fatal. The reason for this is that the carbon monoxide has a very strong affinity for the coloring matter, hemoglobin, of the red corpuscles of the blood. The red corpuscles of the blood are the substances which carry the oxygen of the blood to all parts of the body; a poisoning by the carbon monoxide of city water gas means a chemical poisoning of the red blood corpuscles. Suffocation from carbon dioxide or hydrosulphuric gas is a different thing, but suffocation from the carbon monoxide is [illegible] very dangerous, as it is so subtle and so hard to overcome. Consequently, considering the [illegible] of human beings, it might be a good idea to follow [illegible] for the pipes of city water gas [illegible] a [illegible] [illegible] [illegible] [illegible]. Of course, such a law would be difficult to enforce; however, it suggests at least a remedy [illegible] of the great danger to which thousands of lives may be exposed every in our houses. The carbon monoxide, therefore, although a very poisonous gas, has a very feeble odor; but it happens that the hydrocarbons which are used to "enrich" the city water gas contain [illegible] compounds which have a very strong and penetrating odor; and this very fortunately is what gives warning of [illegible] in the gas pipes or [illegible] [illegible].

Before we leave the subject of carbon monoxide you will like to make a little of it, using the simple apparatus illustrated by the accompanying illustration. This consists of a flask, provided with a cork, a delivery tube and the pneumatic trough. The flask contains an ounce or two of common oxalic acid mixed with strong sulphuric acid. These two are heated, as shown. The mixed gases pass over to the pneumatic trough, which in this case is not filled with common water, but both the pneumatic trough and the inverted jar for the collection of the carbon monoxide are filled with milk of lime. The gas coming off from the generating flask (containing the oxalic acid and sulphuric acid) is a mixture of carbon monoxide and carbon dioxide, and the milk of lime will absorb most of the carbon dioxide, leaving the carbon monoxide in the flask jar.

From the milk of lime well stirred, as [illegible] there will be plenty of chemical to absorb the carbon dioxide. You will want to collect several jars of this carbon monoxide, which you will test very much in the same way that you did the hydrogen and the marsh gas, for it is a combustible gas, burning with a blue flame. [illegible] the jars from the pneumatic trough [illegible] [illegible] [illegible] the carbon monoxide, it doesn't matter very much whether you leave the jars [illegible] [illegible] [illegible] [illegible] [illegible], because the carbon monoxide gas is almost as heavy as the atmosphere. You will note that it burns with a blue flame and that the [illegible] [illegible] [illegible] [illegible] [illegible] in the jar, unless the gas burns [illegible] [illegible] mouth of the jar in the [illegible] [illegible]. The reaction for the production of the carbon monoxide [illegible] the decomposing action of the sulphuric acid on the oxalic acid will be as follows:

[illegible]

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Contents PAGE

The Engineer in the Navy

Rear-Admiral Melville, in his address to the American Society of Mechanical Engineers, at the Washington meeting, conveyed very decidedly the impression that the engineer in the navy had not profited as much as was expected by the consolidation of the line and the staff. "The only justification," he said, "for the personnel law adopted ten years ago was the statement made by former President Roosevelt that 'on a modern war vessel every officer has to be an engineer;'" and yet the admiral in command of the fleet on its recent cruise had boasted that he had brought the fleet to San Francisco without a single engineer aboard. In true concordance with the spirit of the personnel act he would have said that he got the fleet there as he did because every officer on board was an engineer. If present tendencies are followed the real engineering of the navy will be left to a class of warrant machinists, insufficiently paid and without official recognition or prestige.

There should be no conflict between the line and the engineering staff, neither should there be any attempt to merge the one into the other. There must always be the courtly authoritative executive officer skilled in tactics, and in diplomatic usages, fitted becomingly to represent his Government in any position in which he may be placed; fitted, should occasion require, to fight his vessel or his fleet with all the grim and determined purpose for which it has been constructed and maintained and drilled and manœuvered through years of peace. There must always be the man who represents the muscle of the organization, who wins his laurels at the designer's board in the construction shops and among the mechanism which makes the fleet an effective instrument in the commander's hands. The world is learning the worth of the latter class. The term, "engineer," is becoming to mean something more, as Professor Hutton aptly put it, than a greasy individual with a bunch of waste in one hand and an oil can in the other, and when honors come to be divided the man who builds and engines ships and is responsible for the design and operation of their motive power will receive as much credit for a successful cruise as the man who walks the quarter deck and classes him with the man who peels the potatoes.

In this connection it is interesting to reread an editorial which appeared in POWER for December, 1897:

A conference has been held by a board consisting of seven line officers and four engineer officers, presided over by Assistant Secretary of the Navy Roosevelt, to endeavor to conciliate the differences which have existed for years between the engineer corps and the line. From the public reports of their conclusions, they appear to have sacrificed the efficiency of the service to peace and goodfellowship in the ward room. The line has taken the engineer corps unto itself. The engineer officers will hereafter, if the plan carries, be required to do line duty, and will acquire the long-coveted actual rank and title. The line officers will also be required to do engineering duty to the end that every officer upon the ship may be able to serve either upon the bridge or in the engine room. In order that the engineering duties may not be too onerous for this hermaphrodite functionary, it is proposed that the "machinists" who are enlisted men "shall have more to do with running the engines." This seems to be a case of the lion lying down with the lamb—inside of him. The line has always maintained that the actual care and operation of the engines required only practical mechanics, and that they could do what "bossing" was needed.

"Success lies in limitation." Efficiency comes from specialization. Perry and Farragut labored and shone in an altogether different field from Ericsson and Isherwood. The engineering of a man of war is a department of itself. It should be made to include and control the care and operation of all the machinery in the vessel. No possible excuse can be offered for making a distinction, for instance, between the engines which run the dynamos and any other of the auxiliaries and placing them and the men who run them under the command of a line officer, over whom the chief engineer has no control. The chief engineer should have absolute authority in his department, should be responsible only to the chief officer or his direct representative, and not subject to annoyance nor interference from petty officers of the line. The number of engineer officers should be increased to meet the demand of the more numerous, more powerful, and more complicated vessels which the navy is acquiring, and the officers of the engineering department should have a positive and well-defined standing as regards rank and priority in keeping with the importance and responsibilities of their position. They are not, as it is often made to appear, men from civil life employed to assist in operating the vessel, but a part of a military organization matriculated from the same institute as the officers of the line, and their course is no less difficult, the requirements no less severe. They do not, as we understand it, wish to be known as that which they are not. To be chief engineer of a man of war is a position of responsibility and importance. To be known and recognized as the Chief Engineer is honor enough among those who understand the requirements of the office. It is a position to be proud of, not to be hidden under a meaningless title. But what is the position of the Chief Engineer relatively to the other officers? Some of them have the relative rank of captain, others of commander, lieutenant-commander, etc.; but this does not mean that they have an authority even in their own departments commensurate with those titles, or that they assume among the other members of the personnel positions in accordance with their relative rank. What they ask is positive rank with appropriate titles.

Anonymous Communications

Letters asking for information are frequently received to which the writer has failed to add his signature, or in some other way made a reply except through the columns of the paper impossible.

Questions are often asked which while not of sufficient general interest to be published are of special interest and importance to the individual, and if possible these are answered by mail.

Communications which are anonymous by intention or accident cannot be answered or placed on file and the questioner and the paper are both losers, because someone did not identify himself with his letter.

It is usually assumed that the omission of the signature or a place of residence is accidental, but when a correspondent uses the stationary of his employer and carefully tears from the top of the sheet all printed matter, except the date line, and affixes one, two or three initial letters to the end, it may be taken for granted that he intends to conceal his identity.

All letters received are treated confidentially and are accessible only to those who have a moral and legitimate right to their contents, but the signatures are required for two imperative reasons, either of which is sufficient in itself—as a guarantee of good faith on the part of the writer, and for the purposes of filing for future reference.

A third reason, although perhaps not as important, is that it is not always possible to reply by mail to a correspondent whose name or address is hypothetical.

While on this subject, it may as well be intimated that there is much more satisfaction derived from a letter which is written upon one side of the paper only than from one which jumps from the first to the fourth and then to the third page and finally finishes on the second page of society notepaper.

Grammar, spelling and penmanship are matters of secondary importance and even the English language is not imperative, for correspondence is received from India, China, Japan, Russia and, in fact, from all parts of the world, and Choctaw, if legibly written and properly signed, will receive the same prompt and courteous attention that is given to the most elegantly typewritten and carefully edited letters that reach the office.

In conclusion, it is urged that correspondents write upon one side of the paper only, leave a generous space between the lines and write signature and address as legibly as possible, thus coöperating with the paper to make it satisfactory to all interested.

Decision on Anthracite Case

On May 3 the Supreme Court of the United States, in the case of the Government against the anthracite roads, handed down a decision to the effect that the commodities clause of the Hepburn rate act was constitutional. On the surface this decision, which was a reversal of the finding of the Federal Circuit Court for the Eastern District of Pennsylvania, was a sweeping victory for the Government, but by the court's interpretation of the law victory actually rests with the coal roads.

It is generally understood that the original purpose of the Hepburn act was to prohibit railroads from carrying commodities which they own or in which they were financially interested, and in this particular case the Government was endeavoring to enjoin the anthracite roads from violating the law by transporting coal owned by them or by coal companies in which they owned stock. The court decided that such ownership of stock in coal companies by the railroads was neither direct nor indirect interest in the commodity, within the meaning of the law, so that the railroads are permitted to continue their coal business through other corporations and even to own the mines, provided the coal is sold in good faith before it is transported. In short, the law is constitutional but is limited to such an extent that it cannot possibly be enforced as intended when the bill was passed.

Only two of the anthracite roads are affected by the decision, and these are the Delaware & Hudson and the Delaware, Lackawanna & Western, both of which own the mines. [illegible] necessary for these companies to transfer the mines to a subsidiary company, of which they may own all of the stock, or sell the coal at the mines instead of transporting it to tidewater before the sale is made. The roads will no longer be allowed to contract for the sale of the independent operators, but their subsidiary coal companies may do so, and as they own all or at least a controlling interest of the stock of these companies, the distinction is merely a question of bookkeeping. The coal combination may continue to operate on practically the same basis as before, continue to regulate the price of anthracite, charging what the trade will bear, and monopolize as they have for a number of years, the anthracite industry. The only change that the decision effects is to compel such railroad companies as would otherwise [illegible] to go through the form of organizing nominally separate coal companies or proceeding to sell the coal prior to shipment from the mines.

Marine Gas Power

Those who have grown accustomed to thinking of the gas engine and producer as a rather cumbrous and widely spread type of power equipment in comparison with steam apparatus were doubtless surprised at the comparison drawn by Mr. Straub between gas and steam equipment for a lake freight boat, which we published last week.* Of course, it was to be expected that a considerable saving could be effected in the space occupied by fuel for a given "radius of action," because of the higher economy of the gas plant; but it is rather surprising to learn that the engine room proper can be made smaller for a [illegible]-horsepower gas engine than for a steam engine of similar output and general shape. The greatest difference in space, however, is in the generating section of the plant, the boiler room, including coal bunkers, having [illegible] square feet of floor area against [illegible] square feet for the producer room, including coal bunkers. The reason, which contributes most to this difference, is the location of the respective firing spaces; the producer is charged from an overhead floor which adds nothing to the length of the producer room, whereas the boiler stokehold is on the same level with the boilers. The coal bunkers of the steam vessel also add to the length of the space occupied by the power equipment, while those of the gas vessel do not, being elevated.

In detail and altogether, the comparison was a most interesting one and we await with some impatience and much eagerness the actual installation of a gas plant such as Mr. Straub describes. If we might venture a suggestion, it would be that the [illegible] for the proposed gas engine.

*Page [illegible].

Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

A Patent Boiler Furnace

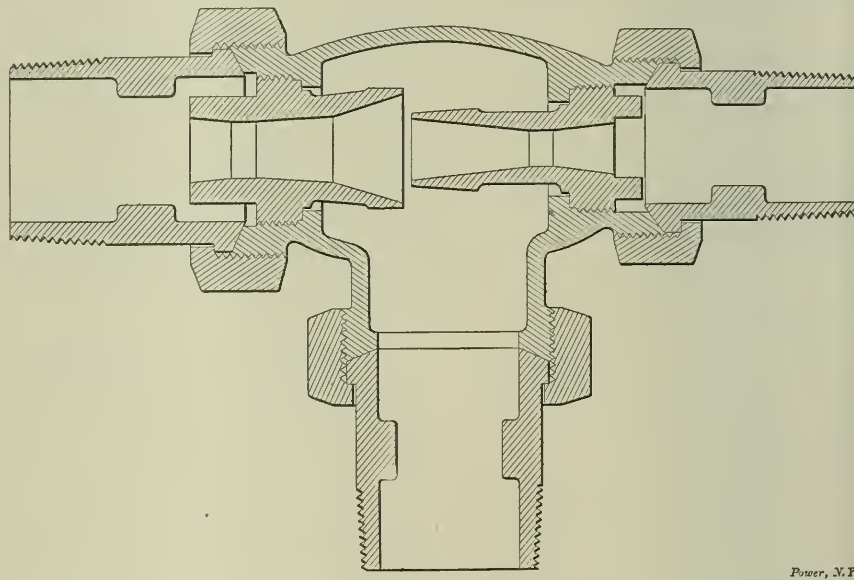
The accompanying illustration shows a patent furnace invented by A. W. Fredrickson, Hardy, Cal. It is in reality a steam boiler and furnace with a water-heating and purifying attachment, the object being to provide an attachment whereby the water may be heated and the sediment contained therein deposited before the water is delivered to the boiler proper in a continuous supply. The device consists of a double steel shell having an intervening space at the top, sides and front, as shown in Figs. 1 and 2. The grate is located in the double-wall section and fuel may be introduced either through the opening *A* or through the ordinary furnace door at the front.

The feed water is introduced in the water legs, where it is subjected to the heat of the inner walls, whereupon the deposits will fall to the bottom of the water legs below the grates, thence it may be blown out through the blowoff passages. The water in this chamber surrounding the firebox will be gradually heated to a temperature substantially equal to that in the boiler proper.

The furnace and heating chamber are separate from the boiler, with the exception of the pipes leading from the upper rear end of the heating chamber, and all the water delivered thereto is expected to be substantially purified and heated to such a temperature that the ebullition will be continued within the boiler in the usual manner.

An Improved Ejector

The Lunkenheimer Company, of Cincinnati, manufactures the ejector illustrated herewith. The claims for superiority made for it are based chiefly upon the tube construction. It is stated to be unsurpassed—on the scores of economy and efficiency—for raising water from deep wells, mines or pits, emptying and filling tanks, or for raising and transferring hot or cold liquids generally, and it is further claimed that it will raise water a greater hight and at higher temperature than heretofore attained. The tubes only are subjected to wear and can be renewed at slight expense. To operate, it is only necessary to turn the steam on fully and after the flow of water is established the steam may be throttled almost wholly.



NEW DESIGN OF EJECTOR

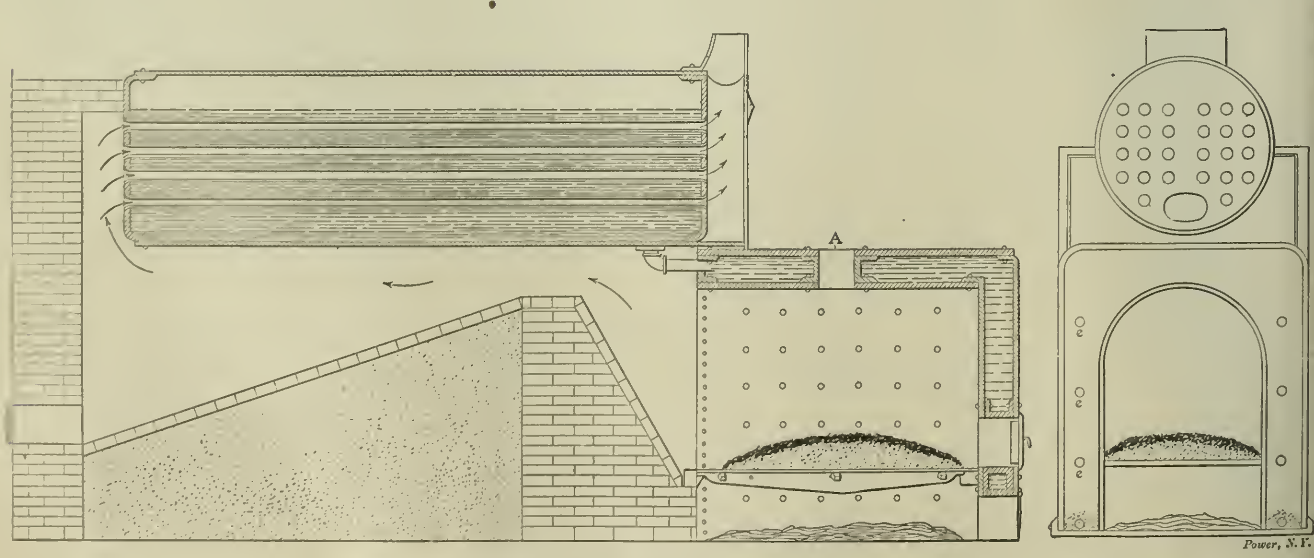


FIG. 1 FREDRICKSON'S PATENT BOILER FURNACE FIG. 2

The New Steam Stack Heater

In the power house there are the smokestack and the steam stack or exhaust pipe. If the boilers operate with an efficiency of 70 per cent., 30 per cent. of the heat units supplied to the furnace (less the small amount lost by radiation) go out of the smokestack. If the engine operates with an efficiency of 10 per cent., 90 per cent. of the heat units in the steam, or 63 per cent. of the heat units supplied in the fuel, go up the exhaust stack or into the river with the overflow from the condenser.

If any use can be found for steam at the temperature of the exhaust, much of the heat which would be rejected by the steam stack or exhaust pipe could be retained and usefully applied, and such opportunities offer in heating feed water, warming buildings and various manufacturing processes. A pound of exhaust steam is just as good for heating or drying purposes as a pound of live steam of the same temperature, and a pound of exhaust steam at atmospheric pressure contains 96 per cent. as much available heat as a pound of steam at 100 pounds pressure. Exhaust steam, as it comes from the engine, contains in addition to the entrained water which it has brought from the boiler and the condensation during its passage, the condensation due to the conversion of heat into work, and is further contaminated by the oil used for lubricating the cylinder. In order, therefore, to apply exhaust steam economically to heating and drying purposes the following points should be observed:

Steam should be thoroughly purified of oil before passing to the heating and drying coils, so that the latter may not become fouled with oil, and so that the condensed returns may be available for boiler feed purposes.

Some receiver or hotwell must be provided for the reception of the returns.

There must be a means of automatically admitting the cold water required to make up for losses by leakage, escape through the back-pressure valve, etc.

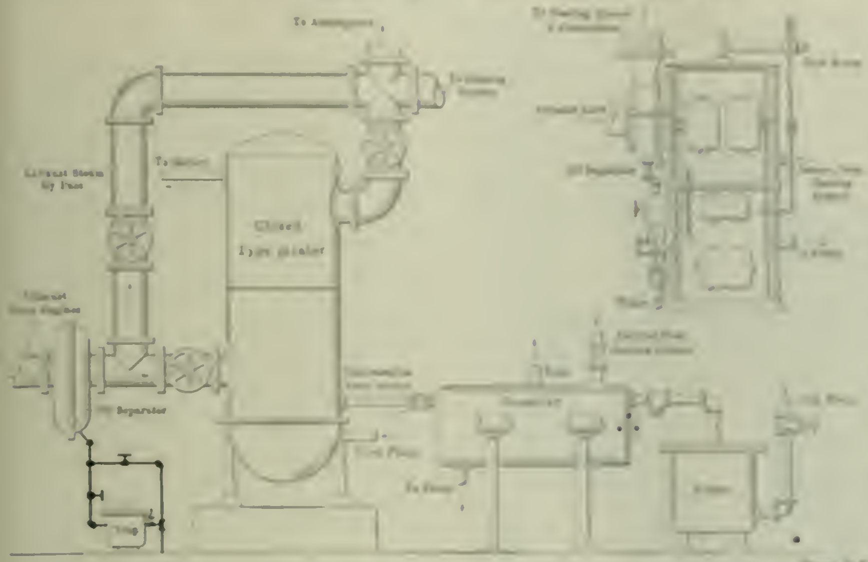


FIG. 1. SHOWING ORDINARY ARRANGEMENT OF A FEED-WATER HEATER [illegible] SEPARATOR AND FILTER [illegible]

It is generally advisable to filter the feed water, and the [illegible] from the feed-water heater and from the heating system must be arranged for. [illegible] is illustrated in Fig. 1.

[illegible]

The new "Steam Stack Open Heater" offered by the [illegible]

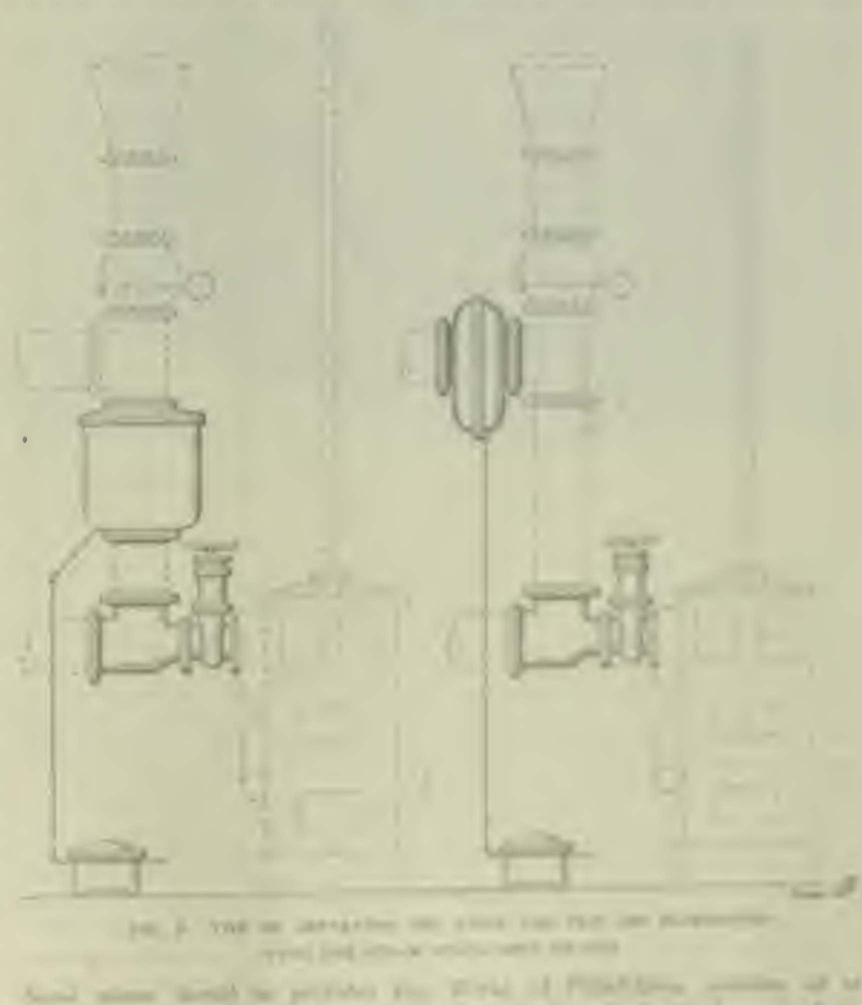


FIG. 2. [illegible]

Good means should be provided for heating the make-up and cold feed water before they are pumped to the boiler.

[illegible] of Philadelphia, combines all [illegible] functions in the single piece of apparatus shown diagrammatically at the right of Fig. 1 and in the views [illegible]

An interior view of this heater is shown in Fig. 3. The exhaust steam is piped to the heater in the usual manner, striking the baffle plate which forms the back wall of the oil separator which removes the oil contained in the exhaust steam. The steam then passes around the ends of the baffle plate and enters the heater where, mingling with the cold-water supply and gravity returns, heats them to its own temperature. The remainder of the steam is then passed on to the heating system thoroughly purified of oil. All oil is carried to the drip tank through a drip pipe. This tank is fitted with a float which operates a valve when the water in the tank reaches a certain hight, when the contents are discharged to the sewer.

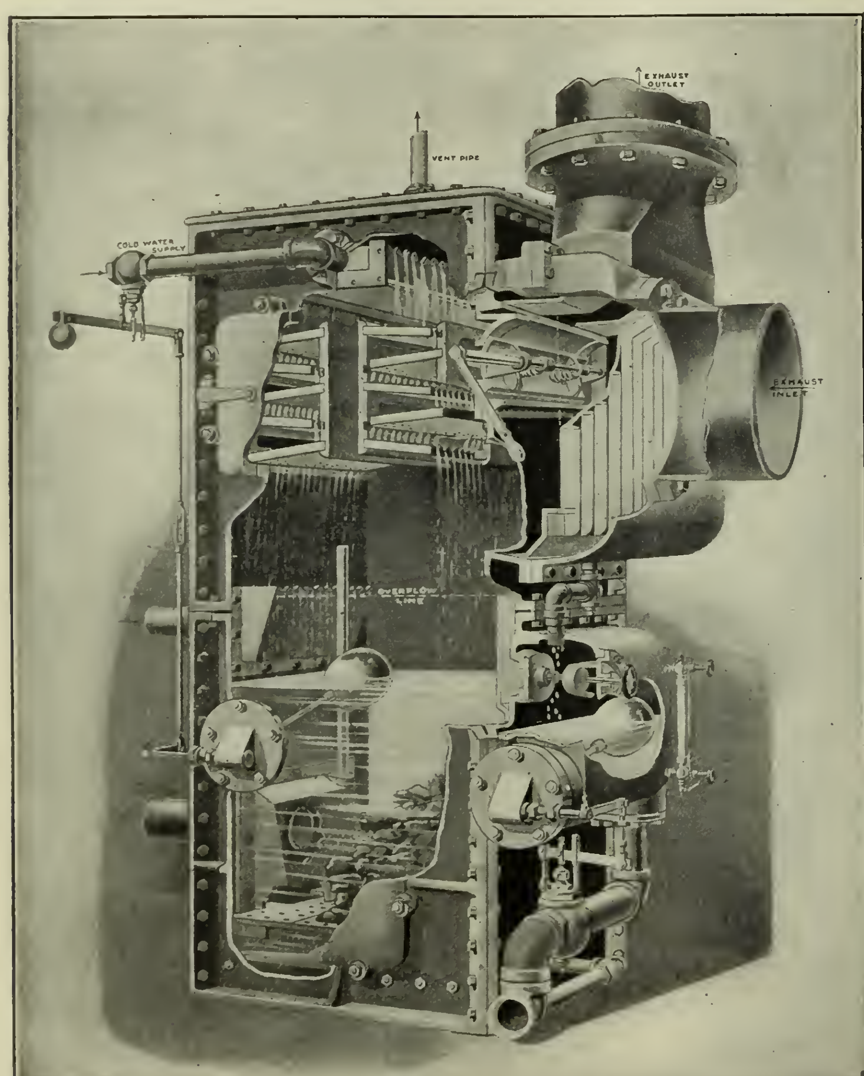


FIG. 3. SECTIONAL VIEW OF THE HARRISON SAFETY BOILER WORKS STEAM STACK OPEN HEATER

After being heated the clean water is drawn from the bottom of the heater, after passing down through the filtering material placed in the bottom of the tank. The water, after passing through perforated plates on which the filtering material rests, passes into a suction box and then on to the feed pump.

There are two features worthy of especial mention in connection with the construction of this heater. By noting the sectional view, Fig. 3, it will be seen that the heater can be entirely shut off from the steam by merely closing the semi-rotary type valve. The valve is shown closed, and the path of the steam is through the oil separator, past the oil-baffle walls and, finding no inlet to the heater proper, it escapes through the exhaust outlet to the heating system. It will be seen that cutting out the heater from service does not prevent the steam from being cleared of oil, as the oil separator is always in service.

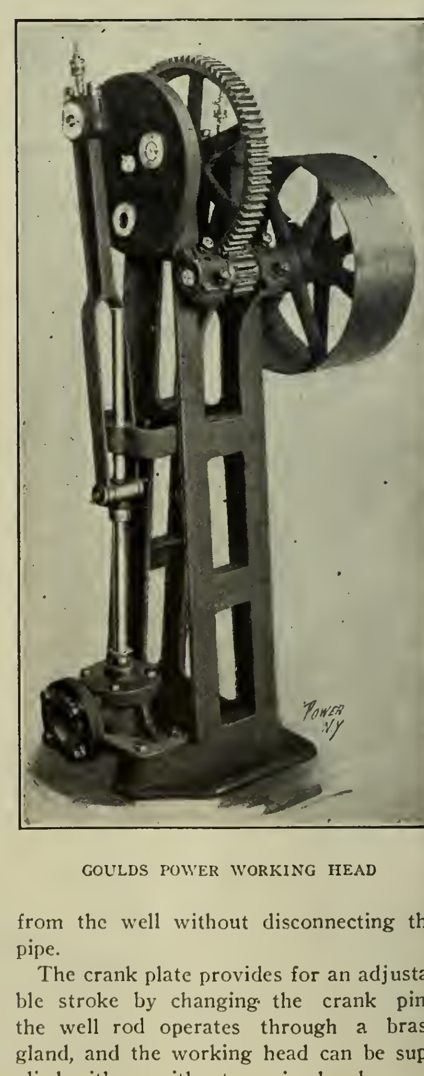
When the steam is passing to the heating system only the small disk valve shown in the oil-drip tank is closed, otherwise steam and oil would back up through the overflow into the heater. When the heater is in service, this valve is open and the overflow and scum from the reservoir, if any, escape into the drip tank and are delivered to the sewer. The float shown in the receiver regulates the water supply so that it remains practically uniform.

Various modifications can be made in the construction of this heater, as in case head room is restricted the steam stack can be connected to the side, rather than the top, or two steam outlets may be used instead of one.

Goulds Power Working Head

With a view of supplying a demand for a compact power working head for operating single-acting cylinders in wells from 50 to 175 feet deep, the Goulds Manufacturing Company, of Seneca Falls, N. Y., recently placed on the market a new type, which is constructed in a substantial manner, owing to the entire frame being cast in one piece.

The gear and crank plate are securely pressed and keyed on the main shaft. The gear and pinion are of charcoal-iron machine-cut from the solid, and the main and pinion shaft run in large babbitted bearings. The well cover is located in the base. It is so arranged that by taking out the bolts which secure it to the frame and disconnecting the well rod, the entire working head can be moved back from the well without disconnecting the pipe.



GOULDS POWER WORKING HEAD

The crank plate provides for an adjustable stroke by changing the crank pin; the well rod operates through a brass gland, and the working head can be supplied with or without an air chamber.

American Society of Mechanical Engineers

Details of the Spring Meeting at Washington; Proposed Amendments to the Constitution; Proceedings of the Gas Power Section

The spring meeting of the American Society of Mechanical Engineers was held at Washington during the week commencing May 3. The sessions were held in the ballroom of the New Willard, where on Tuesday evening the society was formally welcomed to the city by Hon. Henry B. Macfarland, president of the Board of District Commissioners, the response being made by Jesse M. Smith, president of the society. Professional sessions were held on Wednesday, Thursday and Friday forenoons. On Wednesday afternoon the society witnessed a special exhibition drill by troops at Fort Myer, and in the evening, A. P. Davis, chief engineer of the Reclamation Service, presented an illustrated lecture on "Home Making in the Arid Regions."

On Thursday afternoon the members and guests were received by President Taft in the East Room of the White House. On Thursday evening, Rear-Admiral George W. Melville, retired, addressed the society upon "The Engineer in the Navy," criticizing the attitude of the line toward engineering and condemning recent actions of the department in a manner which the morning papers termed "startling," but which seemed to have the sympathy and approval of his hearers. Walter M. McFarland, of Pittsburg, presented, on behalf of a number of his friends, a portrait of the admiral to the historical series of paintings in the National Museum. The portrait was accepted by Dr. C. D. Walcott, representing the Nation.

On Friday afternoon a visit was paid to Mount Vernon. A contemplated balloon ascension and an aeroplane exhibition at Fort Myer were precluded by a thunder squall.

Numerous invitations were received from local institutions of interest, the hospitality of several local clubs was extended to the members and socially the meeting, which was very well attended, was very pleasantly successful.

WEDNESDAY

The first professional session was held on Wednesday forenoon. The membership committee reported 148 names which had been passed upon by the council and they were formally added to the list of members.

Proposed Amendments to the Constitution

Announcements of intended amendments to the constitution affecting the qualifications of associate and junior members were read in anticipation of action to be taken upon them at the annual meeting. That upon associate members reads that:

"An associate shall be thirty years of age or over, and must be so connected with some branch of engineering or science or art or industry that the council will consider him qualified to cooperate with engineers for the advancement of professional knowledge. He need not be an engineer."

To the section relating to junior members it is proposed to add: "A person who is over thirty years of age cannot enter the society as a junior." A further amendment provided for the Public Relations Committee, as proposed by Morris L. Cooke at the last meeting.

O. C. Woolson addressed the society in favor of building a bulkhead around the sunken battleship "Maine," filling it in and erecting a suitable monument upon it.

Papers on Handling Materials

The first two papers dealt with handling materials. "A Unique Belt Conveyer," by Ellis C. Soper, was a description of the installation and operation of a belt conveyer, a quarter of a mile long, requiring less power to operate loaded than empty because the material is conveyed down hill. The only requisite labor to keep it in operation is that of a boy to do the oiling, adjust the rolls, etc.

E. G. Bennett called attention to a 36-inch movable conveyer over 1000 feet long on Riker's Island and other large installations.

In a discussion which ensued upon the life of belting, a member said that in his work a rubber belt lasted 7 or 8 years.

"Automatic Feeders for Handling Material in Bulk," by C. Kemble Baldwin, of Chicago, describes eleven types of automatic feeder in use today, favoring the shaking feeder because of its simplicity and flexibility.

"A New Transmission Dynamometer"

by Prof. William H. Kenerson, described a transmission dynamometer which will be described in a later issue.

There are three factors controlling its sensitiveness, the area of the diaphragm, the ratio of the controlling levers and the diameter of the flanges, so that practically any desired degree of sensitiveness may be had. So, however sensitive it is made, its construction is such that no complication as a measuring instrument would involve an interruption to the operation of the shaft driven through it. The only derangement which suggests itself is the cracking of the balls in the bearing, and the pressure upon them is so slight as to render this hardly possible.

THURSDAY

Gas Power Section

Thursday's session was filled entirely by the Gas Power Section of the society. After reports from the literature, plant operation and membership committees, an interesting report was presented by C. L. Straub on the progress in marine gas producer work abroad. The report indicated that while more has been done in Europe than in America in the application of producer-gas power for marine service, nothing approaching a standardized equipment has yet been developed. The Capitaine producer for gasifying small sizes of anthracite is practically the only one that has thus far shown encouraging results. The largest engine yet undertaken is an eight-cylinder single-acting machine now being built by Vickers Sons & Maxim. No bituminous producer capable of giving absolutely continuous service over long periods under marine conditions has yet been developed.

"Marine Producer Gas Power"

was the title of the first paper of the session. This was read by Mr. Straub at the conclusion of the report just referred to, and printed in very full abstract on page 8[illegible] of the May 11 number.

In the course of the discussion of Mr. Straub's paper, which was quite extended and interesting, E. T. Adams stated that gas engines for land service were now built about 25 per cent lighter in weight per horsepower than they were three or four years ago, because of the improvements in design due to the larger experience gained; therefore the very favorable figures given in the paper need occasion no surprise nor skepticism. Mr. Adams also stated that a plant of large gas engines, with producers and auxiliaries, could be housed in the same size of building that would be required for a steam-turbine plant of equal output with its boilers and auxiliaries, notwithstanding the fact that the turbine is the smallest of all types of prime movers.

Mr. Ober's paper on the "Operation of a Small Producer-Gas Power Plant" was read in abstract by Henry E. Longwell.

Mr. Obert being absent. This paper is printed on page 873 of this issue. The paper did not evoke the discussion which its character merited.

High Compression and Weak Mixtures

"A Method of Improving the Efficiency of Gas Engines," by Thomas E. Butterfield, was the next paper presented. The method consists in using high compression and diluting the combustible mixture with inert gases, such as the exhaust gases of the engine itself. Of course, the mixture is usually diluted to some extent by the products of combustion remaining in the clearance space after each explosion, but the present suggestion is to dilute still farther and to advance the time of ignition in order to compensate for the slowness of combustion produced by the dilution.

Discussing this paper, W. O. Barnes stated that premature ignition due to high compression was not as serious as it was commonly considered. In most cases this sort of preignition indicated faulty design of the combustion chamber, and the vigorous pounding that was sometimes produced by premature ignition was due to the fact that the affected parts were not sufficiently large to take care of the extra stresses caused by the unusual rise of pressure during the compression stroke.

Offset Cylinders

The final paper of the session was one by Prof. T. M. Phetteplace, entitled "Offsetting the Cylinders of Single-Acting Engines." The paper was an exhaustive mathematical analysis of the effects obtained by setting the crank shaft to one side of the line corresponding to the plane of the cylinder centers. The author's conclusion was to the effect that improvements obtained by offsetting are negligible as far as the thermal cyclic efficiency, mechanical arrangement, turning effort and lubrication are concerned; the real advantages are a reduction of the frictional losses due to the pressure of the piston on the walls of the cylinder, resulting in a slight increase in mechanical efficiency and less wear of the piston, piston rings, and cylinder, and consequently longer life; and a reduction of the maximum value of the side pressure of the piston on the walls of the cylinder, allowing the use of shorter connecting rods, shorter pistons, and shorter cylinders, resulting in a shorter and lighter engine and in lower inertia forces due to the reciprocating parts. The most important advantage would be the considerable saving in weight produced by the shortening of parts.

The disadvantage of offsetting lies in the fact that the reductions in average side pressure and maximum side pressure grow less as the speed and inertia force increase, so that for a speed of 1400 to 1500 revolutions per minute, there is either no reduction at all or an increase.

The author's summary of the principal physical results of offsetting was as follows:

Offsetting increases slightly the length of stroke and the crank angle passed over during the stroke toward the crank shaft.

The maximum value for the side pressure of the piston on the cylinder walls decreases as the offset increases up to a value of one-half the crank radius for any ratio of L/R. (L = Length of connecting rod; R = crank radius.)

The work lost in friction due to the side pressure of the piston on the cylinder walls decreases as the offset increases up to a value of 75 per cent. of the crank radius.

Both the maximum value of the side pressure and the work lost in friction increase as the value of the ratio L/R decreases.

Offsetting decreases the height and weight of the engine and increases the life of the cylinder and piston.

The advantages of offsetting as regards the maximum side pressure and work lost may be zero or negative for high inertia forces resulting from speeds of 1500 revolutions per minute or more.

In the course of the ensuing discussion, John H. Norris said that his company (building the Nash engine) had tried offsetting the cylinders over 20 years ago and found that in actual practice no real advantage was obtained by it.

FRIDAY

Papers Presented

The Friday morning session was devoted to the following papers: "Small Steam Turbines," by George A. Orrok (published in the May 11 number, page 850); "Tests on Compressed Air Pumping Systems," by Edmund M. Ivens; "Specific Volume of Saturated Steam," by Prof. C. H. Peabody (published in this issue, page 879); "Some Properties of Steam," by Prof. R. C. H. Heck (published in this issue, page 876); "A New Departure in Flexible Staybolts," by H. V. Wille (abstracted in the February 9 number, page 280).

In addition there was a continuation of the discussion, begun at the February meeting, of "Safety Valves," published in the March 16 number, page 520.

Discussions

In the discussion of Mr. Orrok's paper on "Small Steam Turbines," it was the opinion of Charles B. Rearick that high economy in the small turbine units in many instances is of minor importance. Reliability of service is most important. In nearly all large power plants the exhaust steam is all utilized in feeding water heaters and 80 per cent. of the heat is returned to the boilers. There is only one class of service in which high economy is absolutely necessary, and that is when the unit becomes the prime mover or the main unit for a plant. In this case the turbine is usually all right, for the speed can then be chosen for the best economy.

Charles A. Howard showed by comparing Mr. Dean's paper of a year ago with Mr. Orrok's curves, that the overall efficiencies of the turbine and engine in small sizes after the latter has been in use for some time, are but very little different, with perhaps a little in favor of the engine.

Prof. R. C. Carpenter expressed an opinion that the field of the small steam turbine is somewhat narrow as compared with that of the high-speed steam engine, and that the advantages of the small steam turbine must be due to other reasons than simply that of economy. Figures from the test of a small turbine running noncondensing showed that 350 degrees of superheat had about the same effect as 18 inches of vacuum, and the water rate of a machine given in the paper as approximating 50 pounds per brake horsepower went down to 22 pounds. The small steam turbine has special advantages for many kinds of work and for those kinds of work it was the speaker's opinion that the small steam turbine would ultimately supersede the small piston engine.

R. H. Rice, of West Lynn, Mass., commented on the fact that all of the turbines described are of the impulse, or action type. It was his opinion that the reaction turbine is not suitable on account of the complication and expense of the bucket system for small turbine work, and this leads to the conclusion that the great flexibility of the impulse type will render it the ultimate type of the future, superseding entirely the reaction machines for all classes of service. To the latter statement Professor Carpenter objected, stating that there is no question about the advantages of the impulse turbine for small work, but the reaction turbine for large powers will not drop out where a high vacuum can be obtained.

W. E. Snyder, of Allegheny, Penn., thought that all the emphasis should not be laid on the steam economy. Another point which should receive careful attention is the lower cost of maintenance, particularly where the turbines are used for boiler feed and replace the direct-acting boiler-feed pump generally used. In large plants where all of the large units are condensing, the steam from the auxiliaries is needed to heat the feed water, and a few per cent., more or less in steam consumption, of these auxiliaries, does not materially change the conditions of the total economy of the plant because most of the heat is recovered in the feed water.

Safety Valves

In the "Safety Valves" discussion, A. B. Carhart said that the limit of diameter size of valves for stationary boilers should be 5 inches, and for locomotives, 3½ inches; common practice is in accord with this. Units giving 1 square inch discharge area are the largest allowable for locomotives. Total discharge capacity of 2 square inches for locomotives having 35 square feet grate area, and 3 square inches for the largest ones having 50 square feet grate area, has been demonstrated to be amply sufficient. This should be divided into three units: (a) muffled valve with close adjustment, (b) reserve valve regulated for reasonably greater discharge, and (c) an emergency valve as the real protection against explosion, the other two simply to limit the working pressure under ordinary conditions.

Valves in use are [illegible] limited in regulation. The strain upon the boiler is dangerous when the opening is too large and sudden, and water [illegible] the relief through the safety valve and endangers the cylinders. A smaller valve with high lift is not the equivalent of a valve of larger seat diameter and less lift showing the same discharge area, for the smaller valve gives less percentage of steam discharge, there is greater danger of sticking in opening, more trouble from pounding at the seat and leaking, and the outlet area becomes too large in proportion to the inlet, causing chattering and giving ineffective relief to the boiler. The lift should not exceed 0.08 inch for locomotive valves and 0.10 inch for stationary valves used at lower pressures; prudence and economy would reduce rather than increase this limit.

Every valve has a wide range of adjustment; the lift can often be varied from 0.04 to 0.10 inch by anyone at will, and to still greater limits by exchange of springs in the same valve, to be had for the asking. Limited lift is a matter of preference or judgment, not of necessity, in valves as commonly made. All internal work for large lift of the disk that must be extracted from the escaping steam reduces the velocity and efficiency of the relief and requires an undue throttling of the outlet, strangling the discharge instead of relieving the boiler.

Philip G. Darling said that recent articles place the maximum lifts of safety-valve lifts variously at [illegible] and 0.11 inch for the same size of valve. The great number of these recommended lifts complicate the situation and naturally raises the question as to just what the basis in setting such maximum limits is and whether there are any inherent features or principles of design calling for general restriction in such values. Mr. Darling cited some instances in foreign practice showing that in England [illegible] valve regulations have been discovered limiting spring compression [illegible] inch on valve lifts [illegible] and it was his opinion that [illegible] limits actually restrict the progress of design in this country in spite of a general [illegible] among manufacturers

against advancement in the [illegible] of [illegible] purchase.

In safety valving a boiler, [illegible] of the [illegible] relieving capacity, and if [illegible] with a [illegible] valve, there is a positive [illegible] not only in original cost, but in [illegible] action of [illegible] small valves than large ones.

If it were a [illegible] to the [illegible] different valves which the engineering [illegible] should demand and legislate for, but rather the question of [illegible] Capacities as [illegible] not [illegible] however [illegible] but from the actual [illegible] to the valves themselves. A purchaser, or one specifying safety valves, should be given this capacity information by the different valve makers and he may intelligently select the proper size and type of valve, and the basis upon which this capacity is obtained should be demonstrated as reliable.

A logical policy is for the valve makers to continue to advocate each his own lifts and capacities in the different sizes of valves, but on the other hand for all to get together in agreeing to some sort of a test, to guarantee what the actual relieving capacities of these valves are, stamping them upon the valve as is already being done by one maker. This will give a rational basis for use in the application of safety valves to boilers.

Graft Charges in Chicago

Charges of graft among members of the board of examining engineers for the City of Chicago have been in circulation for some time, but no definite action was taken until recently, when States Attorney Wayman took the matter up, with the result that on Saturday, May 1, the Cook county grand jury returned an indictment charging [illegible], secretary of the board of examining engineers, and John Jenkins, journeyman engineer and member of the board, with obtaining money by false pretenses in the furnishing of an engineer's license to Joseph [illegible].

Louis [illegible], an engineer on the board, who is alleged to have been the "go-between" for the board members, has not [illegible]. The method of operation is said to have been through the [illegible] of advertisements in newspapers published in foreign languages in Chicago, saying that the advertiser could make the [illegible] of license easy. It is alleged that [illegible] answered one of the advertisements and [illegible] told him he would have to pay [illegible] part of which would go to the board. It is further alleged that [illegible] gave him the money and obtained his license.

Other charges have been [illegible] but no other cases [illegible] have been [illegible]

[illegible] Frank E. [illegible] [illegible] of the board of examining engineers [illegible] [illegible] "I [illegible] one of three members of the board. The other members [illegible] I have [illegible] [illegible] the [illegible] of the ordinary [illegible] [illegible] public records and I [illegible] [illegible] I have [illegible] [illegible]"

Following the [illegible], Mayor Busse [illegible] the resignation of the [illegible] and [illegible] that the board would be completely reorganized on different lines, bringing it more closely in touch with the city administration than has been the case in the past, so that its [illegible] could be subject to proper surveillance. Although Mr. [illegible] was not included in the charges, he had voluntarily tendered his resignation as president of the board.

Repairs to Turbines of U. S. S. "Salem"

As stated in the May 11 number, the United States scout cruiser "Salem" was sent to the builder, the Fore River Shipbuilding Company, for an examination of the main propelling turbines, which are of the Curtis marine type. During the [illegible] the starboard turbine was considerably slower than the port, with the same steam supply, thus indicating that some internal derangement had occurred, although there was no difficulty in its operation.

When opened up it was discovered that some foreign body had become caught in the [illegible] space between the nozzles and first row of buckets. It had then [illegible] the edges of the buckets so as [illegible] to prevent any steam passing through them and had broken short [illegible] of the [illegible] The foreign body which caused this had not been found at this writing, but a [illegible] which was found in the first stage, lying on the bottom of the casing, and [illegible] caught in the [illegible] parts.

Examination of the port turbine disclosed a [illegible] body [illegible] which was not a part of the turbine, lying in the first stage [illegible] the [illegible] in the second stage. The damage [illegible] slight.

The [illegible] of both machines were [illegible] to have [illegible] so as to [illegible] the [illegible] against the [illegible] [illegible] with the [illegible] in the first and second stages [illegible] the [illegible] guide blades were worn on the edges; but no blade stripping occurred. As in these stages the guide blades cover only a small part of the circumference, practically all the wear occurred on them and very little on the moving buckets.

All blading was found to be entirely free from any erosion due to the action of the steam, and the surfaces were as smooth as when first installed.

This shows that turbines can withstand considerable abuse and still remain in operative condition; as even in this condition the vessel made 24½ knots for 24 hours and for the first 8 hours made 25 knots, while the contract speed required was 24 knots for 4 hours. Also, the operation of the turbine was all that could be desired, and except for the drop in revolutions, it would not have been known that any internal damage had occurred.

The damage is being repaired, and is expected to be finished in 30 days from the vessel's arrival at the yard. The accompanying photograph shows the damaged buckets on the first row of the fifth stage. The three bucket rows of the fifth stage are marked 1, 2 and 3, the damaged row being No. 1.

The company officials state that they make no charge of vandalism regarding this damage, as it was quite possible for stray bolts or nuts accidentally to drop into the turbine during installation.

THE DAMAGED BUCKETS OF THE U. S. S. "SALEM"

The resistance to failure by shear and diagonal tension and the effectiveness of metallic-web reinforcement are discussed in Bulletin No. 29, "Tests of Reinforced Concrete Beams: Resistance to Web Stresses," by Arthur N. Talbot, just issued by the Engineering Experiment Station of the University of Illinois. This bulletin of 85 pages gives the results of tests made in the laboratory of applied mechanics of the university.

Copies may be obtained gratis upon application to the director, Engineering Experiment Station, Urbana, Ill.

The fifth annual convention of the Southwestern Electrical and Gas Association will be held in Dallas, Tex., May 20, 21 and 22 next.

Meetings of State Associations, N. A. S. E.

Iowa, Cedar Rapids, May 20, 21, 22.
Kentucky, Henderson, June 4 and 5.
Pennsylvania, Erie, June 4 and 5.
New Jersey, Hoboken, June 5.
New York, Syracuse, June 11 and 12.
California, San Francisco, June 14 to 19.
Connecticut, Waterbury, June 25 and 26.
Massachusetts, Springfield, July 9 and 10.
Michigan, Bay City, July 15, 16, 17.
Ohio, Columbus, September 13.

Pennsylvania N. A. S. E. Convention

The tenth annual convention of the Pennsylvania State Association, N. A. S. E., will be held at Erie, Penn., June 4 and 5 next. Erie being the engine- and boiler-manufacturing city of the State, it is expected that this convention will be the largest, in point of attendance, ever held by the Pennsylvania N. A. S. E.

Annual Convention of the A. O. S. E.

The annual convention of the American Order of Steam Engineers will take place at Reading, Penn., during the week commencing June 7. Headquarters will be at Penn hotel.

Annual Convention of the Universal Craftsmen

The annual convention of the Universal Craftsmen, Council of Engineers, will be held at Washington, D. C., August 3, 4, 5 and 6. Headquarters will be at the National hotel.

The Fidelity and Casualty Company reported 19 boiler explosions in this country, including two engine boilers, between March 15 and April 14, inclusive; there were also a number of minor boiler accidents. From March 19 to April 7, inclusive, three flywheels were reported burst.

On Saturday evening, May 22, Illinois Association No. 3, N. A. S. E., of Waukegan, Ill., will hold an open meeting at which the following will speak: L. M. Eckstrand, on "Coal;" J. W. Swearingen, on "Pumps;" J. W. Townsend, on "Some of the Mishaps of the Past."

Announcement is made that the annual convention of the American Street and Interurban Railway Association and its affiliated associations will be held at Denver, Colo., October 18, 19, 20, 21 and 22, 1909.

Inquiries

Questions are not answered unless they are of general interest and are accompanied by the name and address of the inquirer.

Cause of Bent Fire Tubes

In a fire-tube boiler some of the tubes are curved so that they are nearer together in the middle than at the ends. What bent them?

H. S.

At some time the bent tubes have been hotter on one side than on the other, and the stress caused by the unequal expansion resulted in a permanent deformation or bend.

Cause of Leakage with Cold Water in Tank

Why do the girth seams of a horizontal water tank leak when the tank is half full of cold water but do not leak when the water is hot? The tank is used as a hotwell with exhaust steam admitted above the water.

G. H.

Difference in temperature between the upper and lower parts causes strains which open the seams enough to allow a slight leakage.

Producer Gases

Please explain the differences between water gas, producer gas and coal gas.

G. J. R.

Any gas made from coal is coal gas, but the name is commonly applied to the lighter gases driven off from coal by the application of moderate heat. Water gas consists chiefly of carbon monoxide and hydrogen formed by passing steam through a bed of incandescent coke. Any gas made in a gas producer is producer gas, but the name is commonly restricted to the gas made by passing air and steam through a bed of incandescent fuel and a bed of fuel not yet brought to incandescence.

"Mud" in a Water Column

Our water column used to get choked with mud. How is the circulation produced that carries the mud into the column connections?

C. H.

What you designate as mud is probably iron oxide made by the union of oxygen and iron. Corrosion of the iron in this case would produce a spongy mass of nodules which would in a very short time entirely fill the pipe leading to the bottom of the combination and stop the pipe, not because of any peculiar kind of circulation which carried mud into the pipe, but the lack of enough circulation, by blowing or otherwise, to carry the mud away.

Storage Battery Requirements

What size of storage battery is required to give a normal discharge rate of 20 amperes at 110 volts, and how is the size determined?

C. C. C.

Each cell must have 24 square inches of surface area on the positive plates for each ampere of discharge rate. For 20 amperes, therefore, the positive plates of each cell must have 480 square inches of surface. Each cell gives from 1.8 to 2.5 volts, according to its condition; at the beginning of the discharge 50 cells would give 110 volts, but toward the end the battery would drop to about 90 volts. It would be advisable to put in 60 cells in order to keep the potential up to 110 volts.

Different Pressures for Boilers Connected to Same Steam Line

I have two boilers connected to the same steam line. One is horizontal and the other is vertical, but otherwise they are the same, in thickness of shell, in diameter and in riveted joints. Why is it that the inspector allows five pounds more pressure on the vertical boiler than on the horizontal one?

A. O. L.

It is not just clear how more steam pressure can be carried on one boiler than on the other as long as both are connected to the same steam main. If the shells are equal in strength the lower steam pressure should be allowed on the vertical boiler, owing to the extra pressure of water in the vertical boiler due to its hight.

Why the Manhole Joint Leaks

In a 11x15-inch manhole a new gasket is required every time the plate is removed, and when the pressure falls below 20 pounds the joint always leaks. What is the cause?

A. B.

The face of the plate does not fit the face of the ring. When the gasket is new it is somewhat elastic and the joint is tight under the rising pressure. At working pressure the pressure on the back of the plate exceeds the stress of the bolts and the plate is held in place by the pressure on its back. As the pressure is reduced the plate, which has been warped by the pressure to fit the ring, tends to resume its natural shape and as it does so it opens a crack for the escape of steam.

Book Reviews

THE ENGINEERING INDEX ANNUAL FOR 1908. Compiled from the engineering index published monthly in *The Engineering Magazine* during 1908. Published by The Engineering Magazine, London and New York. Cloth, [illegible] pages, [illegible] inches.

Although the 1908 volume is not materially larger than the 1907 Annual it indexes [illegible] more articles [illegible] [illegible] [illegible] volume than in its predecessor. [illegible] and planning [illegible] has been used, also in standardizing the classification—particularly in following a uniform system for placing articles of doubtful classification, and in using cross references so freely that [illegible] to the goal.

This is the seventh volume of the Index since the work was first undertaken, and the third since it assumed the "Annual" form, and it makes available a continuous index to the engineering and technical literature of the past 25 years. The list of periodicals included comprises [illegible], representing [illegible] nations and [illegible] languages.

MILLWRIGHTING. By [illegible] F. Hobart. Hill Publishing Company, New York. Cloth; [illegible] pages, [illegible] inches; illustrated. Price, $[illegible].

The old-fashioned millwright has become lost between the mill architect or mechanical engineer and the contractor and erecting man, and yet there must be somebody to [illegible] the work [illegible] [illegible] the designing engineer, to [illegible] [illegible] [illegible] [illegible].

[illegible]

Resolutions on the Death of Ira Watts

The Combined Association, N. A. S. E., of Manhattan and the Bronx has adopted the following resolutions:

"In every association there are a few men who, by reason of their sterling qualities and unselfish devotion, stand out prominently among its membership, and whose counsel and efforts can least be spared to the common cause. Such a man was our late friend and companion, Ira Watts, the news of whose death in far away Spokane, Washington, comes as a blow to us, his fellow engineers and associates.

"An accomplished engineer, a faithful officer, an untiring worker, an exemplary citizen and an ever-ready helpmate, he was an ornament to his profession, a pillar of strength to the association, and an example worthy of emulation to his fellow men.

"The General Committee of the National Association of Stationary Engineers of Manhattan and Bronx, New York, in regular meeting assembled, desirous of giving public expression to their sense of bereavement at his loss, and of recording their appreciation of his high qualities, do hereby

"Resolve that in the death of our beloved brother, Ira Watts, the engineers of America and especially the General Committee of the National Association of Stationary Engineers of Manhattan and Bronx, have lost one of their most useful, esteemed and representative members, one whose place in our counsels and in the hearts of his fellow men it will indeed be hard to fill; and be it also

"Resolved, that we extend to those even more near and dear to him the sympathy of fellow mourners and of sharers in the deep affliction which his untimely calling away has imposed upon ourselves as well as them, and be it further

"Resolved, that these resolutions be spread in full upon the minutes, and that a copy thereof be forwarded to the family of our deceased brother."

Business Items

The Tatnall Engineering Company, of Philadelphia, announces that it has severed its connection with the Wetzel Mechanical Stoker Company.

Muralt & Co., engineers, have opened a branch office in the Temple Court building, Bay and Richmond streets, Toronto, Ont., with J. Eugh as manager.

The repair shop of the Crocker-Wheeler Company, Ampere, N. J., has been placed in charge of Edmund Land, who, for five years, held an executive position with the Wheeler Condenser and Engineering Company.

B. Elshoff, for 12 years assistant superintendent of the Allis-Chalmers-Bullock Company, of Cincinnati, and for the past two years superintendent of the electrical department of the Allis-Chalmers Company, of Milwaukee, recently severed his connection with the last-named company. Mr. Elshoff may eventually accept a position with an eastern firm, but for the present will remain in Milwaukee.

The Keystone Lubricating Company, of Philadelphia, claims that the best and most economical method of lubricating the guide rails of freight and passenger elevators is to use a refined high-grade petroleum-oil grease applied by a simple compression-cup lubricating device carried by the car. Keystone grease is stated to be in use for this work in a large number of the principal office, warehouse and factory buildings in the country.

The increasing demand for Bird-Archer boiler compounds in the Orient has necessitated the opening of the following new offices by the Bird-Archer Company, of New York: Honolulu, J. P. Lynch, 42 Young building; Manila, Lambert Springer Company, 99 Plaza, Santa Cruz; Yokohama, T. M. Laflin, Exchange market; Hong Kong, Shanghai and Singapore, United Asbestos Oriental Agency, Ltd. All of these agents have competent steam engineers to direct boiler owners in the proper use of the compounds.

Walter B. Snow, publicity engineer, 170 Summer street, Boston, Mass., announces the association with his staff of Carl S. Dow, engineering department, Harvard University, late publicity manager, B. F. Sturtevant Company, and formerly in charge of instruction and textbook departments, American School of Correspondence. Mr. Dow brings to the organization a diversified experience, which will add materially to the value of the service rendered in all lines of technical publicity.

The Public Service Corporation, of New Jersey, has recently purchased from the Hewes & Phillips Iron Works, Newark, N. J., eight special engines, 16½ inches in diameter by 24-inch stroke, to run 175 revolutions per minute. They will be direct-connected through flexible couplings to blowing apparatus. They are to be used in distributing illuminating gas under pressure to the outlying districts of Newark and Jersey City. The engines will be arranged with a special pressure control, the governors working to fractions of ounces. These engines are of the heavy-duty tangye type.

The American Blower Company, of Detroit, Mich., has adopted a method of following up every engine it ships by means of a blank report which it forwards to the purchaser, accompanied by a form letter, and followed by a "follow-up" letter in case a prompt response is not forthcoming. The report or information blank asks the customer for information concerning the size of engine, for what it is used, when installed, the revolutions per minute, steam pressure, if oil has been added and how often, the quantity of oil added each time, and how often and where adjustments have been made. By this means the company "keeps tabs" regarding every engine it sends out.

In a pamphlet, entitled "Automatic Draft Control for Steam Boiler Furnaces," the Green Fuel Economizer Company, of Matteawan, N. Y., describes an appliance recently brought out for so regulating the draft of steam boilers that the pressure within the firebox shall be at all times neutral. To accomplish this, just enough pressure is supplied under the grates to force the air through the fuel, while enough draft is applied in the smoke flue to draw the gases of combustion through the boiler. This system of draft is thought to have an important bearing in connection with the researches which have recently been made by the engineers of the United States Geological Survey with the object of increasing greatly the rate of steam production per square foot of heating surface in steam boilers.

New Equipment

The Chickaska (Okla.) Light, Heat and Power Company will erect a new power house.

The Standard Chemical and Oil Company, Troy, Ala., will rebuild its electric-light plant recently burned.

The Merchants Heat and Light Company, Indianapolis, Ind., has secured a site for a new plant, to cost $300,000.

The Boston Confectionery Company, Cambridge, Mass., will install a 200-horsepower gas engine in plant, also other equipment.

The Greenwich Cold Storage Company, New York, has been incorporated with $25,000 capital by H. R. Carberry, I. C. Mosher, P. J. McKeen, etc.

The Fitzgerald (Ga.) & Ocilla Electric Railway & Power Co. is making arrangements for the construction of a power plant on Lake Beatrice.

The Lytle Creek Power Company, San Bernardino, Cal., has decided to spend $300,000 in extending system. Duplicate plant will be installed.

The North Carolina Sanatorium for Treatment of Tuberculosis, Greensboro, N. C., will build power plant to furnish heat, power, water and light.

The Scotia Worsted Company, Woonsocket, R. I., is making preparations to construct a new power house. New engine and boilers will be installed.

The Springfield (Mass.) Street Railway Company is making plans for improvements to cost about $80,000, which will include new electrical equipment, etc.

The Thousand Island Electric Light and Power Company, Clayton, N. Y., is thinking of substituting a gas-producer plant for the present steam plant.

12,500-H. P. Turbines of the "North Dakota"

Description of the Curtis Marine Type Turbines Built for the First American "Dreadnought," Which Requires a Total of 25,000 H. P.

The United States battleship "North Dakota," now building at the Fore River Shipbuilding Company's works at Quincy, Mass., and the first of the American "dreadnoughts," is 510 feet long, 85 feet beam, draws 27 feet and has a displacement of 20,000 tons. She has a full speed of 21 knots, requiring an aggregate of 25,000 horsepower which is supplied by two Curtis marine reversible turbines driving twin screws. The turbines are designed to run with [illegible] pounds gage pressure, [illegible] degrees of superheat and [illegible] inches of vacuum.

The velocity acquired by a jet of steam expanding through this range in one bound would be some [illegible] feet per second, so excessive that it would not be possible to build a turbine the blades of which could run at anywhere near one-half the speed of the jet, the condition of maximum efficiency. By dividing the expansion into a number of stages, the lesser velocity which the steam has acquired from the lower range of expansion can be taken out in each stage before it is allowed to expand to the next, and the speed of the jets be brought down within practical limits by using such a number of stages, as in the Rateau, that the temperature fall through each range, and thus the energy and velocity generated, will be small, or by using a fewer number of stages and making the jet act successively upon several rows of blades in each stage, which is the characteristic of the Curtis. In Fig. 3, for example, the steam is entering the first stage from the steam chest at the top through the two valves which are open, and, expanding in the two left-hand nozzles, acts upon the first row of moving blades, which are, however, running at [illegible] one-half of the jet velocity that they do not take its energy all out of it and bring it to rest. It therefore passes between the stationary blades and is reversed so that it acts upon the middle row of moving blades in the direction of their movement, where its velocity is still further reduced, and by the time the operation has been repeated the third time the steam leaves the discharge edges of the moving blades at the first stage pressure, but with its velocity practically all gone. It then acquires new velocity by expanding through the second set of nozzles to the second stage, where the operation of absorbing the velocity in successive moving and stationary blades is repeated. Notice that in the diagrams the passages for the steam are made wider as it gets away from the nozzle. This is not because the steam is expanding, for no expansion takes place in the compartment in which the wheel revolves.

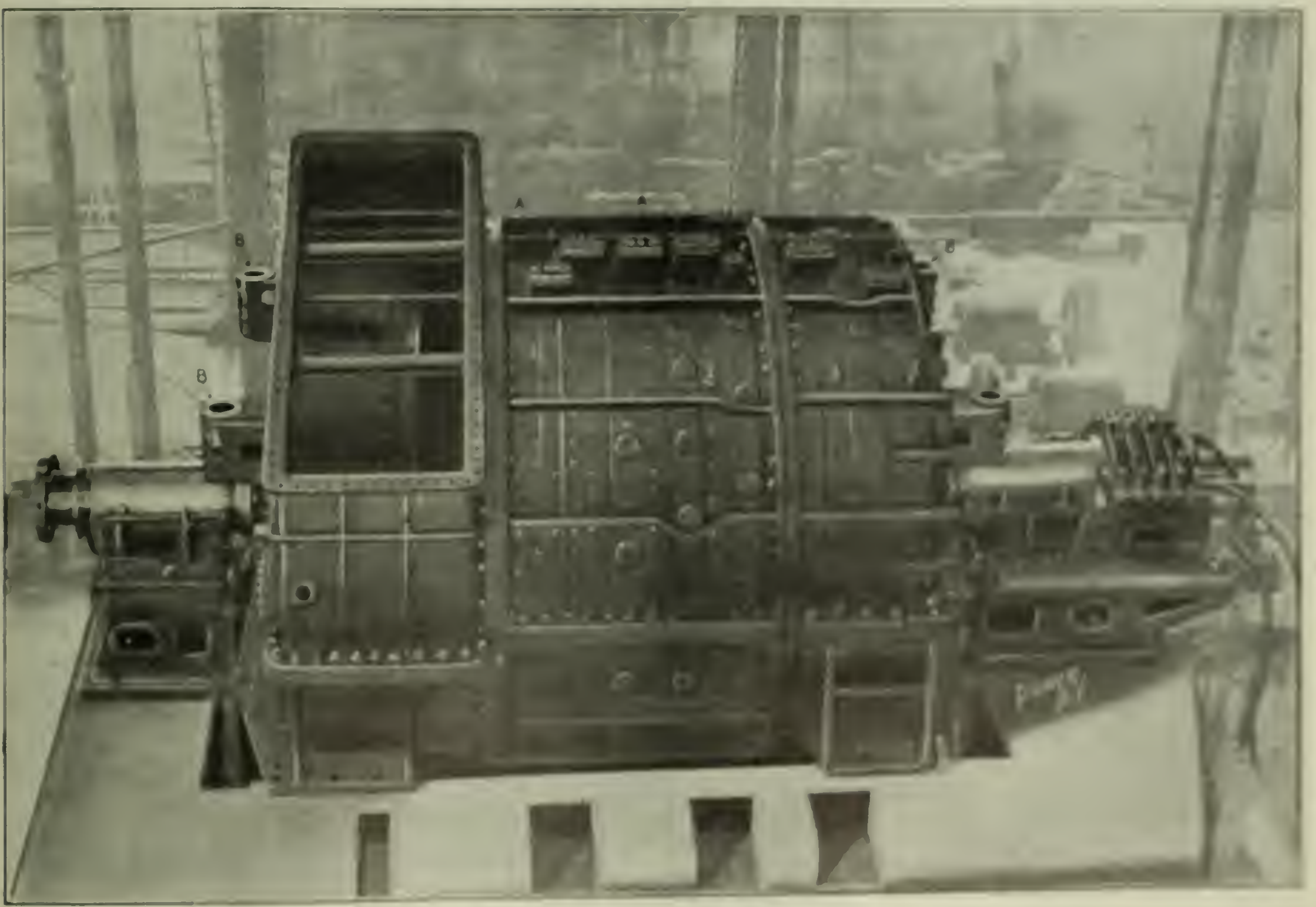


FIG. 1. [illegible]

but because the velocity of the flow is decreasing continuously, and larger passages are required to pass the same volume at the lower velocity.

An important advantage of this method is that steam is not admitted to the shell and working parts of the turbine until its pressure and temperature have been reduced by expansion in the first set of nozzles. Only the steam chest upon the front of the turbine case (or the rear when reversing) is subjected to the initial pressure and temperature.

In the turbines of the "North Dakota" the expansion range is divided into nine stages, as shown in Fig. 2. Between the "ahead" steam chest on the front of the turbine and the compartment containing the first wheel there are 20 nozzles, of which 18 are controlled by sliding valves, each operated by a key upon the squared head of the protruding stem, as shown at *A*, the motion being communicated to the valve through bevel gears and a screw thread, as the drawing shows. No valves are used to control the nozzles between the stages, experience having proved it an unnecessary refinement. For continuous running, enough of the first-stage nozzles are left open to give the required speed and the throttle is left wide open, giving initial pressure in the steam chest, which is of cast steel to give the required strength without excessive weight. Manœuvering is done with the throttle. In order to avoid excessive pressure in the shell, the nozzles of the first set are so proportioned as to reduce the initial pressure of 265 pounds to 75 pounds absolute (60 gage), and the resulting velocity is such that four sets of running blades with three sets of intermediate reversing blades are required in the first stage, while three rows of running blades and two of stationary blades suffice for the remaining stages. The distribution of pressures in normal continuous running is as follows:

	Gage.	Absolute.
Steam chest	265	280
First stage	60	75
Second stage	35	50
Third stage	15	30
Fourth stage	5	20
Fifth stage	— 4	11
Sixth stage	— 9	6
Seventh stage	—11.4	3.3
Eighth stage	—12.9	1.8
Ninth stage	—13.7	1

The first nozzle is convergent-divergent on account of the greater expansion, while for the remaining nozzles a parallel passage with a convergent approach suffices for the lower expansion ratios. The area through the nozzles is increased progressively by increasing both the number and cross-section to accommodate the greater volume of the expanded steam. The 20 nozzles of the first stage occupy only about 42 degrees of the circumference. The passages leading to the nozzles of the third stage are shown at the top of the circular casting which is standing upright at the left in Fig. 3 and which

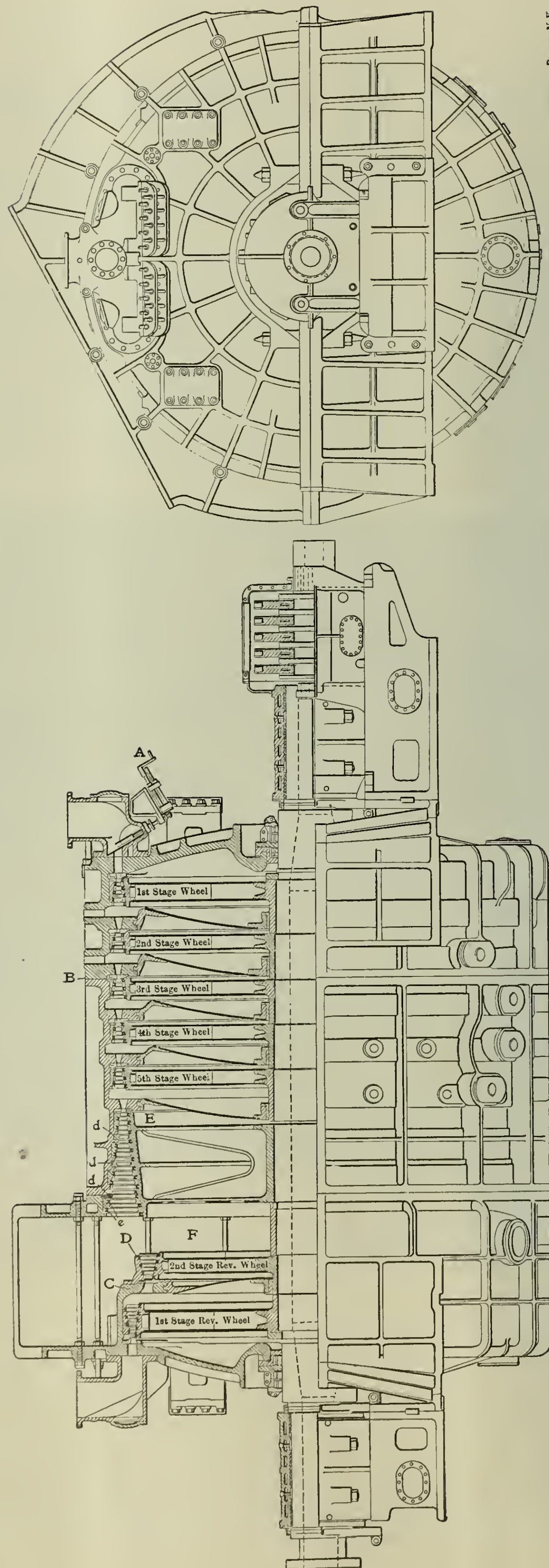


FIG. 2. SECTIONAL AND END VIEWS OF THE CURTIS TURBINE FOR THE "NORTH DAKOTA"

FIG. 3. PARTS OF TURBINE IN SHOP

FIG. 4. EXHAUST END OF CASING

is shown in section at B in Fig. 2, the head section containing the first three stages being of cast [illegible] with the joint at B. [illegible] and the sixth stage in the [illegible] around the entire [illegible]. The exhaust end of the casing which occupies the center of Fig. 3 and is shown on a larger scale in Fig. 4 has a [illegible] ring [illegible] the [illegible], this being the ring shown at C in Fig. 2. The ring of [illegible] part of which is standing on the casing, is that which is shown at D, Fig. 2. [illegible] to have [illegible] blades only on [illegible] of the [illegible], [illegible] one each of the [illegible] which [illegible]. The [illegible] blades, which are [illegible] into the [illegible] shown in Fig. [illegible] are of [illegible] and are shown in Figs. 8 and 9 in the [illegible] machines which are used for [illegible] them on.

The wheels are made up of disks of boiler plate, which are turned and [illegible] as shown in Fig. 10 which shows the [illegible] of the wheel after one side has been covered with the boiler plate. Some of the completed wheels are shown in the foreground and elsewhere in Fig. 3. The increased area required for the passage of the steam through the wheel at the diminishing velocity is obtained by lengthening the successive blades, as will be apparent from the segment of the casing, shown in Fig. 9, containing the three rows of stationary reversing blades for the second reverse stage.

For reversing, two wheels are used, running, when not active, in the vacuum at the discharge end of the turbine to avoid windage. Efficiency being here of little moment on account of short and infrequent use, only nine rows of running blades are used, five upon the first and four upon the second wheel.

The inlet pipe is 13½ inches in internal diameter, while the exhaust outlet is 4 feet in width by 9 feet in length, having thus more than 40 times the area of the inlet.

The blades for the first five stages are carried upon wheels running in compartments divided by steam-tight diaphragms, while the last four stages are grouped upon a single drum, the difference in pressure upon the front and back of which, i.e., at E and F, Fig. 2, is used to balance the thrust of the propeller. The separation of the stages upon the drum is effected by bringing the nozzle rings *ddd*, Fig. 2, sufficiently close to the drum to prevent leakage. The low-pressure difference existing between these stages, which will be seen by referring to the foregoing table of the pressure distribution, and the small amount of steam which will pass through a given opening at the very much diminished density of these lower stages, make this matter of separation comparatively easy.

The blades are made from extruded stock, furnished to the works by the Coe Brass Company, in bars of the required crescent-shaped section and of various sizes. The bars are cut to the required length and finished with a projection upon each end, as in Fig. 10. The blades are set into channel bars worked out of the solid

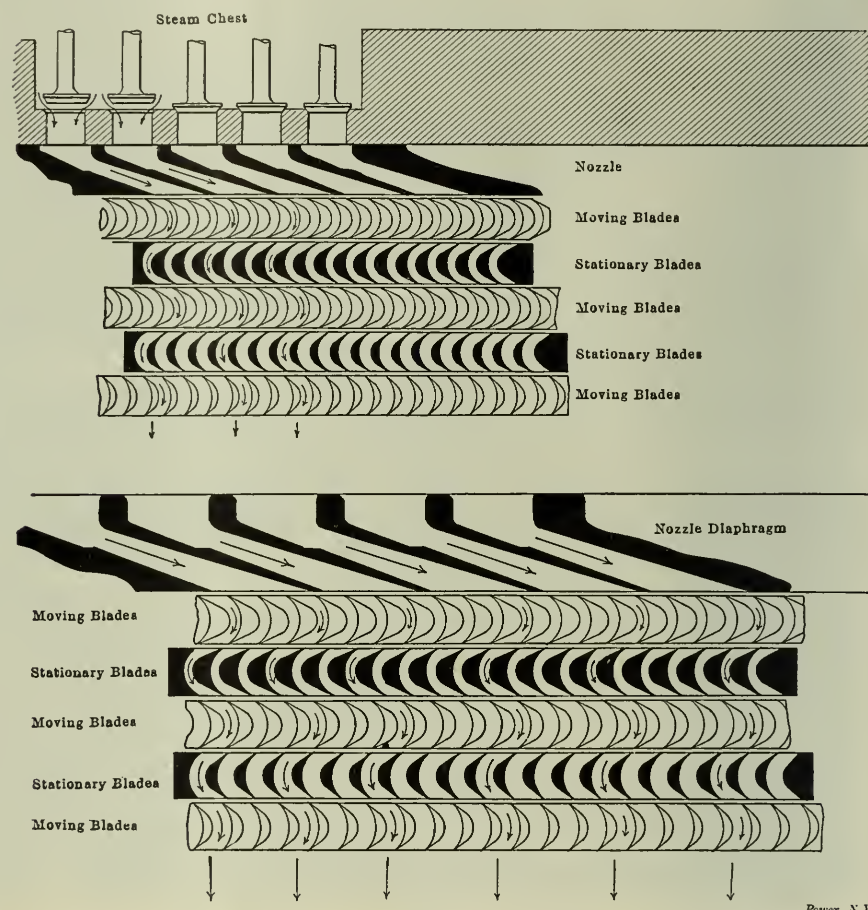
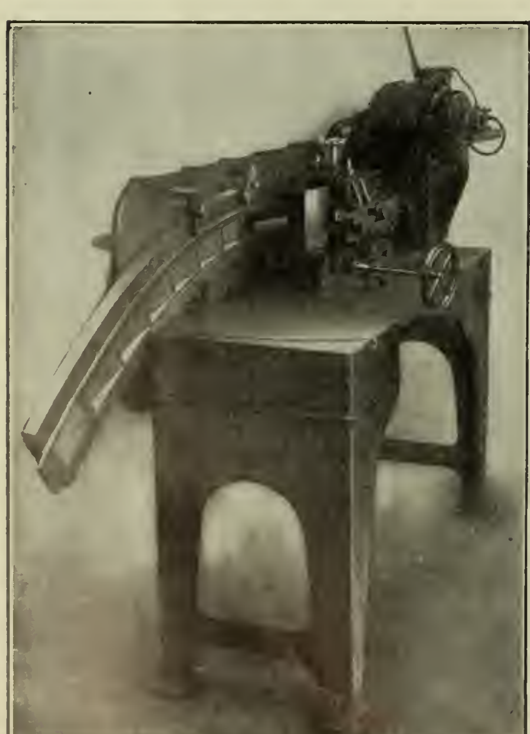


FIG. 5. DIAGRAM OF NOZZLES AND BUCKETS IN CURTIS STEAM TURBINE



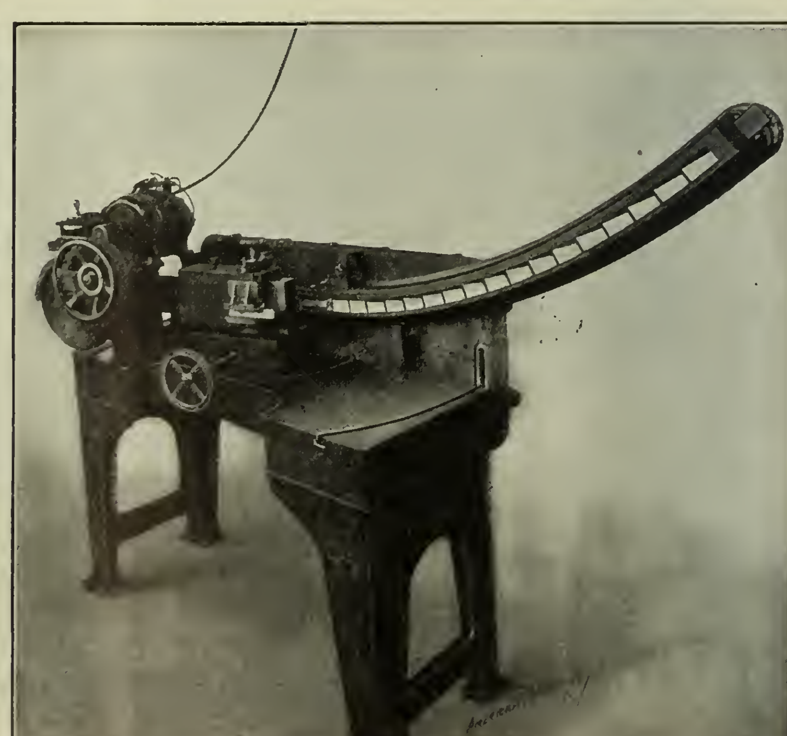


FIG. 6 TURBINE NOZZLE-PLANING MACHINE FIG. 7

FIG. 8. INTERIOR OF WHEEL

grooved for their reception, and secured by calking the material of the drum into grooves cut into their sides as shown in Fig. 11. The shroud, which consists of a plain strip of steel punched to receive the projections on the upper ends of the blade, is then riveted on as shown in Fig.

FIG. 10

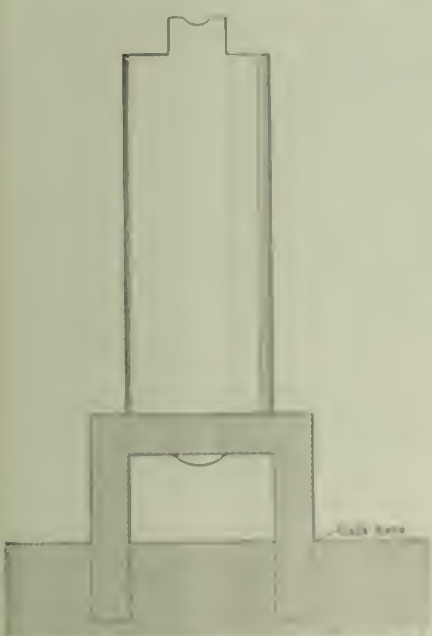


FIG. 11

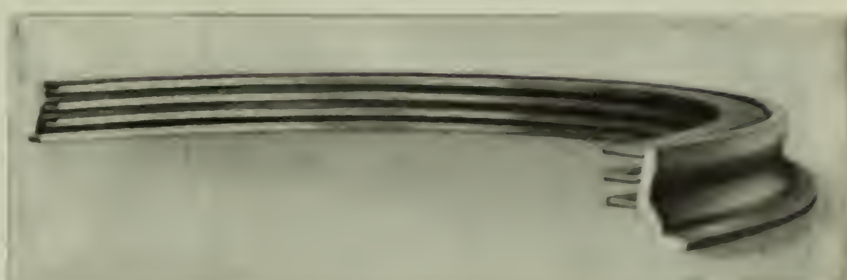


FIG. 9. STATIONARY REVERSING BLADES

by special milling machines, with regularly spaced holes into which the projections on the lower ends of the blades are set and riveted over as shown in Fig. 11. The fins of these channel bars are then slotted crosswise, as shown in Fig. 12, in the same way that a carpenter saws a molding which he wishes to bend, and the sections of blading are then cut to the radius of the drum, which is

FIG. 12. SECTIONS OF BLADING

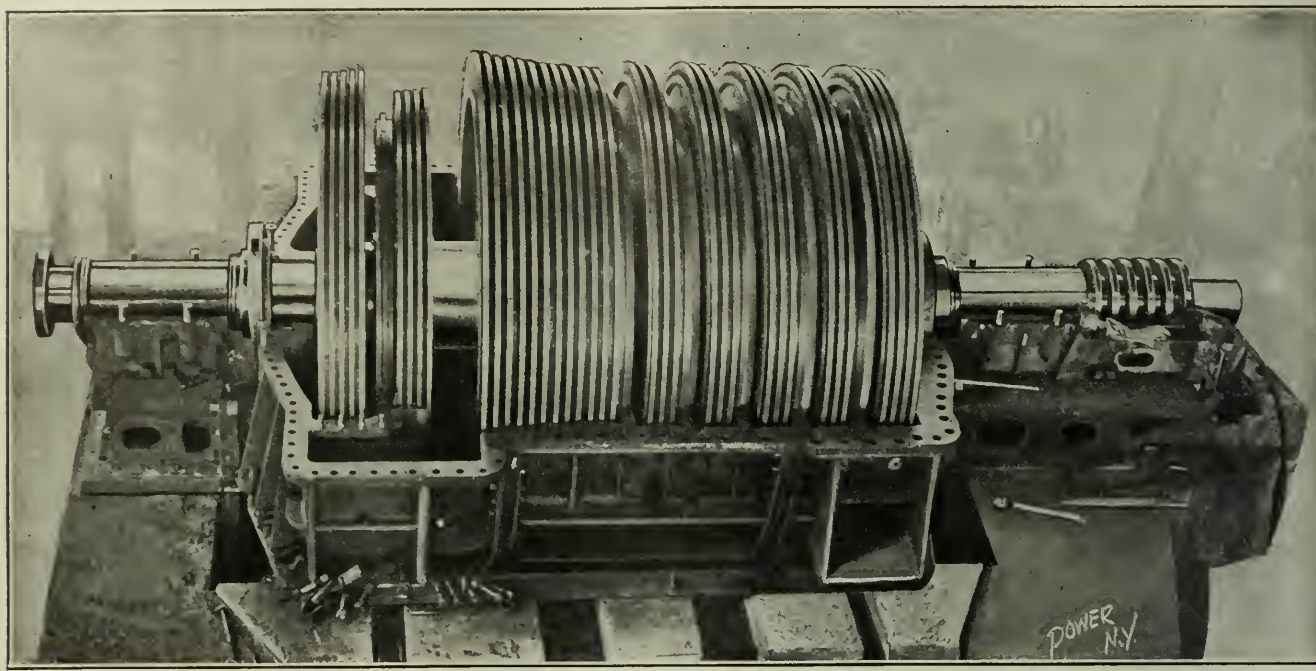


FIG. 13. ROTOR IN PLACE IN CASING

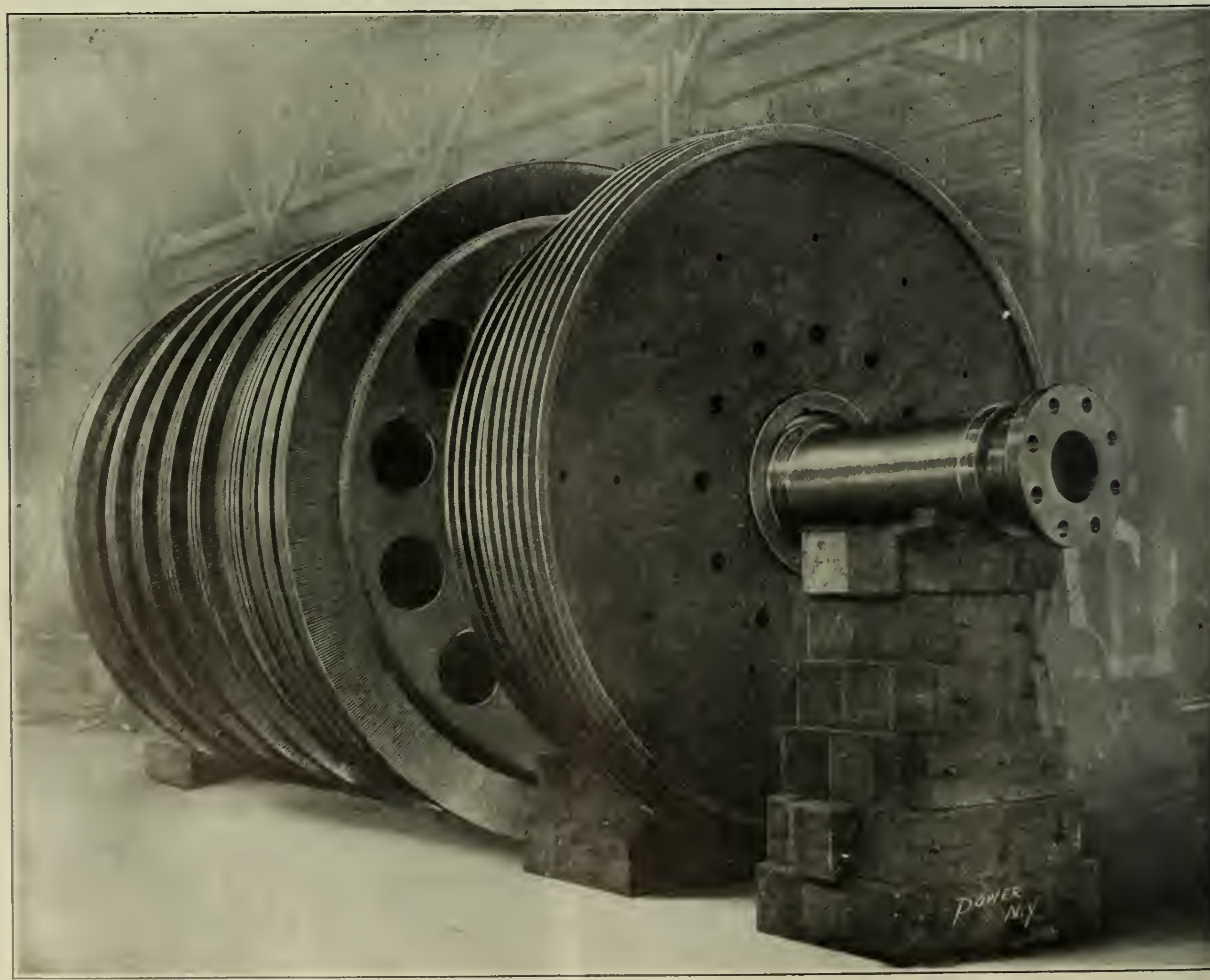


FIG. 14. ROTOR, SHOWING REVERSE WHEELS

15, where the first row is shown with the shrouding yet to be put on. The parts detached and assembled are shown in Fig. 12. Fig. 13 shows the rotor completely bladed and in position in the lower half of the casing. The first stage, with four rows of moving buckets, is at the right, then the four stages with three rows of blades each, then the drum with the 12 rows of the last four stages, and beyond these, at the extreme left, the reversing

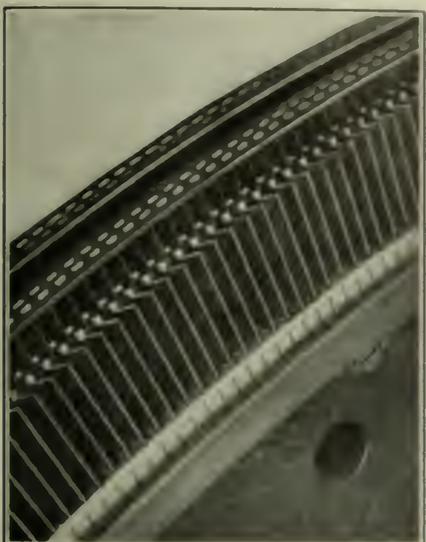


FIG. 15. SECTION OF WHEEL RIM AND BLADES

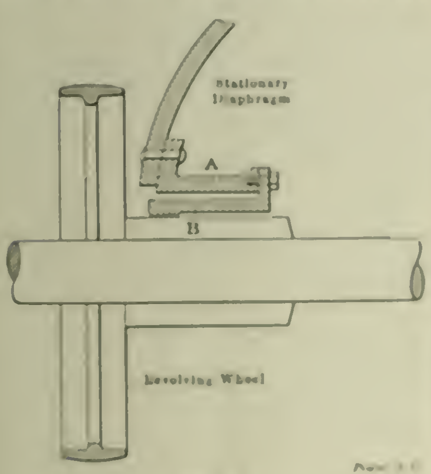


FIG. 16

elements. The inward projections of the casing between the wheels, which show plainly in this view, are grooved to receive the diaphragms as shown in Fig. 5.

The diaphragms are made of boiler steel varying from three-quarters of an inch in thickness at the first stage to three-eighths at the division between the fifth stage and the drum. These are riveted onto cast-steel rings mortised into the projections of the casing, as just mentioned, at their outer edges and to cast-steel rings surrounding the shaft and carrying the packing rings at their inner edges. The details of the packing rings are shown in Fig. 16. To the cast-steel block *A* bolted to the inner edge of the [illegible] diaphragm is bolted a bronze casting *B* carrying upon one end the rings of the labyrinth packing. Sufficient clearance is allowed between *A* and *B* to permit *B* to expand freely should the free end become heated from the contact of the rings. This construction has proved a complete remedy for interstage packing troubles.

Fig. 14 is a view of the rotor from the low-pressure end, the short blades of the [illegible] and those of the final row 10 inches in length. There are altogether about [illegible] moving buckets in the eleven stages, the rotor weight complete about [illegible] and the complete turbine without auxiliaries weight about [illegible] tons.

The concentric rings at the extreme right in Fig. 13 are those of the thrust bearing. Since the pressure is the same throughout the compartment of any one stage, there is no tendency of the rotor

FIG. 17. UPPER HALF OF EXHAUST END OF CASING

FIG. 18. LOWER HALF OF EXHAUST END OF CASING

high-pressure end of the revolving element being immediately in front, the long blades of the final wheel of the second section in the middle and the short blades of the initial stage at the far end. The wheels of the first five stages are [illegible] to the general line of [illegible] (see Fig. 20) and at the rated speed of [illegible] revolutions per minute have a velocity on the pitch line of [illegible] feet per second. The blades of the first row are [illegible] built into the base of the blades and [illegible] are incapable of keeping the [illegible]. As [illegible], they [illegible] from [illegible] of an inch in a [illegible] depending upon the proximity of the [illegible] blade holders, as shown in Fig. 1. The longitudinal clearance, the distance between the stationary and moving blades, must be kept within limits to prevent the dissipation of the energy of the jets in eddy currents, and at a wheel revolving submerged in a body of water and actuated by a water jet entering beneath the surface would have to be placed close to the entering jet to get the full benefit of its velocity before it was dissipated in stirring the other water. For this reason, the axial clearance is kept down to 1/10 of an inch on the first wheel and to ¼ of an inch on the last. The thrust block serves to maintain these clearances, and is properly placed at the high-pressure end where they are the smallest, allowing whatever movement may occur by differences of temperature or mechanical effects to take place in the wider spaces at the more distant blades.

Drain pipes connect each stage with the next so that the condensed steam in any stage will pass to the next one of lower pressure and there give up a part of its heat to useful work. The exhaust chamber drains to the condenser and the discharge is assisted by a small steam-operated ejector.

Where the shaft passes out through the ends of the casing, it is provided with carbon stuffing boxes which prevent steam leaking out at the head end or air leaking in at the back end where a vacuum exists. The rear stuffing boxes are supplied with boiler steam in the spaces between the carbon packing to prevent air leaking in and lowering the vacuum, and are drained to the fourth-stage compartment.

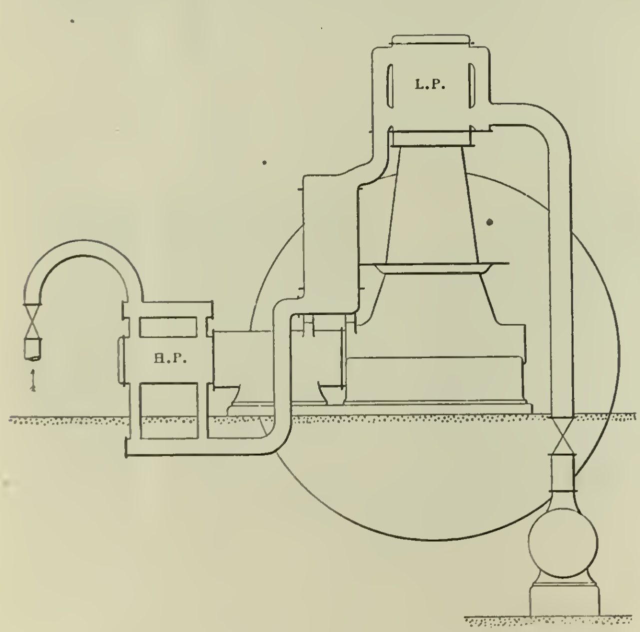
Fig. 17 is a view of the upper half of the exhaust end of the casing, showing in front the two rows of stationary blading *ee* in Fig. 2 and farther back the stationary blading for the reverse elements. The long straight flange on top is that of the discharge passage for the exhaust steam. Fig. 18 shows the lower half of the same section of the casing. Fig. 1 shows the starboard turbine assembled. The capped projections at *AA* are openings or peepholes into the several compartments. Through the sockets *BB* extend vertical rods or stanchions to guide the upper case when it is lifted from the lower.

Should the High or Low Pressure Cylinder be the Vertical in an Angle Compound?

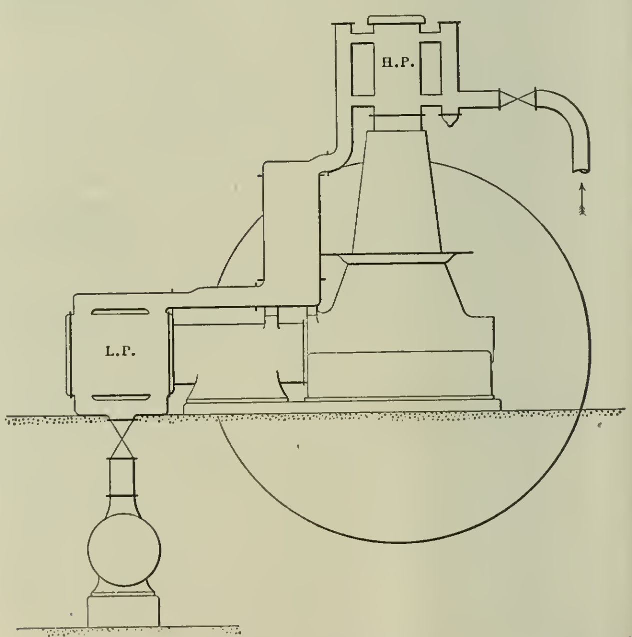
The Greenwich station of the London County Council Tramway has four angle-compound reciprocating engines of the Manhattan type, with the exception that instead of running the low-pressure cylinder vertically, as is done at the Manhattan station, and generally in America, the low-pressure cylinder is placed horizontally at the floor level, and the high-pressure cylinder run vertically in the elevated position. The leading thought in the American practice is to take the weight of the heavy low-pressure piston off of the cylinder. The engines, which were built by John Musgrave & Sons, Ltd., are mentioned by John Hall Rider in a paper upon the "Electrical System of the London County Council Tramways," recently presented before the Institution of Electrical Engineers, as of particular interest from the fact that they are the first of this angle-compound type to be installed in the United Kingdom.

The weight of the low-pressure piston is partially carried by a tail rod, and Mr. Rider gives the accompanying diagrams to show that the course of the steam and water, and, therefore, the drainage, is progressively downward in the case of the English engine, and upward, with the opportunity for forming pockets, in the case of the American engine. There is an advantage for the American engine besides the favorable position of the low-pressure piston, which these sketches do not show, and that is, that if the condenser is placed on the level of the low-pressure cylinder sufficient hight will be available to drop the water out of it through a barometric tube. The performance of these engines, which are coupled to 3500-kilowatt generators, is as follows:

	Full Load.	Half Load.
Duration of test	6 hours	3 hours
Average steam pressure at stop valves	180 lb.	181 lb.
Average steam temperature at stop valves	460° F.	446° F.
Average revolutions per minute	94.46	94.81
Mean total indicated horsepower	5,315	2,622.9
Mean total kilowatts	3,494	1,780
Total water from all sources	353,909 lb.	89,049 lb.
Average weight of water per hour	58,984 lb.	29,683 lb.
Water per indicated horsepower per hour	11.098 lb.	11.31 lb.
Water per kilowatt per hour	16.88 lb.	16.67 lb.
Vacuum	26.74 in.	26.8 in.



IMPERFECT DRAINAGE SYSTEM OF AMERICAN ENGINE



Power, N.Y.

NATURAL DRAINAGE OF RECIPROCATING ENGINE

The 5000-kilowatt Parsons turbines are guaranteed by Willans & Robinson, Ltd., their builder, to run on 15 pounds per kilowatt-hour, with steam at 180 pounds pressure, superheated to 550 degrees Fahrenheit and a 95 per cent. vacuum. No bonus is offered for better results than this, but a penalty will be incurred if the results are worse. The British Westinghouse Company is to furnish two Rateau turbines of the same capacity.

Large Gas Engines for Electric Stations*

Relative Merits of Internal- and External-Combustion Engines; Comparison of the Costs of Generating Power under Conditions Assumed

BY L. ANDREWS AND R. PORTER

Hitherto the use of large gas engines has been chiefly confined to iron and steel works, where they are run on blast-furnace and other waste gases for driving blowing engines and generating electric power, which is used for rolling mills, etc., in the works, the surplus power being sold at a very low rate for municipal lighting and tramway loads, and for industrial works in the neighborhood.

In Germany the manufacture of large gas engines is an established industry on a large scale. Even in 1900 out of 49 smelting works 41 had either installed gas engines or had placed orders for them, the engines actually installed at that time aggregating over 295,000 horsepower. While there have been a few blast-furnace gas-engine installations working in this country for some years, the engines used have been mainly limited to capacities of from 300 to 500 brake horsepower.

The use of large gas engines for driving electric generators is a subject that is also receiving considerable attention in the United States. A few months ago the National Electric Light Association appointed a special committee to report on the use of large gas engines for driving electric generators, and the report was presented to the association at its convention held in Chicago last May. [This report was abstracted in POWER AND THE ENGINEER for June 9, 1908.—EDITOR.]

While the authors believe that there is an important field for the use of large gas engines for driving electric generators, they do not consider that there is at present justification for the suggestion that has been made that the internal-combustion engine will, in the early future, be used to the exclusion of the external-combustion engine.

The situation, as far as present knowledge goes, may be briefly summarized as follows:

The internal-combustion engine is very much more economical than any external-combustion engine yet known.

The capital cost of a gas engine and producer installation is greater than that of a steam turbine and boiler installation of equivalent maximum capacity.

There is no material difference in the reliability nor in the cost of labor, stores and repairs of the respective systems.

In cases, therefore, where the cost of fuel is low, and the load factor is low, it will generally be a mistake to use gas engines.

On the other hand, where the load factor is high or the cost of fuel is high, there can be no doubt that gas engines will prove to be by far the cheapest prime movers to employ for driving electric generators.

The majority of cases to be dealt with will doubtless fall between these two extremes, and engineers responsible for the design of future power houses will have many points to consider before definitely deciding whether the prime movers for the electric generators shall be steam- or gas-driven, or a combination of the two. As the conditions which go to determine whether gas engines should or should not be used are in most cases so widely

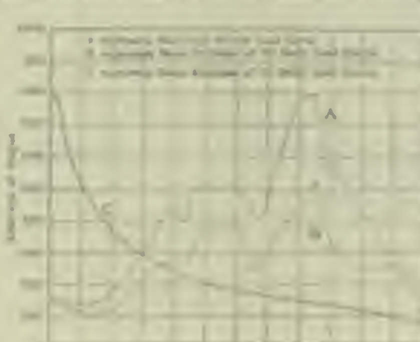


FIG. 1

different from the conditions under which experience has, up to the present, been obtained, it is extremely difficult for engineers to utilize the available knowledge upon the subject to the best advantage. We have, therefore, endeavored to collect facts from a large number of different sources, and to apply the information obtained to one or two hypothetical electric-supply stations as nearly comparable as possible with some of the existing supply stations in different parts of the country. For comparative purposes we have endeavored to show what would be the respective total cost of generating power by steam turbines and by gas-driven generators under the assumed conditions specified.

For the first scheme to be considered we have assumed that the maximum continuous load to be dealt with shall be 8000 kilowatts.

That the nominal and standby capacity of the plant shall be such as to carry the maximum load of 8000 kilowatts for at least two hours, should any portion of the plant break down at the time when one unit is already laid off for overhaul.

That the power generated is utilized for public and private lighting, and that for a tramway and general industrial motor load the load factor is 25 per cent. and the efficiency of distribution

$$\left(\frac{\text{energy sold to users}}{\text{energy generated}} \right)$$

equals 80 per cent., and that the usual daily load curve is approximately of the shape shown in Fig. 1.

That the cost of good bituminous slack, having a calorific value of 13,000 B.t.u. per pound, is 10 shillings per ton delivered at the generating station.

CHOICE OF SITE

The points to be considered in selecting a site for a gas-driven station are practically the same as for a steam-driven station, viz.: (a) A plentiful supply of water for cooling purposes. (b) Transport of fuel. (c) Suitability of site relatively to position of center of distributing area, as affecting cost of feeders. (d) Liability of nuisance to adjoining property. (e) Cheapness of land. (f) Cost of constructing foundations for plant, buildings and chimneys.

In choosing a site for a steam-turbine station it is often good policy to sacrifice other advantages in order to get a site with a plentiful supply of cold water for condensing purposes. This advantage has usually, however, to be heavily paid for. As the latitude in the choice of a site is very limited, the cost of land will probably be very much greater. The cost of foundations will also generally be greater, added to which the right of using the water will generally have to be paid for; and, finally, it is more than probable that the site available will not be a good one from the point of view which American engineers term "the electrical center of gravity"—that is to say, the cost of feeders will probably be much greater than if a more central position were selected. It is consequently often very much cheaper, on the whole, to install cooling towers for condensing purposes. Inasmuch as it is impossible to estimate the cost of obtaining a site with a plentiful water supply, as this will vary largely in every case, we have based our comparisons upon the assumption that cooling towers will be

*Abstract of a paper read before the Manchester Section of the Institution of Electrical Engineers of Great Britain.

used in conjunction with a public water supply.

We assume that a convenient piece of land has been secured, bounded on one side by a railway track and on the other side by a roadway, the width of the land being 325 feet, and the length being ample to allow for all probable future extensions. A convenient layout for the steam plant will be that shown in Figs. 2 and 3. Figs. 4 and 5 show a corresponding layout for the gas plant. (We have shown natural-draft cooling of the usual dimensions in Figs. 2 and 4, but since these plans were made we have been advised by the Midland Engineering Company that its Zylberlast cooling towers occupy only two-thirds of the space shown for the same capacity. If, therefore, these towers were used, the space occupied by the cooling towers for both steam and gas plants would be reduced by this extent.) Either layout provides ample yard-space room for cables, stores, etc., without encroaching on the ground available for future extensions.

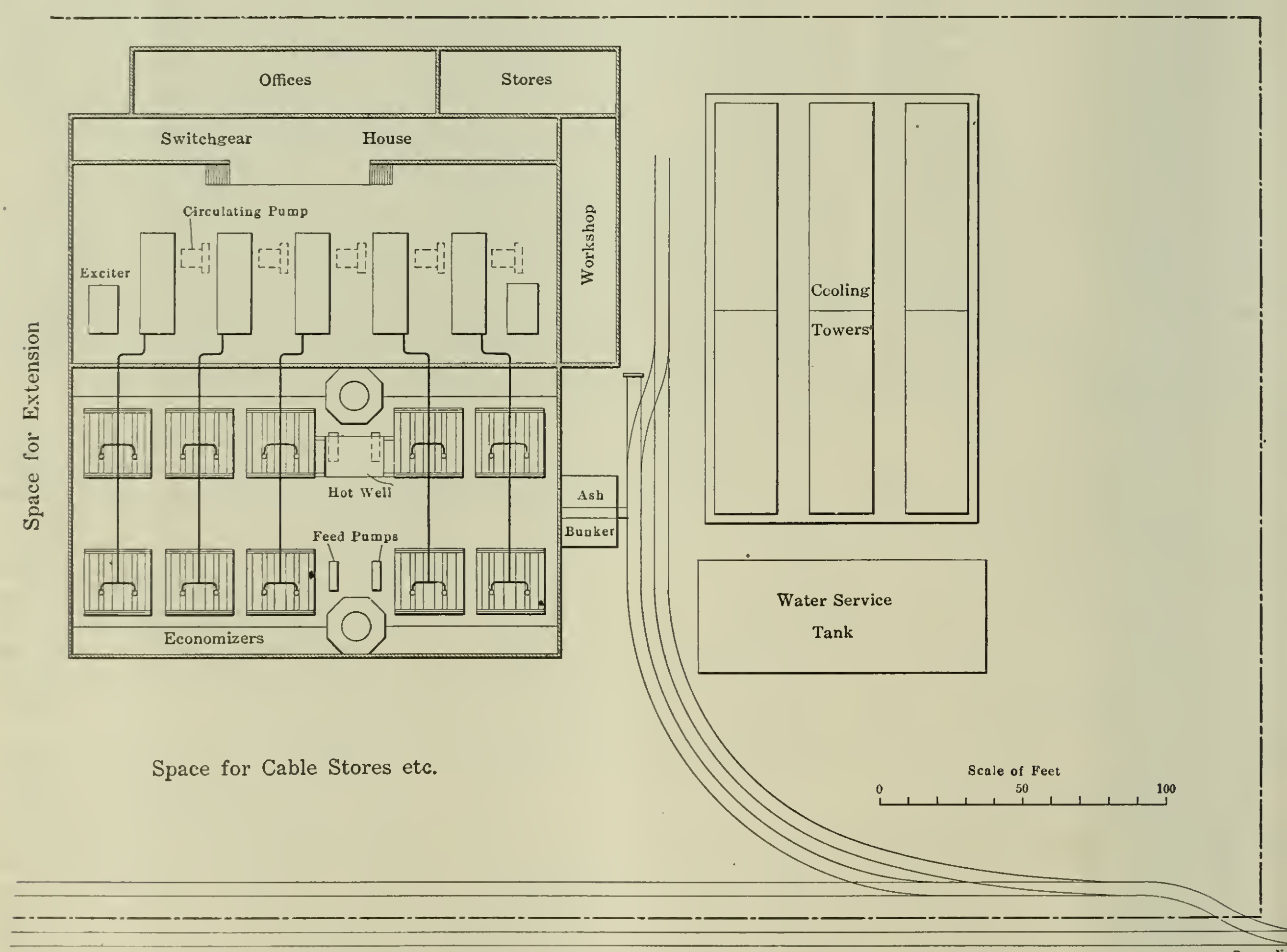


FIG. 2. PLAN OF 10,000-KILOWATT STEAM PLANT

Type of Generating Plant

For the steam plant we have assumed steam turbines of the horizontal type direct-coupled to three-phase generators and each turbine exhausting into a separate contraflow surface condenser placed directly below the turbines; that the cooling water would be obtained from a town supply and circulated by electrically driven centrifugal pumps through natural-draft cooling towers, a separate pump being installed for each unit.

For the gas plant we have assumed engines of the slow-speed double-acting tandem type, working on the four-stroke cycle and direct-coupled to three-phase generators; the flywheel to overhang. The cooling water for the engines, as in the case of the steam plant, would be obtained from a town supply and circulated by means of small piston pumps driven from the engine shafts, the water being cooled in natural-draft cooling towers.

Capacity of Generator Units

Experience has shown that large units in steam plants are considerably more economical, both in first cost and running cost, than smaller units, and as they can at present be obtained in much larger sizes than gas engines, they have, in some cases, a considerable advantage in this respect. For a maximum output of 8000 kilowatts, it appears that the most economical arrangement would be five units, each having a normal capacity of 2000 kilowatts, with an overload capacity for two hours of 33⅓ per cent. In the event of two units being laid off simultaneously, the remaining three would then be capable of supplying the maximum demand for a period of two hours as specified.

The output of gas-engine units is, at present, limited to about 1500 brake horsepower per cylinder, this being the largest size that has yet been made. The arguments against the use of very large steam units for the hypothetical case under consideration also apply to gas units. In fact, for the gas scheme it does not appear to be advisable to use even such large units as 2000 kilowatts because the overload capacity of gas engines is only 10 or 12 per cent., and consequently three 2000-kilowatt plants would be able to deal only with a maximum demand of from 6600 to 6700 kilowatts; six units of this capacity would, therefore, be required to deal with the specified maximum demand and provision for standby. A more economical installation would be seven units each having a normal capacity of 1450 kilowatts and a maximum capacity of 1600 kilowatts. With such an installation if two generators were laid off simultaneously the remaining generators would be able to deal with the full maximum demand of 8000 kilowatts for two hours, as specified.

In Fig. 6 are presented curves showing the approximate capital cost of engines and generators erected complete with pipework, foundations and flywheels necessary for the above-specified cyclic regularity for both single and twin tandem engines of outputs varying from 500 to 5000 brake horsepower. A curve is also plotted showing the corresponding capital charges for an equivalent output generated by a number of 500-horsepower units in parallel. These curves show that the capital cost of a twin tandem unit is appreciably higher than a single tandem unit of the same output. The cost of fuel, oil and repairs will be slightly higher for the twin tandem combination, though not appreciably so. The cost of driver's wages for the twin tandem will be practically double that of the single tandem set, as experience has shown that one engine driver is required for each line of engines, whatever the output of the engine. These remarks apply to cases where the total maximum demand is insufficient to justify the use of larger units than can be obtained in single tandem sets, as in the assumed case. From the foregoing, it appears that for the conditions under discussion a single tandem engine is the best type.

Boilers for Steam Plant

We have assumed that boilers of the water-tube type would be used for the steam plant, fitted with self-contained superheaters and automatic stokers, and that these boilers would be grouped into units corresponding to the output of the turbo-generators, the normal capacity of each battery of boilers being equal to that of the normal output of its turbo-generator. In calculating the boiler capacity we have assumed that the steam consumption of the turbines under working conditions including the steam for feed pumps and exciters, would be 20 pounds per kilowatt-hour generated. We have, therefore, provided for four 10,000-pound boilers for each 2000-kilowatt turbine. In order to keep the boiler house about the same length as the engine room we have provided two rows of ten boilers, grouped in five batteries of four boilers. An economizer is provided for each boiler.

Producers

From inquiries made in Germany and the United States, it would appear that large producers for gasifying bituminous coal have not been entirely satisfactory in either of these countries. This is, perhaps, partly accounted for by the fact that the class of coal available in both these countries contains a far greater percentage of ash and is much more liable to clinker than the bituminous coal available here. Whatever the cause may be, the fact remains that there are numbers of bituminous producer installations in this country working satisfactorily in conjunction with large gas engines. One firm of English producer makers alone has in service plants supplying gas to large engines having an aggregate output of over 50,000 brake horsepower. From information obtained from users it appears that these producers are giving entire satisfaction. Difficulties were experienced in the early days in the removal of tar, dust and other impurities, but the efficient cleaning appliances now included in every properly constructed producer plant appear to have either eliminated these difficulties or reduced them to such an extent that the percentage of impurities carried into the engine with the gas has no deleterious effect.

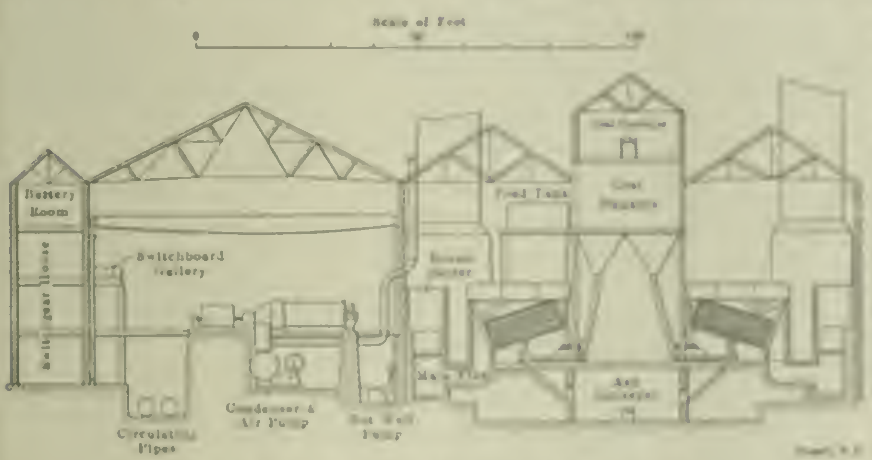


FIG. 3. ELEVATION OF 10,000-KILOWATT STEAM PLANT

Difficulties arising from variations in the quality of the gas caused by charging or clinkering the producers practically disappear when a number of producers are connected together to feed into a common main or common [illegible] the gases from the various producers are mixed together, and the effect of any variation in the quality of the gas from individual producers is thereby neutralized. To derive the full benefit of this feature the producer plant should not be divided into units corresponding to the generator units, as has been recommended for steam boilers.

Ammonia Recovery

A very important point to be considered in designing a gas-engine station is that of providing for the recovery of sulphate of ammonia. There are numbers of recovery plants that have been working for some years, where the sale of the by-product has almost equalled the cost of the fuel used. Results obtained have been so entirely satisfactory that one is at first sight tempted to think it would pay to provide for sulphate of ammonia recovery in every instance. There are, however, many expenses incidental to the recovery of sulphate of ammonia in addition to the fuel.

The following points must be taken into consideration as affecting the use of ammonia-recovery plants: (1) The first cost of the recovery plant, particularly for small sizes, is very much greater than the first cost of nonrecovery plant. (2) Considerable extra labor is involved in operating the plant. (3) The purchase of sulphuric acid, of which approximately [illegible] ton is required for every ton of sulphate of ammonia turned out, is quite a heavy item. (4) The yield of heat units per ton of coal is slightly less if sulphate of ammonia is recovered than the yield from nonrecovery plants. (5) The extra cost of repairs and the cost of handling and packing the by-product absorbed some of the profits obtained by the recovery process.

Experience up to the present appears to indicate that it is not worth while to attempt to recover sulphate of ammonia unless the total output of the plant is greater than 3000 horsepower, and then only at an exceedingly good load factor. For a maximum output of 8000 kilowatts it would probably pay to install an ammonia-recovery plant, even for so poor a load factor as in this case. An even more profitable arrangement, however, would be to provide for ammonia recovery on one portion of the plant, which could be kept working at a very high load factor almost continuously, and to use nonrecovery equipment for dealing with the peak load and remaining portion of the total output. For the particular conditions now under discussion the Power Gas Corporation, to which we are indebted for this suggestion, recommends the use of eight producers, of which only [illegible] would be arranged for ammonia recovery.

Coal Handling and Storage

For both the steam and gas plants we have assumed that coal bunkers will be provided capable of carrying a fortnight's consumption of fuel under maximum load conditions. In the case of the steam plant we have assumed that the coal bunkers would be placed over the firing floor of the boilers. These bunkers would have a capacity of 1500 tons. In the case of the gas plant the coal would be stored in bunkers placed on the ground at the back of, and parallel with, the producers. It would be unloaded by hand from the railway trucks on the elevated siding at the back of the bunkers, from which it would gravitate into the coal-conveyer buckets and be hoisted by these into the hoppers over the producers. These hoppers would be of sufficient capacity to carry 24 hours' supply under mean load conditions. The ashes raked out from below the producers would also be lifted by the same conveyer into the ash hopper provided for the purpose. A sectional elevation of one of the producers with the coal- and ash-handling arrangements used is shown in Fig. 7.

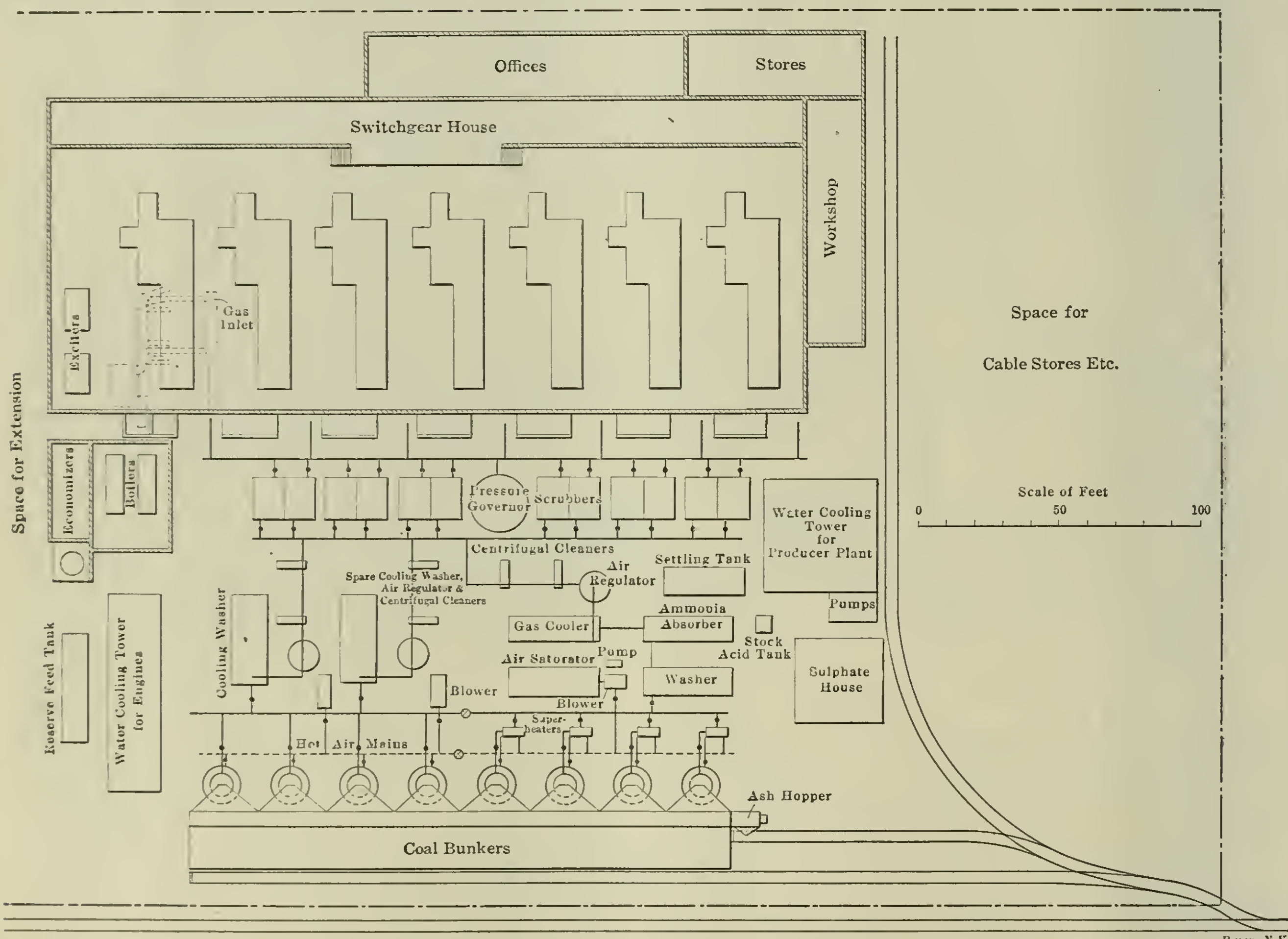


FIG. 4. PLAN OF 10,000-KILOWATT GAS PLANT

Building and Foundations

The cost of the engine room and engine foundations for the gas-driven plant is, of course, considerably greater than that of the steam plant, but no building is required for the producers (beyond small boiler and sulphate houses) and the cost of the foundations for the producers is very small compared with the cost of boiler foundations, flues, chimneys, etc. The total cost of buildings amounts to considerably less, therefore, for the gas station than for the steam station. We have based our estimate of the cost of buildings for the gas-driven plant upon tenders actually received. The price covers a substantial steel-frame building with brick walls, lined internally with a glazed brick dado 6 feet high and with tiled engine-room floor. We have included suitable store, workshop and office accommodation in each case.

Exciting Plant, Switch Gear, Etc.

We have assumed that for both the steam plant and the gas plant the field circuits of the generators would be excited from busbars fed by two steam-driven exciters, each capable of generating the whole of the exciting current required on full load. The exciters would be supplemented by a battery capable of maintaining the full field current required for a period of 24 hours.

In the case of the gas plant the steam for the exciters would be furnished by one of the small coal- or tar-fired boilers installed for this purpose. The exhaust steam from the exciter engines would be used in the producers, any additional steam required by the latter being raised by boilers heated by the exhaust gases from the main engines.

The switch gear would be of the remote-control type, the oil-break switches being placed in a switch room running the length of the engine room.

The capital cost of the switch gear for the gas plant will be somewhat higher than for the steam plant, as two additional generator panels and connections will be required.

Capital Outlay

The total capital cost of the respective steam and gas plants for the specified maximum load of 8000 kilowatts will, we estimate, be as stated in Table 1.

TABLE 1. COST OF GENERATING STATIONS.

STEAM PLANT.

5 2000-kilowatt turbo-generators, erected complete	£39,500
5 surface condensers with air and circulating pumps	9,875
Circulating pipes	1,200
Cooling towers erected complete	6,900
20 water-tube boilers erected complete with mechanical stokers, economizers, superheaters, feed pumps, water-service tank and feed tank, water-softening plant and all pipe work	31,300
Buildings with engine and boiler foundations, 2 chimneys and flues	33,600
Overhead traveling crane	1,000
Steel structural work, coal bunkers, coal and ash conveying plant	8,900
Exciters, battery, switch gear and connections to generator	7,250
	£139,525

Or £13.952 per kilowatt installed.

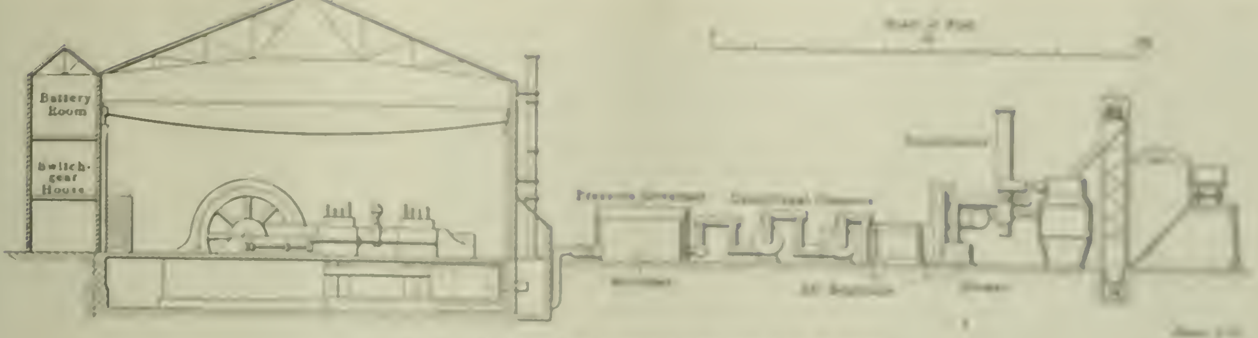


FIG. 5. ELEVATION OF [illegible]-KILOWATT GAS PLANT

Gas Plant

7 1450-kilowatt gas engines, generators, air compressors, gas, water, air and exhaust pipes and all auxiliaries erected complete	£ [illegible]
4 ammonia-recovery producers, erected complete with superheaters, blowers, cooling and washing towers, centrifugal cleaners, scrubbers, ammonia absorber and all pipe work	18,400
Duplicate blower, washer and centrifugal cleaners	3,780
4 non-recovery producers with necessary scrubbers, etc.	10,340
Steam-raising plant, economizers, feed pumps, etc.	4,850
Water-cooling towers, pumps and water softener	1,[illegible]
Buildings and foundations, etc.	24,271
Overhead traveling crane	1,250
Steel structural work, coal bunkers, coal and ash conveying plant	6,1[illegible]
Exciters, battery, switch gear and connections to generators	7,750
	£176,871

Or £17.087 per kilowatt installed.

Running Cost

The fuel consumption of a gas plant, as of a steam plant, is dependent upon at least four important factors: The actual output; the no-load losses, which include friction, windage and electrical losses incurred in running the generator on open circuit, together with all power required for exciters, pumps, and other auxiliaries; the standby losses of boilers or producers, and the ratio of the actual ascertained fuel consumption under day by day working conditions to the theoretical consumption based upon the test results, which we will term the "discrepancy factor."

The steam- and fuel-consumption curves shown in Fig. 8 have been plotted from a number of published tests of steam turbines and gas engines of different sizes. The ordinates above the zero line represent the steam and fuel utilized for the actual generation of electric power and those below indicate the fuel required per hour to run the generators at full voltage on open circuit. The former are approximately proportional to the units generated and are practically independent of the hours the plant is run, whereas the latter are approximately directly proportional to the hours the plant is run and are not appreciably affected by the units generated. It will be noted that the slope of the "consumption per unit generated" curves of steam turbines gradually decreases as the output of the plant is increased, whereas the corresponding curve of gas-driven generators is constant for all outputs. Various tests on gas engines of outputs ranging from [illegible] to [illegible] brake horsepower show that the actual consumption of fuel per unit generated exclusive of no-load losses is approximately 1 pound per kilowatt-hour for any output from no load to full load.

The [illegible]-kilowatt steam turbine curve is plotted from the recently published tests of a [illegible]-kilowatt turbo-generator at Manchester. The total steam consumption at full load was [illegible] pounds, or [illegible] pounds per kilowatt-hour generated exclusive of steam for exciter and auxiliaries. The characteristic of the steam-consumption curve at lighter loads appears to indicate that the no-load consumption of the plant would be approximately [illegible] pounds of steam per hour. We have, therefore, plotted the no-load consumption of [illegible] pounds below the zero line, and the balance of [illegible] above the zero line, which gives a steam consumption per actual kilowatt-hour generated of 13.4 pounds. To the no-load ordinates below the zero line we have added the estimated steam consumption of exciters, air and circulating pumps, feed pumps and all other auxiliaries, which are taken at [illegible] per cent. of the total full-load steam consumption, and from this second curve we are able to ascertain the no-load losses of any size of plant. The corresponding curve showing the no-load losses of gas engines with all auxiliaries is also plotted below the zero line.

The standby loss, through radiation of heat from boilers and steam pipes, and by leakage of cold air through the brickwork of boilers, is a very heavy item in all steam-driven electric-generating

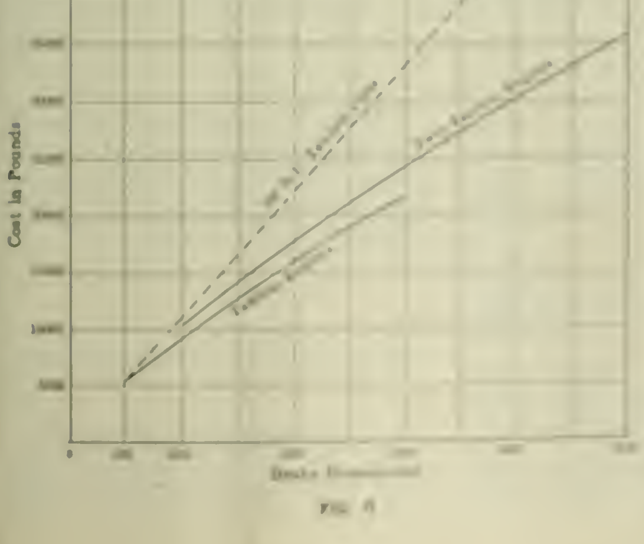


FIG. 6

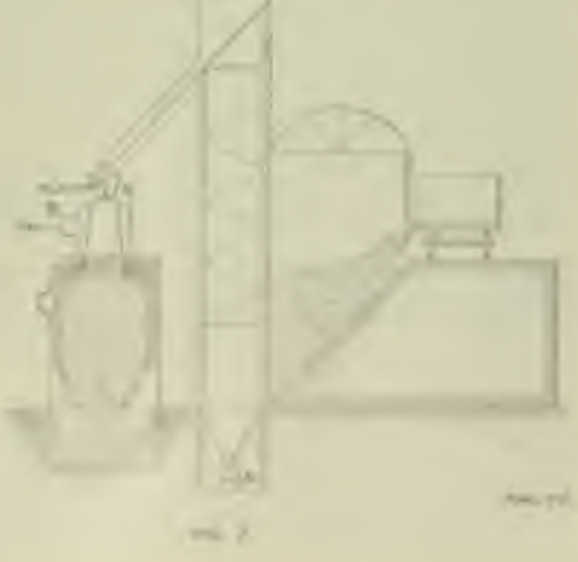


FIG. 7

stations, as the conditions of load are generally such that the majority of the boilers are banked for many hours every day. Collings Bishop, of Newport, found that two boilers, each rated for an evaporation of 10,000 pounds per hour, require 224 pounds of coal per hour for banking = 11.2 pounds of coal per hour per 1000 pounds of steam. As four such boilers are required for each 2000-kilowatt unit in connection with the steam-turbine station on which we have based our calculations, the coal for banking these boilers will be at least 448 pounds per hour per plant unit.

The fuel required for banking producers is only a small fraction of that required for banking boilers. The standby losses of the producers for the scheme under consideration are guaranteed not to exceed 50 pounds per hour per producer.

Discrepancy Factor

It is difficult if not impossible to keep this factor within reasonable limits, by reason of variations in the quality of the fuel supplied; fuel utilized in heating up cold boilers; the gradual fouling of boiler tubes, condenser tubes, etc., between cleaning periods; errors of judgment as to the correct time for running up and shutting down plant units, and other seemingly small details. For both the steam plant and the gas plant we have added 25 per cent. to the ascertained fuel consumption under test conditions to cover this factor.

For a maximum demand of 8000 kilowatts a load factor of 24 per cent. and a distribution efficiency of 80 per cent., the kilowatt-hours generated per annum will be 21,000,000. From Fig. 8, the steam consumption of a 2000-kilowatt turbo-alternator per kilowatt-hour is 15.5 pounds, or, assuming an evaporation of 8 to 1, 1.94 pounds of coal. The chart also shows that the no-load consumption for a plant of this size amounts to 900 pounds per hour.

Fig. 9 indicates the average hours the respective plant units would be required each day to deal with the assumed load curve. The minimum total engine hours would be 35 hours per day, or 12,800 hours per annum, and the banked boiler hours would be 45 hours per day, or 16,800 hours per annum. The total annual coal consumption for the steam turbines will therefore be as follows:

	Tons.
21,000,000 kilowatt-hours at 1.94 pounds	18,170
12,800 engine hours at 900 pounds	5,140
16,800 banked boiler hours at 448 pounds	3,330
	26,640
Discrepancy factor (1.25)	1.25
Total	33,300

= 3.55 pounds per kilowatt-hour generated.
Overall thermodynamic efficiency = 7.4 per cent.

For the gas station, Fig. 8 shows that the no-load consumption of a 1500-kilowatt gas plant amount to 800 pounds of coal per hour, and the useful output consumption to 1 pound per kilowatt-hour generated. Fig. 10 shows the minimum average engine hours per day for the gas plant and the average hours per day the producers would be banked. It appears from this that the total engine hours would be 17,450 hours per annum, and banked producer hours would be 35,000 hours per annum. The total coal consumption for the gas plant will therefore be as follows:

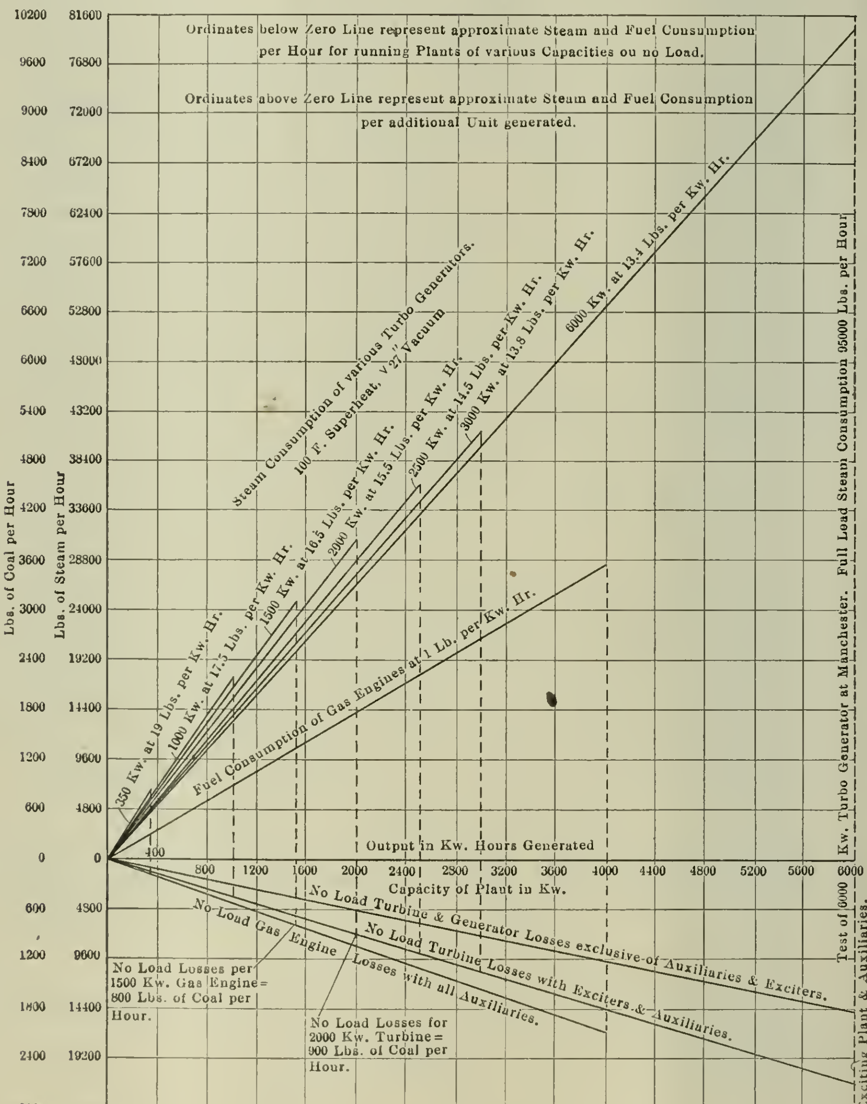


FIG. 8

	Tons.
21,000,000 kilowatt-hours at 1 pound of coal	9,360
17,450 engine hours at 800 pounds	6,230
35,000 banked producer hours at 50 pounds	782
	16,372
Discrepancy factor (1.25)	1.25
Total	20,465

= 2.18 pounds per kilowatt-hour generated.
Overall thermodynamic efficiency = 12 per cent.*

*Since these estimates were prepared, we have obtained actual fuel consumption results, taken over a considerable period, at a number of modern steam and gas installations, which show an actual average thermal efficiency for the steam stations of 6.7 per cent., or 10 per cent. less than our estimate based on theoretical conclusions; whereas the actual gas installations show a mean efficiency of 13.9 per cent., or 10 per cent. greater than our estimate (see table 3).

It is estimated that approximately 71 per cent. or 14,580 tons of the total coal consumption would be gasified in the ammonia producers and would yield at least 586 tons of sulphate of ammonia. Estimating the value of this at £11 per ton, which is considerably less than its present market value, the sale of this by-product would yield £6446 per annum. One ton of sulphuric acid, costing 30s. per ton, is required for each ton of sulphate of ammonia, and the cost of bags for packing the ammonia is estimated at 1s. 6d. per ton. The cost of acid and bags will therefore be £922, reducing the total amount to be credited on account of sale of sulphate of ammonia to £5524.

Oil, Waste and Stores

The cost of oil for the steam-turbine plant is estimated at 0.003d. per kilowatt-hour generated. This figure, which, it is thought, is considerably below the average oil consumption in steam-turbine generating stations, is based upon a figure given in the paper by Parsons, Stoney and Martin on "Steam Turbines." The oil consumption for large gas-driven generators is stated, by different authorities, to be from 0.2 to 0.37 gallon per 1000 horsepower-hours, the average cost of the oil used being 1s. 6d. per gallon. Taking the higher figure, the oil consumption per plant unit will be 0.74 gallon per hour, costing £970 per annum. The cost of the oil for the auxiliaries is estimated at £200 per annum. Total £1170 per annum.

The cost of waste and engine-room stores is estimated at 0.002d. per kilowatt-hour generated for both the steam plant and for the gas plant, thus bringing the total cost of oil, waste and stores to £438 for the steam plant, or 0.005d. per unit, and to £1345 for the gas plant, or 0.0154d. per unit.*

Water

Each steam unit requires 288,000 gallons of condensing water per hour, of which it is estimated 3 per cent. will be evaporated from the cooling towers. The water evaporation will therefore be 8640 gallons per hour × 12,800 engine hours = 110,500 thousand gallons per annum; at 6d. per thousand gallons, this will cost £2760 per annum.

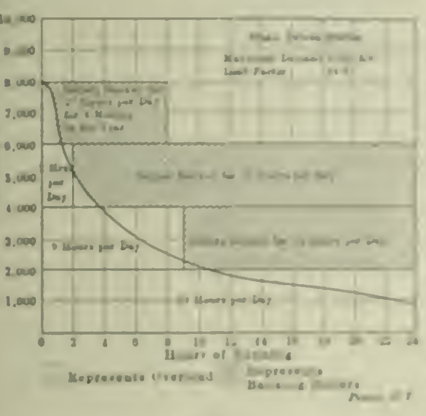


FIG. 13

The cooling water required for the gas engines would be about 12 gallons per kilowatt-hour of output; each 1500-kilowatt plant will therefore require 18,000 gallons per hour. Again assuming an evaporation of 3 per cent., the water evaporated from the engine cooling towers will be 540 gallons per engine hour × 17,450 engine hours = 9420 thousand gallons per annum. The water consumption for the producers is estimated at [illegible] gallons per day = 14,700 thousand gallons per annum. The total water for the gas plant will therefore be [illegible] thousand gallons at 6d. per 1000 = £[illegible].

Labor

The labor charges are estimated as follows:

Steam Plant

	£	s.	d.
2 operating engineers at £5 per week	[illegible]	[illegible]	[illegible]
2 switchboard attendants at 40s. per week	[illegible]	[illegible]	[illegible]
4 assistant engineers at [illegible] per week	[illegible]	[illegible]	[illegible]
4 oilers and cleaners at 25s. per week	[illegible]	[illegible]	[illegible]
2 firemen at [illegible] per week	[illegible]	[illegible]	[illegible]
8 "boiler" house and auxiliary plant staffs (including labor for cleaning boilers) at 30s. per week	[illegible]	[illegible]	[illegible]
4 men for unloading coal and removing ashes at 28s. per week	[illegible]	[illegible]	[illegible]
Total labor charges per annum			£[illegible]

Gas Plant

	£	s.	d.
2 operating engineers at £5 per week	[illegible]	[illegible]	[illegible]
2 switchboard attendants at 40s. per week	[illegible]	[illegible]	[illegible]
8 assistant engineers at 35s. per week	[illegible]	[illegible]	[illegible]
[illegible] assistant engineers at 30s. per week	[illegible]	[illegible]	[illegible]
[illegible] oilers and cleaners at 25s. per week	[illegible]	[illegible]	[illegible]
[illegible] producer hands at 35s. per week	[illegible]	[illegible]	[illegible]
8 producer hands at 28s. per week	[illegible]	[illegible]	[illegible]
7 ammonia recovery hands at 30s. per week	[illegible]	[illegible]	[illegible]
[illegible] men for unloading coal and [illegible]			
[illegible] at [illegible] per week	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]

Total labor charges per annum, £[illegible]

Maintenance and Repairs

This is the most difficult item to estimate with any degree of accuracy for either the steam or gas plant. With steam turbines the principal risk appears to be that of the blades stripping. With large gas engines the most serious risk is that of the fracture of the piston or of the cylinder liners. Troubles of this nature, while somewhat frequent in some of the earlier gas engines, owing to makers not having had experience to enable them to design these parts as to reduce the expansion and contraction under wide ranges of temperature to a minimum, are, however, fast disappearing.

As far as the actual wear and tear of the moving parts is concerned, this will probably be smaller in a gas engine than in a steam turbine. Practically the whole of the weight of the pistons and piston rods is carried on guides external to the engine cylinder; the wear upon the cylinder liners, therefore, is only that due to the pressure of the piston rings against the liners. It was thought at one time that the wear on the exhaust valves would be considerable, and in the early design of engines it was considered necessary to water-cool these valves to prevent overheating of the valve faces. Ehrhardt & Sehmer came to the conclusion some two years ago that the water-cooling of exhaust valves was an unnecessary complication, and they have now entirely abandoned this practice for all sizes of engines. Numbers of examples are recorded of large engines in continental generating stations that have been running for 12 or 18 months without being opened up.

The repairs for generators would certainly be lower for a gas-driven plant than for a steam-turbine-driven plant.

One of the principal items in the maintenance of a steam station is that of the repairs of steam pipes, whereas the maintenance of pipe work in connection with a gas engine will obviously be extremely small. The principal liability of repairs to pipe work appears to arise from the risk of the exhaust pipes being attacked by sulphuric acid if the water is allowed to mix with the exhaust gases and combine with the small percentage of sulphur in them.

The cost of producer repairs appears to be a very small item, and will undoubtedly be only a fraction of the cost of repairs to high-pressure steam boilers. The Power Gas Corporation estimates that the total cost of repairs to the entire producer plant, including the ammonia-recovery appliances as shown in Fig. 2, would not exceed, on the average, £[illegible] per annum over a period of a number of years.

We are of opinion that the total cost of repairs for the 10,000-kilowatt gas-driven station, including all machinery, apparatus and buildings, would not exceed £[illegible] per annum. We have estimated the repairs and maintenance of

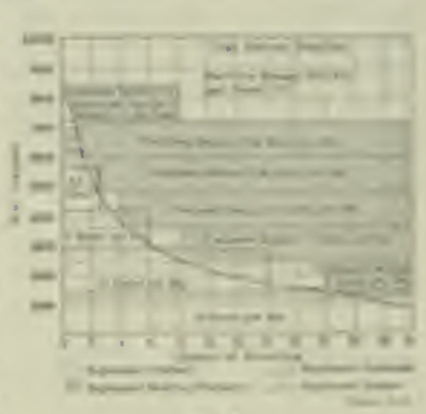


FIG. 14

the steam plant at the same rate as the gas plant, though we believe that this is a lower figure than has yet been secured in any steam station over a period of several years.

Amortization, Depreciation and Interest

As the use of large gas engines is so comparatively new in this country, some engineers may be inclined to think that the designs will be so altered during the next few years as to render it necessary to set aside a large amount to provide against obsolescence. Those, however, who have visited some of the large gas-engine installations on the Continent will have been impressed by the great similarity in general design between all the engines that have been erected during the past three or four years. The very first gas installation at the [illegible] Iron and Steel Works, for example, includes engines running with the same [illegible] from [illegible] to [illegible]. These engines [illegible] to be [illegible] and [illegible] have been [illegible] under [illegible] conditions than the [illegible]

*The cost of oil, waste and stores for the gas-engine plant at the [illegible] works of John Cockrill & Co. is stated to be [illegible] per kilowatt-hour generated, the output of the plant being 24,000,000 kilowatt-hours per annum.

gines appear to be running in every way as satisfactorily as those of more recent date.

The correct amount to allow for interest and depreciation on electric-generating machinery is a somewhat debatable point. It is usual in preparing estimates for industrial plants to allow 10 per cent., but Mr. Snell, in his paper on "Cost of Electrical Power for Industrial Purposes," justifies the figure of 6¼ per cent. As this point has a very important bearing on the comparison of steam- and gas-engine cost, we have in each case shown the comparative cost, including these charges at 10 per cent. and alternatively at 6¼ per cent. The total running costs of generating 21,000,000 kilowatt-hours under the above conditions will, we estimate, be respectively as follows:

	Gas.	Steam.
Total cost of coal at 12s. per ton	£12,280	£19,968
Less sale of sulphate of ammonia	5,524	
Net cost of coal	£ 6,756	£19,968
Oil, waste and stores	1,345	438
Water	555	2,550
Labor	3,180	2,590
Repairs	4,000	4,000
Interest and depreciation at 10 per cent. on capital	17,687	13,952
Total cost	£33,523	£43,668
Total cost per unit	0.383d.	0.498d.
Total cost, allowing 6¼ per cent. for interest and depreciation.	£26,900	£38,428
Total cost per unit	0.306d.	0.438d.

The total cost (including 6¼ per cent. for interest and depreciation) of generating power by steam = 45 per cent. greater than the cost of generating power by gas.

Effect of Price of Coal and Load Factor

In the particular case considered, the conditions are more favorable to the use of gas engines than in many of the existing provincial municipal electric stations in this country. There are at present only 15 public electric central stations working at a load factor of over 24 per cent., though many more have load factors varying from 20 to 24 per cent. In many cases, too, a suitable coal can be obtained at less than 12s. per ton delivered at the works. We will, therefore, go to the opposite extreme, and consider the case of a generating station having the very poor load factor of 10 per cent., and able to obtain fuel at 8s. per ton. We will also assume that the maximum output is only 4000 kilowatts, and that the use of the sulphate of ammonia recovery plant for a portion of the producer plant, as

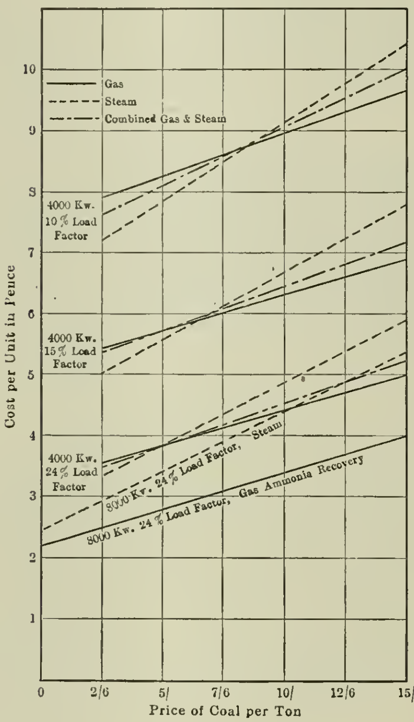


FIG. 11

in the scheme previously considered, is not justifiable. Under these conditions the saving in fuel effected by using gas

TABLE 2. OPERATING COST FOR A 4000-KILOWATT STATION.

Load Factor 10% Coal, 8s. per Ton.

	A. Steam.	B. Gas.	C. Combined.
Coal	£ 3,916	£ 2,073	£ 2,791
Oil and waste	95	297	248
Water	710	100	170
Labor	2,400	2,500	2,745
Repairs	1,250	1,250	1,250
Interest and depreciation at 10 per cent	7,452	9,578	8,639
	£15,823	£15,798	£15,843
Cost per kilowatt-hour generated	0.878d.	0.867d.	0.868d.
Total cost including interest and depreciation at 6¼ per cent	£13,037	£12,209	£12,608

engines is little more than sufficient to pay the 10 per cent. interest and depreciation charges on the higher capital outlay of the gas plant.

It has been suggested that for such conditions a combined gas and steam plant might be used, the gas plant being utilized

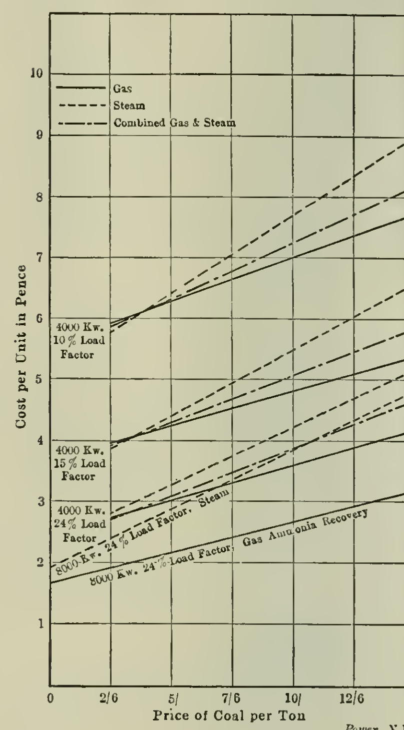


FIG. 12

for the long hour portion of the load curve and the steam plant with its lower capital charges for the peak load. Table 2 shows the estimated annual running costs with plants consisting respectively of, (A) five 1000-kilowatt steam turbo-generators; (B) seven 700-kilowatt gas engines and generators, and (C) four 1000-kilowatt steam turbo-generators and two 700-kilowatt gas engines.

The table shows that under the conditions stated and with a 10-per cent. charge for interest and depreciation, there is no choice between the different types of plant, as far as running cost is concerned, but with interest and sinking fund charges of 6¼ per cent. the combined station shows an overall economy of 3 per cent. over that of the steam plant, and the all-gas plant an improved econ-

TABLE 3. GAS PLANT EFFICIENCIES.

No. of Inquiry.	Period Covered, Months.	Kw.-Hours Generated.	Maximum Demand, Kw.	Load Factor, Per Cent.	Plant Factor, Per Cent.	Tons of Fuel.	Estimated Mean Calorific Value (B.t.u.)	Class of Fuel.	Price Per Ton.	Fuel Per Kw.-Hour Generated.	Overall Thermodynamic Efficiency.
A	7	988,980	700	27.00	83.0	900	11,300	Soft bituminous slack	......	2.038	15.00
B	12	253,550	207	13.80	82.0	53,631 1,000 cu. ft. gas.	130,000	Mond gas	2d. per 1,000	...	12.40
C	1	120,100	350	57.00	83.0	98.7	14,392	Pocahontas	......	1.840	12.85
D	1	48,000	185	38.50	62.0	4.5	11,500	Bituminous Staffordshire	10 s.	2.125	13.90
E	10	1,115,000	242	63.00	77.0	970	12,500	Gas coke	16 s.	1.950	14.10
F	6	592,500	500	26.60	80.0	546	12,000	Linby slack	......	2.060	13.75
G	4	260,700	368	33.00	90.0	215	13,000	Lancashire slack	......	1.800	14.60
H	12	21,910,208	2,520	99.00	....	20.185	11,000	Inferior Lancashire slack	9 s.	2.064	15.05
								Average overall efficiency of above eight replies =			13.95

omy of 6 per cent. over the all-steam plant.

The charts, Figs. 11 and 12, show similar comparisons with coal at various prices ranging from 2s. 6d. to 15s. per ton; the former is based on 10 per cent. allowance for interest and depreciation and the latter on 6¼ per cent.

It will be seen that under no condition is it worth while, when building a new station, to install a combination of steam and gas plant. With a nonrecovery plant and coal above a certain price, a gas plant is more economical, and below that price a steam plant alone is more economical than either a gas plant alone, or a combined steam and gas plant. This applies only to entirely new installations. There are many existing installations equipped with comparatively inefficient apparatus where a large economy would be effected by installing one or more gas engines to be used for the flat portion of the curve, the inefficient machinery being used only to carry the peak load and for emergencies.

It will also be seen that if the size of the installation or the load factor permits of a recovery gas plant being used that is more economical than a steam plant, however low the price of coal.

Table 3 gives the results of eight inquiries as to the actual operating efficiencies of gas plants. The kilowatt-hours generated are the total number supplied to the feeders. Current used for driving auxiliary apparatus in generating stations, lighting, etc., is not included under this heading. The load factor is calculated from

$$\frac{\textit{Kw.-hours supplied to feeders} \times 100}{\textit{maximum load on feeders} \times 8760}$$

The plant factor is calculated from

$$\frac{\textit{Kw.-hours supplied to feeders} \times 100}{\textit{plant hours run} \times \textit{capacity of plant}}$$

The fuel consumption is the total fuel used for all purposes. The calorific value of the fuel is the engineer's estimate of the mean calorific value based on periodic calorimeter tests.

The eighth regular prize competition of the Austrian Engineers' and Architects' Society has been announced. A solution is asked for the following question:

"How is it possible to avoid the injurious effects of the so-called higher harmonics of current and voltage waves which permanently or temporarily enter the alternating circuit; or how may their production be generally prevented?"

Three prizes are offered, the amounts being $600, $200 and $100. Persons who desire to obtain further particulars and to ascertain whether they are eligible to enter the competition, should address "Oesterrlicher Ingenieur und Architekten-Verein," Eschenbachgasse 9, Vienna, Austria.

Superheat and Wiredrawing

By F. L. Johnson

Upon returning from lunch the other day, I found my friend Sawyer sitting by the window poring over a work on "Water Power Engineering." As I seated myself after shaking hands and hanging up my hat, he said:

"It has always seemed to me that it was about an even thing between the cost of a steam and a water horsepower, when all of the factors of the problem are considered and properly treated. But reading this book has brought fresh to my memory two incidents that are in no way connected with water power, and I do not understand why they come to me now, for I have not thought of either of these for years. As I said, they can have no connection with water power, for they were examples of a gain that may be made in some instances by the use of steam superheated by wiredrawing.

"Several years ago I was visiting an engine room where I noticed two check valves, opening inwardly, attached to the indicator piping of the cylinder. Asking why they were there, the engineer closed the outer end of one, by putting his hand over it, and at once the exhaust valves began to rattle, showing that the cutoff was so short that expansion was carried so far below atmospheric pressure that during part of the stroke air and exhaust steam were drawn into the cylinder through the exhaust pipe lifting the valves from their seats, making a disagreeable rattle which the air let in through the check valve stopped by equalizing the pressure above and below the valve.

"While I was looking at the arrangement, the chief engineer from the new power plant, a comparative stranger and recent arrival in town, came in and introduced himself. He was shown the check valves and some indicator diagrams with and without the checks in operation. He smiled and said:

"'That is an ingenious way of stopping a disagreeable noise. You probably do not know that you are using a patented device, but as the patent expired a great many years ago, I do not think you will have to pay a royalty for its use.'

"Then, after a moment, he continued: 'I am a stranger to most of the engineers in town and I do not wish to be fresh, but I think I can help you in this case by making your engine run better without the check valves than it does with them, and by reducing your very small coal bill by nearly one-half.'

"These remarks were met somewhat doubtfully but with a spirit of willingness to learn of better methods, and the visitor was invited to go ahead. The engine was a 10x20, running at 75 revolutions per minute, and the steam pressure in the boiler was 80 pounds. It was a 72-inch by 18-foot boiler, with 33 square feet of grate surface, and a safety valve set to blow at 100 pounds. From 80 pounds the boiler pressure was raised to 85, by changing the weights on the damper regulator. Then the visitor went to the throttle and slowly closed it until the drawing-in of air at the check valve ceased and the drop of the [illegible] showed that cutoff was taking place in the vicinity of quarter stroke. Then he sat down and said:

"'Let us watch it awhile.'

"In a few minutes the engineer went to the belt-driven, [illegible] boiler-feed pump and changed the position of the bypass valve slightly. Asked what he was doing, he said that water was getting in the boiler and that he was cutting down the feed. He further stated that at the time the pressure was raised the water was slowly falling, and he expected to increase the feed instead of decreasing it.

"After sitting and chatting for awhile longer, the visitor said:

"'You have rather a hard combination here from which to get good results. Your grate surface is too large for the boiler, the boiler is too large for the engine and the engine is too large for the work to be done; but we can do considerably better than we are doing. If you have the [illegible] and some firebrick, I will come in next Sunday and we will fix up the boiler a little.'

"He was there the next Sunday, all right, and got right into the furnace and laid firebrick faster than two masons and better than I ever saw them laid before. He reduced the grate area from 33 feet to 24 by building a new firebox inside the old one. While washing up and changing his clothes, he said:

"'I will come down in the morning and see how the plant runs, for I am as much interested in it as you are.'

"After some general conversation and an exchange of cigars we went away.

"About three months afterward I went into that plant again, just to see how it was coming on. I asked the engineer if that man from the central station had saved him half the coal, as he promised.

"'Yes,' confound him [illegible]. 'In the old way I used to pile all my scraps into the furnace and get rid of them without any bother, but now, with the small grate that won't hold any coal, a lot of rubbish don't burn. He said he would cut the coal bill in half. He did better. I use about half the fuel I did before, but as I have just as many scraps to burn, I think I do not really use more than quarter of the coal that I did. That engineer at the central station knows how to run engines and boilers all right, and I am free to say that although I have been in the business twice as long as he has, he can give me cards and spades and then some and [illegible].'

Relighting the cigar that he had allowed to go out, Sawyer blew a few smoke rings and then said:

"I spoke of two instances of superheating by throttling, and although I wandered a little by telling of more than the throttling of the steam supply to an underloaded engine, I will stick to the text in the story that I am going to tell you now. Once I went from Duluth, Minn., to Ashland, Wis., on a tug. Besides myself there was another passenger, who wandered into the engine room and got into conversation with the engineer.

"After awhile the stranger asked the engineer to experiment a little for the sake of what could be learned by it. The lake was as smooth as glass, and the fireman had not changed the speed of the feed pump for an hour. The throttle was wide open and the engine was making 85 revolutions per minute. After counting the revolutions several times for a period of five minutes, to insure accuracy, the engineer was asked to close the throttle until he could plainly hear the steam rushing through it, which he did. Then the fireman was asked to note the water level and not to change the speed of the pump without notifying the engineer. After about fifteen minutes the speed of the engine was again counted and was found to be 86½ revolutions per minute, instead of 85, as before the throttle was partially closed.

"Soon the water was perceptibly higher in the boiler and shortly the fireman reported that he would have to slow the pump slightly. He also said, on being asked, that the boiler never fired easier nor steamed better. For several hours the experiment went on; in fact, until I turned in to sleep; and when I awoke we were at the dock, and I have seen neither the engineer nor his visitor since.

"But the facts are these: With a partially closed throttle there was an increase in the speed of the engine of more than one and three-quarters per cent., and a decrease in the amount of coal and water used. I do not know the man who suggested the experiment, nor do I know if anything ever came of it. But it has made me think a whole lot about wiredrawing and superheat, for in both of these cases the steam was superheated. When it entered the cylinder it had a temperature above that due to its pressure."

Then, looking at his watch, he said:

"I have stayed longer than I intended to and must move along. I will be in again in a couple of weeks," and he left me to think of superheat and wiredrawing.

If the work in the cylinder is done by heat, how is more heat utilized by checking the supply? I do not know and that is why I ponder over it.

Changing One Thermometer Reading To Another

By A. L. Hodges

As we are so unfortunate as to have two types of thermometer in common use, and as articles appear right along in engineering magazines, in which one or the other is used, sometimes both, it is absolutely necessary not only to know each individually, but to know their relations and common points. Of course, most of us are familiar with the formula to do this, but a formula is not as easy to remember as a simple diagram showing the relations. The writer has had a good deal of experience teaching engineers and has always found that the accompanying diagram enabled them to remember the relations better than anything else.

Besides the Centigrade and Fahrenheit thermometers, we have to do with the "absolute" thermometer, when dealing with a gas or with superheated steam. Any absolute temperature may be derived by simply adding 273 to the Centigrade temperature; but this has been included in the diagram.

To make the diagram, all one has to do is first to draw two vertical lines to represent the Centigrade and Fahrenheit thermometers, mark on the Centigrade line two points, 0 and 100, and mark opposite these, on the Fahrenheit line, 32 and 212, respectively. It is easy to remember that these are the freezing and boiling points of water on the respective thermometers. It will be seen that one degree on the Fahrenheit scale is equivalent to 5/9 of one on the Centigrade, because the same distance that indicates 100 on the Centigrade scale shows $212 - 32 = 180$ on the Fahrenheit. To change from one reading to the other, an addition or subtraction of 32 is necessary, as will be seen by reference to the diagram.

Suppose it is desired to change 50 degrees Centigrade to the corresponding reading on the Fahrenheit scale. As every degree Centigrade is equal to 5/9 degree Fahrenheit, it will be necessary to multiply 50 by 9/5 to get the number of Fahrenheit degrees above freezing point of water. But even this will not give the correct Fahrenheit reading unless 32 is added. This rule is expressed by the simple formula:

$$F = 9/5\ C + 32,$$

where F is the Fahrenheit reading and C the Centigrade.

From similar reasoning, then, in case it is desired to change from Fahrenheit to Centigrade, we must multiply by 5/9, but only after subtracting 32, because the Centigrade zero is at the freezing point of water. This is expressed by the following formula:

$$C = 5/9\ (F - 32),$$

where the symbols have the same significance as before.

As regards the "absolute" thermometer, it is graduated in degrees of exactly the same value as those of the Centigrade; so in changing the absolute to Centigrade, or *vice versa,* it is not necessary to multiply or divide by a fraction. If 50 degrees Centigrade is to be changed to absolute, simply add 273 degrees and the thing is done. If an absolute reading is to be changed to Centigrade, simply subtract 273 degrees and the correct result appears. Thus, 290 degrees absolute = 17 degrees Centigrade; also, 200 degrees absolute = − 73 degrees Centigrade, simply algebraic subtraction. So the formulas between the absolute and the Centigrade are very simple:

$$A = C + 273 \text{ and } C = A - 273.$$

If we try to change the absolute to Fahrenheit, or *vice versa,* without employing the intermediate Centigrade formula, the operation becomes slightly more complicated, but a glance at the diagram will make things clear. First, change −273 Centigrade degrees to Fahrenheit degrees by multiplying by 9/5. This gives the number of Fahrenheit degrees, below the freezing point of water, equivalent to zero, absolute. But to change this to the Fahrenheit reading it is necessary to subtract 32, which will give us − 459⅖. From this the logical formula results:

$$F = 9/5\ A - 459\tfrac{2}{5},$$

and the reverse formula, of course, is:

$$A = 5/9\ (F + 459\tfrac{2}{5}),$$

the symbols meaning the same as before, for the reading on the respective thermometers signifying the same degree of heat or cold.

Several peculiar things appear if certain relations are required. For instance, at what temperature do Centigrade and Fahrenheit read the same? Simply substitute Centigrade for Fahrenheit or Fahrenheit for Centigrade in (1) or (2) and it is found that at −40 (or 40 below zero) on either scale means the same degree of coldness. This is verified by the diagram. Similarly, several such points are shown on the diagram.

They are easy to memorize and come in handy occasionally. For example, when the temperature Fahrenheit is 320 degrees and it is desired to change it to Centigrade, the diagram enables one to know that the Centigrade reading to correspond is exactly ½, or 160 degrees. So, for approximate results anywhere within a few degrees of 320, simply divide by two. With the absolute scale there is one point that reads the same as the Fahrenheit, namely, 549¼; but, from the nature of things, no point on the absolute scale is the same as the Centigrade, for it is necessary to add 273 to the Centigrade, no matter what it is, to get the absolute.

What Zero Absolute Means

The zero absolute means just what it says: That a body is perfectly cold at that temperature, containing no heat whatever. Therefore, there can be no "minus" degrees absolute, or "below zero" absolute, even in theory. To realize fully the significance of an absolute scale the mind must have a clear mental picture as to what heat really is and exactly what happens to a body when that body gets hotter or colder.

Heat is defined as "molecular vibration." To grasp this, one must think of every body, no matter of what material composed, as being made up of very small particles, called molecules, that are in a state of constant vibration at all ordinary temperatures, jumping about in little cells of their own.

When the body becomes warmer, as we say, what happens to these molecules? It has been shown that they go faster in their vibrations, occasionally knocking one another away to make room for themselves. In the case of a solid, for instance iron, if heated, all the molecules at once seem to go faster and through longer distances. They knock one another about until room is made. This, of course, is transmitted outward to those on the surface of the body and they seek the line of least resistance and consequently extend their paths outward. What has happened to the body in the meantime? As everyone knows, it has grown larger or "expanded." Yet no matter has been added, for a hot body weighs no more than the same body cold.

Heat, then, means simply the amount of vibration of the molecules. When we cool a body it contracts, that is, the molecules go slower and through shorter distances. When the molecule has no motion whatever we have the absolute zero. It is needless to say that this condition of affairs has not so far been reached experimentally by inhabitants on this earth, and will probably never be reached, for the vibration of a molecule is presumably of such nature that it can never become quite still, although approaching that condition as a limit.

This absolute scale is of peculiar interest in the case of a gas. It has been found experimentally that all gases when cooled 1 degree Centigrade contract almost exactly 1/273 of their volumes at zero Centigrade. So if we could cool a gas to —273 degrees Centigrade, or absolute zero, it would have practically no volume. This is in perfect accord with the theory of gases being composed of little molecules very, very far apart in relation to their sizes, so far apart that they seldom hit one another in their vibrations. So it stands to reason that if they had no vibration and were packed closely together, their volume would be very small indeed. Even if absolute zero could be reached it would be of no value in proving the small volume of a gas because all gases liquefy or solidify long before absolute zero is reached. The last to liquefy is helium, which a German professor claims to have frozen at —271 degrees Centigrade or 2 degrees absolute. This has not been verified, however.

DIAGRAM FOR CONVERSION FROM ONE THERMOMETER TO ANOTHER

Sewalls Falls Plant Near Concord, N. H.

2000-Kilowatt Water Power Plant Containing the First Installation of Vertical Multirunner Direct-connected Open-flume Turbine

BY S. RICE

Up to the time of the installation of this type of turbine, the vertical single-runner turbine, with gearing to jack shaft direct-connected or belted to generators, had been developed and extensively installed, with a view to meeting conditions prevailing for low-head developments in which limited space and extreme variations of water level are controlling factors. These particular turbines are said to have given, however, the first commercial demonstration of a method hydraulically efficient and desirable from a construction and operating standpoint.

The Sewalls Falls plant of the Concord Electric Company is located on the Merrimac river, 4½ miles above the city of Concord, N. H. The Merrimac river at this point drains an area of about 2350 square miles and has a normal flow of about 2500 second-feet and an average fall of about 16 feet. The total development aggregates 2000 kilowatts.

In the winter of 1904-05 the company decided to add 1000 kilowatts to the capacity of the original plant, then consisting of five 200-kilowatt generators belted to twin turbines in plate-steel casings, in order to supply power to the street-railway system projected by the Boston & Maine Railway in the neighborhood of Concord, and to various other consumers of electric power. The design had to provide for flood variation of some 19 feet. Due to the excessive tailrace excavation required, it was impracticable to locate the addition at the northern end of the old power plant. Placing the installation at the southern end made it necessary that the building be as compact as possible, on account of forebay extensions and in order to reduce foundations and to simplify the protection from the thrust of the river.

Fig. 2 shows the design adopted, which includes two 900-horsepower vertical triplex open-flume turbines direct-connected to two 500-kilowatt vertical generators, with a speed of 100 revolutions per minute, excitation being furnished by a motor-driven exciter generator. How well the plan adopted fulfils the conditions may be observed from Figs. 1, 2 and 3, where it will be seen that the generator floor is above flood mark and that the power house is approximately one-third the length of the old one, being at the same time equal in capacity.

Turbines

There are two turbines, as heretofore stated, designed for operation under a normal head of 16 feet. These machines, as shown in Fig. 5, each consist of a twin center-discharge turbine mounted above a single turbine by means of substantial column construction. The turbine gates are of the swivel type operated through regulating shafts and connections. The advantages of swivel gates over cylinder gates for this type of turbine are:

First—That swivel gates give increased efficiency at partial gate opening and equally good efficiency at full gate opening, while the efficiency with cylinder gates is low, due to the fact that excessive hydraulic disturbances, eddies, etc., occur at partial gate openings.

Second—With the use of the swivel type, the increase or decrease in power, resulting from opening or closing the gates, occurs uniformly throughout the stroke from wide open to closing position, which characteristic is necessary for uniformly sensitive regulation from no load to full load. With the cylinder type, a considerable closing of the gates from wide-open position is necessary before any reduction in power is effected. Moreover, at very small gate opening (required for friction load) the friction eddies in the water, while passing through the gates, is so great that no power whatever is developed in the wheel. This inevitably results in impaired regulation at full- and friction-load gate openings.

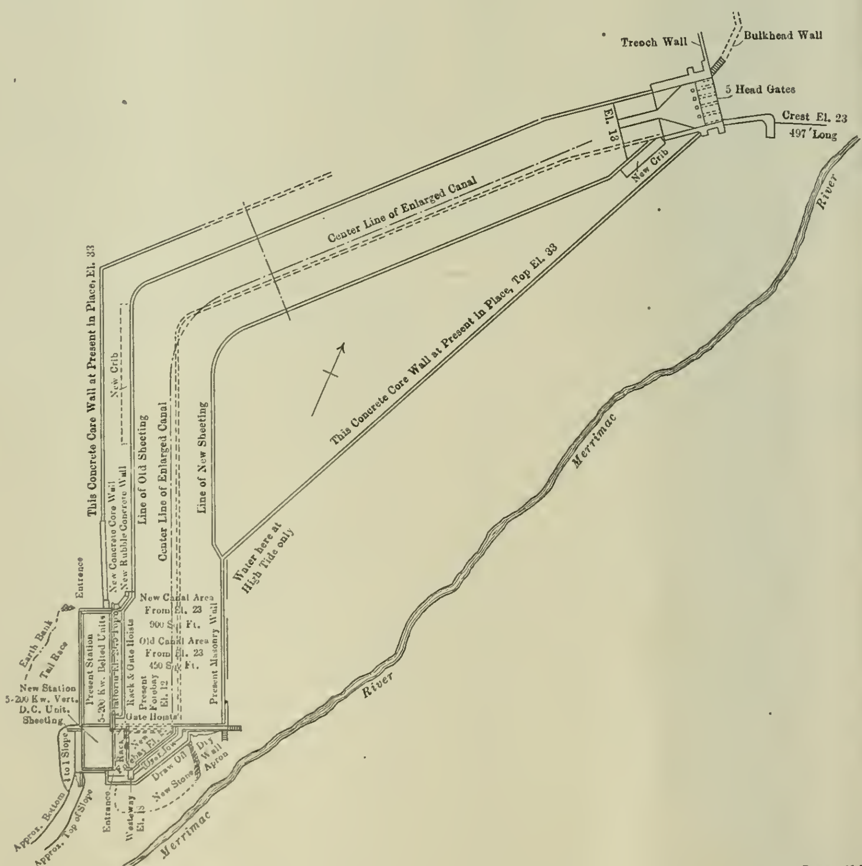


FIG. 1. GENERAL PLAN OF DEVELOPMENT

The bronze runners, shown in Fig. 7, are designed to develop 900 brake horsepower at a 16-foot head and 615 brake horsepower at a 12-foot head, with a constant speed of 100 revolutions per minute. The characteristics of these runners enable normal speed to be maintained under a reduction of normal head, with but slight loss in efficiency, thus making

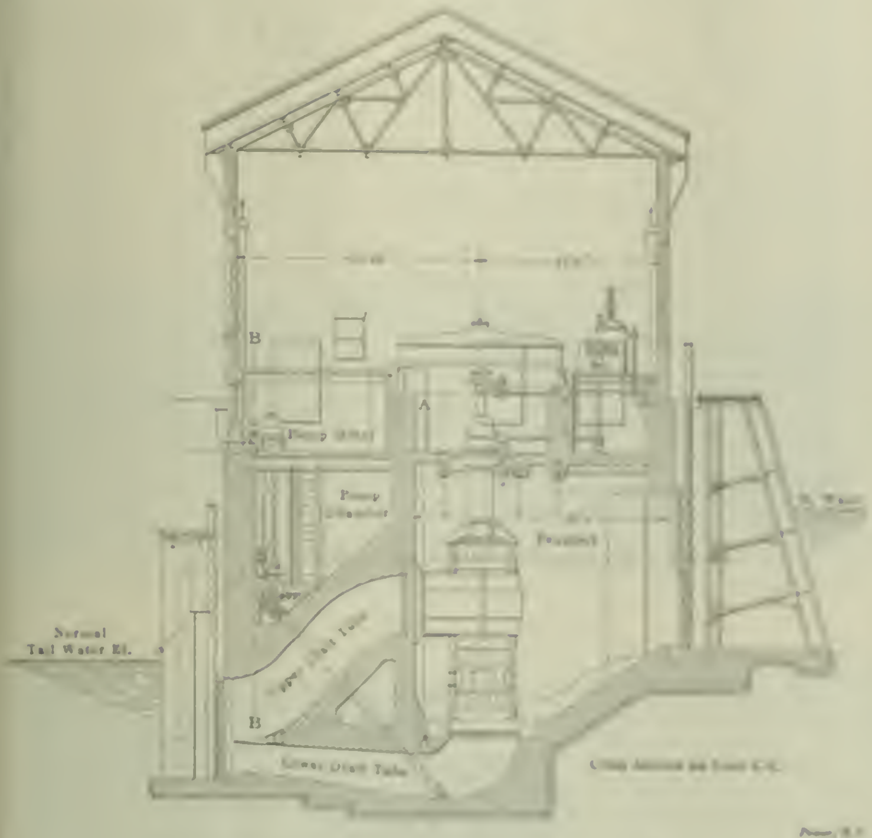


FIG. 2. TRANSVERSE SECTION OF NEW STATION

draulic disturbances. The object in this, as with all draft tubes, was to so construct them as to abstract a maximum practicable amount of its kinetic energy from the water before discharging it into the tailrace. How little attention has been given to the proper design of draft tubes in this country will be readily seen by referring to illustrations in the current hydraulic turbine catalogs showing the short, straight draft tubes and settings which they recommend. A striking example of the losses incurred with such draft tubes is shown in a recent case where 25 per cent. actual increase in plant capacity was obtained by replacing a straight, short wrought-iron draft tube of the catalog type mentioned above with one properly designed and constructed of concrete.

Thrust Bearings

The thrust bearings furnished are of the standard Allis-Chalmers oil-bath self-contained type. A view of the outside casing and base ring is shown in Fig. 5. The bearing is built to run wholly in a bath of oil and has demonstrated, during years of continuous commercial operation, that it requires minimum operating attention. A further advantage of this thrust bearing is its economy in the use of oil. In a plant containing eight 875-horsepower vertical turbines, which was recently described in this paper, an av-

them particularly adaptable to variable head developments.

Tests made after installation have established the fact that remarkable uniformity in efficiency is maintained through a wide range of gate opening, a feature of great importance from the standpoint of economy of water.

Governors

For regulating the speed of the turbines the governors used are of the oil-pressure type, as described on pages 455-459 of the September 15, 1908, number of POWER AND THE ENGINEER. In this installation they are arranged so as to be entirely self contained, the rotary oil pump, tanks, regulating cylinder and governor mechanism proper being mounted on a single base. The governor head and pump are driven from the main shaft by means of bevel gears, and the regulating piston is connected to the regulating shafts by means of a simple link arrangement, avoiding, as is the builder's regular practice, the use of gearing and the lost motion inherent in such arrangements.

Draft Tubes

As shown in Fig. 2, the concrete draft tubes were designed to lead the water to the tailrace from the center discharge casing and lower runner with uniformly decreasing velocity and minimum hy-

FIG. 3. LONGITUDINAL SECTION OF NEW STATION

tual saving of over $6000 a year in oil was effected by replacing the pressure thrust bearings, originally installed, by oil-bath bearings of this type.

Three metal guide bearings were supplied with each turbine. They are supported by the center discharge casing and fed with oil from above.

Electrical Apparatus

There are two 500-kilowatt three-phase 60-cycle 2600-volt vertical direct-connected revolving-field generators of the type shown by Fig. 8. These machines revolve at a speed of 100 revolutions per minute, and the features of especial interest are the stator and rotor. The stator is bolted to the cast-iron supporting ring which is carried upon concrete foundation beams worked into the lower floor, as shown in Fig. 2, and has bolted to its top the spider which supports the guide bearing. The rotor is of the "umbrella" type, constructed of cast steel and especially designed to withstand the stress due to its great diameter and posi-

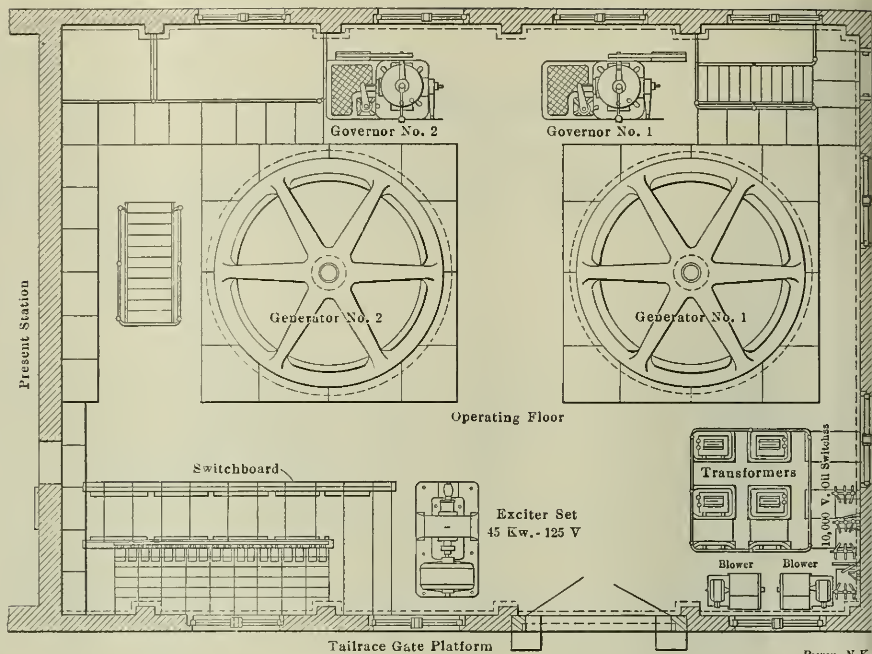


FIG. 4. PLAN OF OPERATING FLOOR

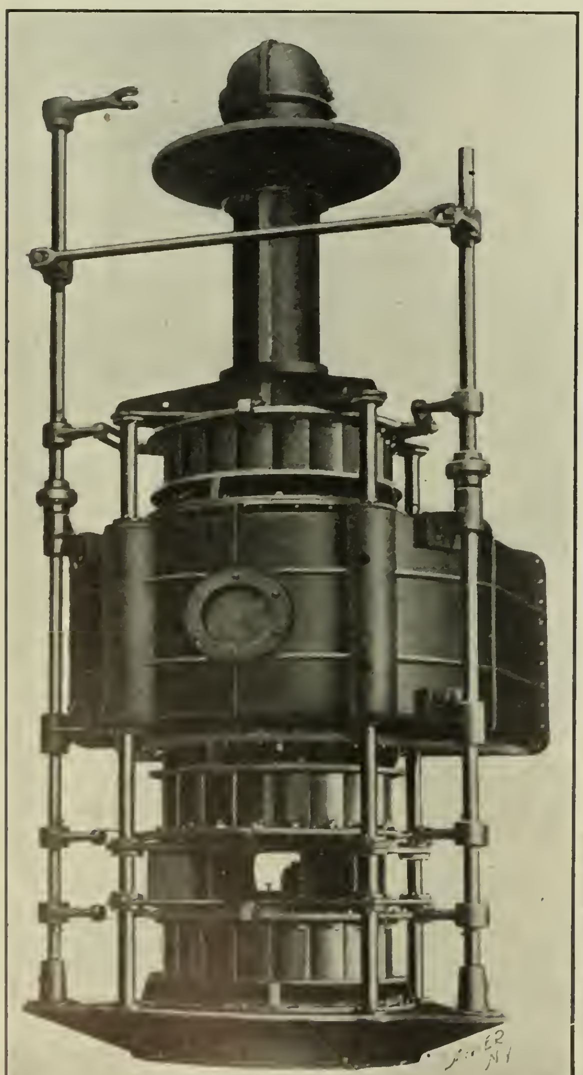


FIG. 5. 900-HORSEPOWER ALLIS-CHALMERS VERTICAL TRIPLEX TURBINE

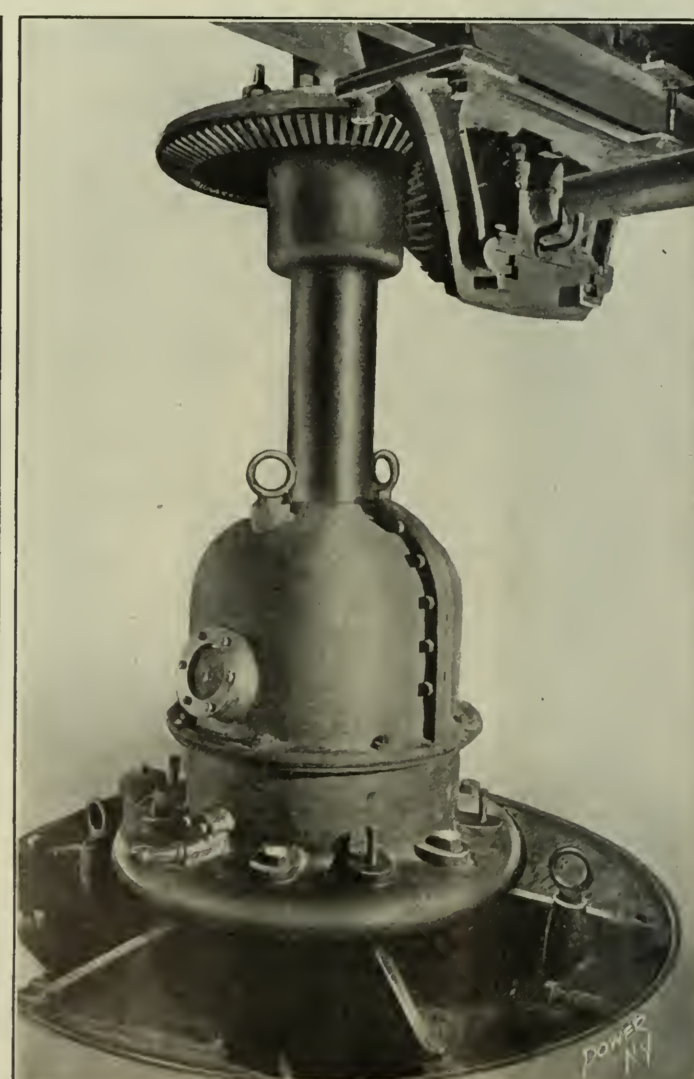


FIG. 6. THRUST BEARING OF TURBINE

tion with reference to its field coils. It is mounted on a short shaft, the collector rings being arranged immediately above the coupling to which the turbine shaft is connected.

Excitation is furnished by one 45-kilowatt 125-volt compound-wound generator, direct connected on the same cast-iron baseplate to a 75 horsepower 60-cycle three-phase induction motor wound for 2000 volts, and a speed of 680 revolutions per minute. This type of exciter was chosen in preference to a waterwheel unit on account of the necessity of economizing space as much as possible.

The switchboard is of blue Vermont marble, 21 feet 4 inches long and divided into eleven panels. The generator, exciter and exciter motor have each a separate panel with a blank panel for a future line. A portion of the switchboard is shown in Fig. 8.

The 10,000-volt air-blast step-up transformers are placed on the lower floor. These transformers are provided with ducts below and connections to the air shaft communicating with the blowers. A damper is provided for shutting off air from each set of transformers.

General Construction and Development

There are several points in connection with the general construction involved in this development which are of engineering interest, and will be noted in the general drawing, Fig. 1, and power-house arrangement, Figs. 2, 3 and 4.

Power House—The design and dimensions may be seen by referring to Fig. 4. Reinforced and rubble concrete is used for the substructure and the superstructure is of brick, with a slate roof supported by steel trusses. A hand-power crane is provided, the crane girder being carried on steel columns. On the upper or operating floor are located the generators, governor, switchboard, motor generator and blowers for the transformers. In the construction of the floor provision is made for easy access to the space around the generators, to the bulkheads in the lower floor and to transformers. Removable slate slabs resting on leveling strips are used for this purpose and the part of the floor is made level with the remainder, which is of concrete with smooth interior finish.

On the lower, or thrust-bearing floor, are located the thrust bearings, transformers and a 5-inch motor-driven centrifugal pump for unwatering the turbine pits. The generators are supported on circular concrete bases carried on floor arches, and platform with steps is provided for reaching the generator collector rings and brushes. The draft tubes

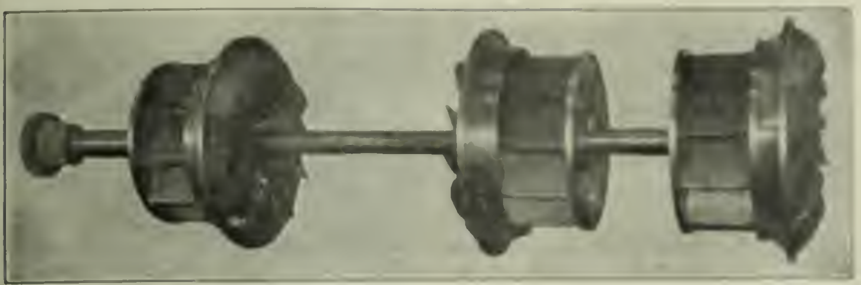


FIG. 7. 55-INCH RUNNERS OF VERTICAL [illegible] TURBINE

[illegible] of reinforced concrete designed as previously described, and the maximum velocity at their outlets is brought down to nearly that of the tailrace. In addition to head gates and tailrace gates, stop log slots are provided.

Dam—The dam is a cribwork structure [illegible] feet long, with planked apron protected by iron plates. The abutments, wing walls and canal head-gate works are of rubble masonry. The elevation of these works is from [illegible] to [illegible] feet above the crest of the dam.

Canals—The original canal, about [illegible] feet in length, was [illegible] feet deep and [illegible] feet wide at the top with a cross-section area of [illegible] square feet. At the time of the installation of the two units, the canal was widened to give double the cross-section. Fig. 1 shows the widened canal as left there. It will be noticed that the inner curve was made with considerably greater radius than that of the original canal, the inner side of which is shown in dotted lines. This was done because it was found that the angle in the old canal was sharp enough to cause considerable erosion at the curve.

The sheeting of the newly excavated side of the canal toward the river consisted of tongue-and-groove hard-pine planks, [illegible] inches thick, placed in a trench and driven to hard pan. The sheeting on the old bank of the canal was repaired as necessary and at the upper corner of the station on the canal a concrete wall was built, making the joint secure. It was estimated that the loss in head in the canal and entrance, and down to the mouth of the tailrace, would not exceed [illegible] feet under normal conditions. The canal head gates are built of selected Georgia hard pine with racks, guides, tracks and hoisting apparatus, and are arranged so that they may be hoisted by hand or by geared motors.

Forebay—For a length of [illegible] feet, the top of the forebay wall has an elevation of [illegible] feet and serves as an overflow. In this wall is a [illegible] gate for drawing down the water in the canal. For ordinary passage of ice, driftwood and handling waste water a [illegible] wide by [illegible] overflow gate is provided. The bottom of the opening is [illegible] feet below the normal surface of the water in the canal and extends [illegible] to the top of the wall. This gate is arranged to lower entirely below the [illegible] and is operated in conjunction with the canal head gates to control the height of water in the canal.

Racks and [illegible]—The racks are built up on a [illegible] steel frame resting on a [illegible] masonry flooring and are braced back against the [illegible]. The gratings are of [illegible] bars spaced [illegible] inches in the clear and are made up in sections with the [illegible] placed back of the [illegible]

FIG. 8. ONE OF TWO [illegible] TRANSFORMERS

of the bars to allow the teeth of the rakes to pass without catching. The whole is made of sufficient strength to act as a dam, should anchor ice close up the openings and the water be drawn from behind.

The head gates are double, each 15 feet 6 inches by 7 feet 6 inches, built in two parts on account of their large size. Two-part gates were required, since solid gates would have necessitated placing the hoisting apparatus much higher and shutting off the light from the station windows.

Since the inception of its developments in 1892 the Sewalls Falls property has changed hands several times, and is now owned and operated by the Concord Electric Company of Concord, N. H., of which Allen Hollis is president and F. P. Royce, vice-president. George B. Lauder is superintendent and chief electrician, and L. D. Martin chief engineer. The consulting engineers are Hollis French and Allen Hubbard, of Boston, Mass., under whose supervision the installation above described was executed.

The Storage Battery

By A. Wohlgemuth

The storage battery, or, as it is also called, the accumulator or secondary battery, does not store electricity in the strict sense of the word; the electricity which it delivers is the result of chemical action caused originally by passing a current of electricity through the battery. This phenomenon was first observed by a French scientist, Planté, in 1860. M.

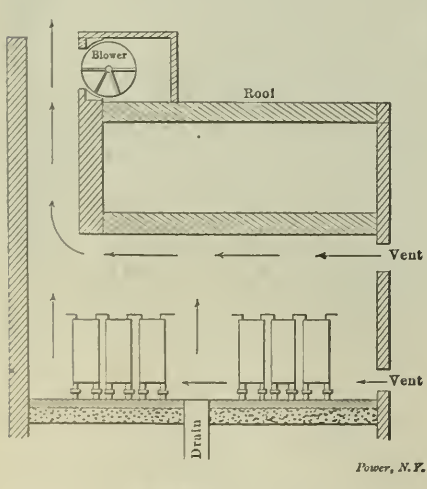


FIG. 1. ARRANGEMENT OF BATTERY CELLS AND PROVISION FOR VENTILATION

Planté passed current through a cell containing two lead plates immersed in a solution of sulphuric acid, and on discontinuing this charge connected the two plates to a current indicator. He noticed that a current of electricity was passing through the instrument, but in an opposite direction from the original current. Charging, discharging and recharging were continued for some time, the discharge becoming stronger the oftener and longer the charge was kept up. At the same time the surface of the plate was changing greatly. The plate to which the positive pole was connected took on a dark-brown color, and became brittle to the touch, while the other, a negative plate, assumed a light grayish hue, and felt soft and spongy. On discharge, the plates gradually assumed their original character. The plates of a modern battery formed in this manner are therefore called "Planté plates."

This forming process is a rather tedious operation, and was improved upon by another Frenchman, Faure, who conceived the idea of using ready-made active material pasted on the plates, instead of the material formed by repeated charging. The substances which can be used, and are used in the manufacture of Faure

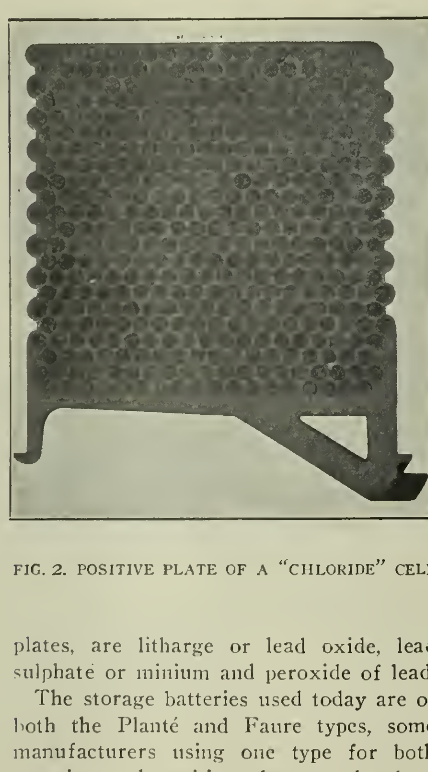


FIG. 2. POSITIVE PLATE OF A "CHLORIDE" CELL

plates, are litharge or lead oxide, lead sulphate or minium and peroxide of lead.

The storage batteries used today are of both the Planté and Faure types, some manufacturers using one type for both negative and positive plates, and others using the Planté type for one polarity and the Faure type for the other. Several diverse methods are employed to get the greatest amount of active material per given area and weight of plate; the kind of battery to be installed in any given case depends largely upon the use it will be put to.

In selecting a location for the battery room, facilities for proper ventilation, light and atmospheric conditions in the room ought to enter into consideration. The temperature should not be allowed to go much over 75 or 80 degrees Fahrenheit and not much lower than 50 degrees Fahrenheit. In modern battery rooms the floor is usually made of concrete protected by layers of tar paper and asphaltum, and finished with vitrified brick laid in asphaltum. Drains are provided and so arranged that collection of water is prevented; this is usually done by sloping the aisles between the tanks and providing cesspools to carry off the water. All drain pipes should be of lead and all metal supports should be covered with several layers of good lead paint, to pre-

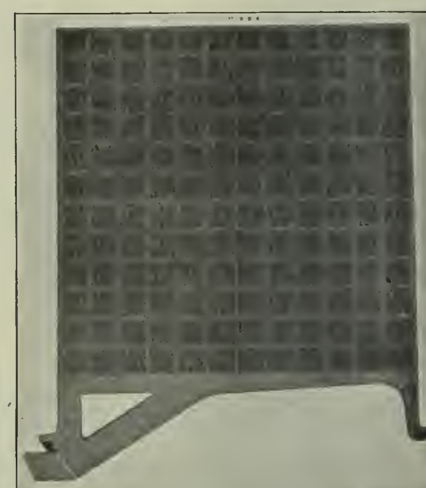


FIG. 3. NEGATIVE PLATE OF A "CHLORIDE" CELL

vent the acid from attacking and corroding the metal. The ventilation of the battery room is a very important matter. There are always gases present and when the battery is charging a large amount of gas and spray is given off, which, if not drawn off, is very injurious to all metal in the rooms. Exhaust fans are used almost exclusively to draw off these gases. (See Fig. 1.)

The tanks containing the plates are made of glass in small installations and of wood lined with lead in the larger plants. Lately, tanks made of earthenware have been installed with more or less success. The tanks are placed on glass or porcelain insulators, which are in turn supported by heavy wooden beams. In a great many instances the beams are done away with and the insulators are supported by mounds of sulphur, topped by a slab of vitrified brick. In all cases the bottom of the tank is from 6 to 8 inches above the floor, to allow free circulation of air and to prevent grounds.

When the tanks are in position heavy glass plates, 3/8 inch thick, two to each cell, are placed longitudinally in the tanks, which act as support for the plates. The latter are now placed in the tanks, negative and positive, alternately, and glass or hard-rubber tubes are put between each plate to act as separators. There is always one more negative than positive plate in each cell, in order to have both sides of the positive plate oppose the negative. The plates are now connected, the negatives of two cells to one strip of lead and the positives of two cells to one strip.

When all the plates are burned in, and all other necessary connections are made, then, and never before, the electrolyte is

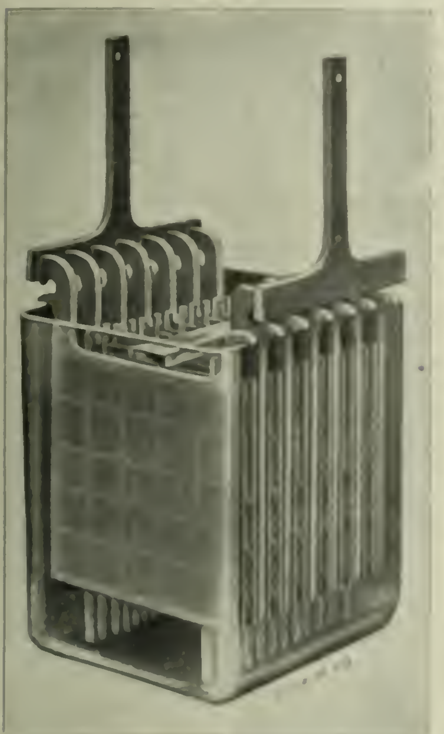


FIG. 4. [illegible] "CHLORIDE" CELL

poured in and the battery is ready for its first charge. This is usually of 24 or 30 hours' duration, and it is good practice to start this charge at a low rate, to prevent excessive heating due to the large internal resistance of the uncharged cell. As the voltage of the battery rises the charging current is increased until the maximum rate is reached. Toward the end of the charge, the current is again decreased, to prevent chemical action of too violent a nature. During the charge careful readings should be taken and great care exercised to get at the condition of the battery. The normal voltage of a fully charged cell in good condition is from 2.2 to 2.5 volts and the density or specific gravity of the electrolyte should be from 1.2 to 1.25.

Like every other apparatus, the storage battery if not treated properly will not do the best work it can. In commercial service the storage battery will develop a great many faults and if not watched intelligently will rapidly decrease in efficiency. There is one point which cannot be impressed upon users of the storage battery too often, and that is that a battery should never be allowed to stand "dead," that is, idle and disconnected from both charging and receiving circuits. As soon as the battery is allowed to lie idle for any length of time, especially in a discharged or semi-discharged condition, local action between the plates will increase enormously and a deleterious process called sulphating will begin. Sulphate of lead, a whitish, nonconducting and insoluble substance, forms on the plate and will soon reduce the efficiency to almost zero. One way to overcome the effect of partial sulphating is to charge the cell at a low rate for a long time—until the sulphate is reduced. If the sulphating has advanced very far, the only remedy is to draw off the acid, disconnect the plates and rinse them in pure water, using a brush to rid the plates of the sulphate. Then immerse them in water for 24 hours and rinse them again. Then reassemble the cell and charge at a low rate until the electrolyte shows signs of activity.

One other fault which gives the batteryman a lot of worry is the short-circuiting of the plates, which is caused either by buckling or by sediment in the bottom of the cell. Buckling of plates is

FIG. 5. POSITIVE PLATE OF [illegible] CELL

due to uneven expansion of the active material, causing the grid to bulge, until it touches the neighboring plate. It is usually the result of too heavy a rate of charging or discharging—more often the latter. Sediment is active material which has dropped off the plate and sunk to the bottom of the cell. If allowed to accumulate, it will finally reach the plates and thus short-circuit them.

The reversal of a cell is as a rule caused by an overdischarge, and by charging the cell at a low rate for a long period of time the cell can be brought back to its normal condition.

At the completion of a charge, the electrolyte of a healthy cell is in a great state of activity. It gasses, or throws off a lot of spray, and bubbles of hydrogen appear on the surface. If any of these signs are missing, the hydrometer will invariably indicate a low specific gravity, and if the attendant is positive that none of the faults already described is present in the cell, then it is advisable to add some fresh acid. To do this while the cell shows signs of other trouble, however, is wrong, as a low specific-gravity reading, in many instances, is an indication of trouble other than low density.

The charging and discharging of the battery must not be carried on in a haphazard manner, but must be done so as to conform strictly with the rated capacity of the battery. The charge or discharge capacity is rated in ampere-hours at an 8-hour rate, and for the majority of plates it is [illegible] ampere-hours per square foot of surface on both sides of the positive plates, and about [illegible] ampere-hours per pound of metal in both positive and negative plates. For example, if a battery is rated at 400 ampere-hours, it can be discharged at 50 amperes for eight hours. If discharged at a higher rate for 8 hours or for a longer time at the proper rate, reversals of cells, buckling of plates and other faults will be the result; and if this habit is persisted in the battery will deteriorate rapidly. A 400-ampere-hour rated battery, for example, rated at 8 hours, can be discharged, if conditions are favorable, at 100 amperes for about two hours, which is only 200 ampere-hours, but it would not stand such a discharge rate for three hours or even two and one-half hours if the performance were repeated often. Although in an emergency, such as breakdown, very heavy discharging is permissible, it must not be regularly practised or the plates will not last long.

If for any reason the use of the battery must be discontinued for any length of time,

FIG. 6. NEGATIVE PLATE OF [illegible] CELL

it is best to place it out of commission altogether in the following way: First give a complete charge and draw off the electrolyte. Fill the tanks with water and discharge the battery until the cells fall to about 1 volt each. Then draw off the water and the battery may remain in this condition until it is again wanted.

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Air Compressor Valves

Fig. 1 shows a simple form of valve used in certain vertical air compressors. Some of these valves have no guide other than that afforded by the spring which tends to close them, and a valve of this type will not wear true on the seat. In Fig. 2 is shown another fault in the design of this type of seat; it has not sufficient metal backing. The constant closing of the valve causes the seat to lower, as shown. I have seen them driven down until they struck the piston head of the compressor. Fig. 5 would be a better construction for these seats. Here the proper amount of metal is allowed for the wear and lowering of the valve, and the piston head is recessed to allow proper clearance for the free working of the valve.

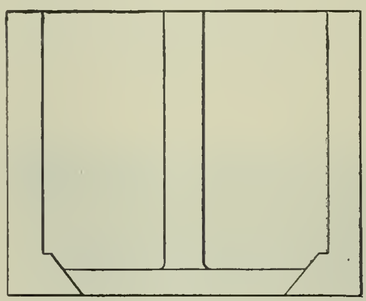


FIG. 1

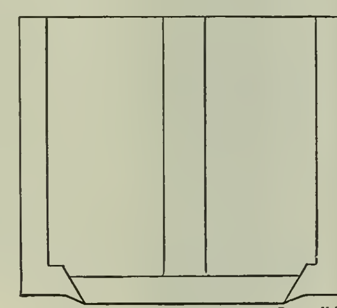


FIG. 2

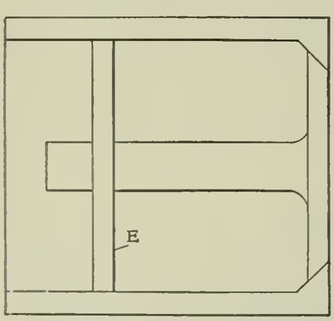


FIG. 3

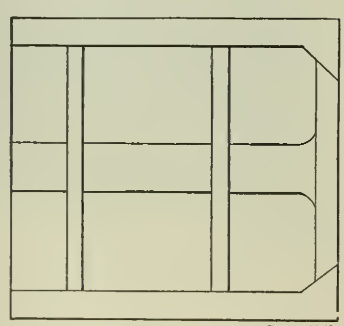


FIG. 4

Fig. 3 shows another form of valve that has a guide disk fast to it. This is somewhat better than the others and will work fairly well on a vertical compressor; but its use on a horizontal compressor would not prove of much value. When they become slightly worn, they will lower on the seat and will hang and leak. The disk *E* might have been made thicker, as it would form a better guide than when so narrow. When narrow in section it tends only to hang the valve when it becomes worn.

In Fig. 4 will be seen a better construction for a horizontal compressor valve, and if these guide disks are placed the proper distance apart, the valve will work satisfactorily, as these guide wings will hold the valve in a true horizontal position. The thickness of these disks should be sufficient to stand the wear.

Fig. 7 illustrates another fault that has been noticed in compressors, that is, the making of the valve too thin as shown by the dotted lines. Were the valve made as shown by the solid lines, the result would be satisfactory. In Fig. 6 will be noticed the Corliss type of compressor valve. I fail to see the advantage gained by the use of such a valve on a compressor cylinder and I think a poppet valve will certainly close more quickly and remain quite as tight. When properly made, the back flow from the compressed air will be less on the poppet type than on the Corliss operated by a crank lever. The Corliss valve will work well at one hundred pounds pressure, but in working air above this pressure it will be hard to lubricate, while the poppet valve can be worked to the limit.

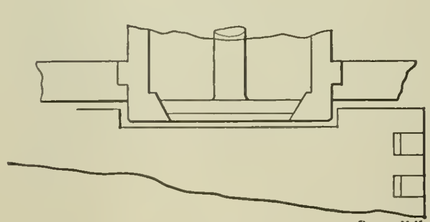


FIG. 5

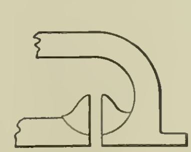


FIG. 6

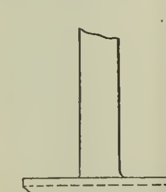


FIG. 7

One other point in relation to compressor valves should be noted; that is, the diameters in which they are made. The same rule will apply here as in a pump. It is better to have two valves than one large one, as the concussion becomes too great when the load is laid on the one. The diameter and the distance traveled by the poppet valve should be watched; too large a diameter and too much travel will cause great pressure and be the means of driving through the seat.

C. R. McGahey.

Lynchburg, Va.

What Is Trouble?

In a recent editorial it was asserted that trouble is frequently the result of ignorance. Undoubtedly the statement is true, but it is not necessarily wilful ignorance. There is a graduation of knowledge from the most ignorant to the most learned and the combined knowledge of every generation is probably but a speck in comparison to infinite knowledge.

There are those who seldom, if ever, have the same trouble the second time. One experience is usually needful to stamp a thing indelibly on the mind. After that it is wilful ignorance to let the same thing happen again. Many engineers make their own trouble as they go along. They haven't learned the lesson of letting well enough alone. They are forever keying up this thing and that, setting valves, regulating governors and "experiencing" generally. There is also a limit to letting things alone, as they will certainly deteriorate with use.

The conservative man who keeps a keen eye out for every evidence of coming trouble, with the view of preventing it, is the man who has the least trouble.

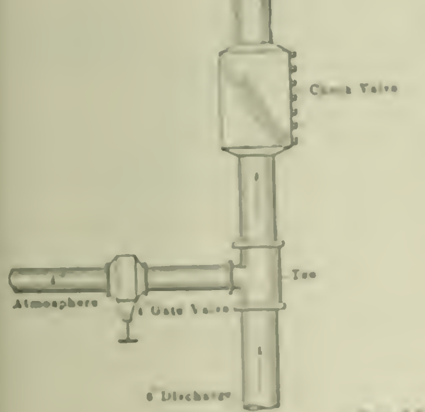
After every phase of the subject has been gone over, however, we must still admit that the best and wisest of men have their troubles.

EDWARD T. BINNS.

Philadelphia, Penn.

Centrifugal Pumps

I recently placed an engine in a small water-works plant to run a belt-driven centrifugal pump of the vertical type placed in the bottom of a circular pit 40 feet deep and connected to a 10-inch well. The discharge was 6 inches in diameter and extended vertically to the surface of the ground, thence horizontally for about 100 feet and discharged into a standpipe 118 feet high. A check valve was placed in the horizontal pipe to keep the water from returning to the well, and as there was always a little sand



CENTRIFUGAL-PUMP CONNECTIONS

when first starting, a 6-inch tee was placed between the check valve and the pump and reduced to 4 inches and a 4-inch pipe led to the sewer. A gate valve was placed in the 4-inch line and closed after the water had cleared. There were no other valves than those described and shown in the sketch.

In starting the pump, the gate valve is opened and the water allowed to flow into the sewer, which it does without lifting the check valve, although it takes more power than it does when pumping into the standpipe. When the gate valve is closed the check valve opens automatically and the load on the engine is decreased 12 per cent., while the amount of water handled is increased 18 per cent.

If it takes more power to pump through the 4-inch pipe to the sewer, why does it not lift the check valve and pump into the standpipe?

A. G. [illegible]

[illegible], La.

Electrolysis and Superheat

I was interested in reading the article by Thomas Sawyer in the March 2 number, under the heading "Electrolysis and Superheat."

It reminded me of several experiences I had which, although electrolysis was not the culprit the action was similar, in eating away brass fittings, etc.

Several years ago the boilers in a certain steam plant were fed from a well on the premises, which gave excellent water containing no scale-making matter, but after this water had been in use for about two years, the plugs in the front manifolds of the down-draft furnaces would blow out. These plugs were brass, and the firemen had several narrow escapes from being scalded. All brass valves and gage cocks were attacked and looked and the affected parts had no resemblance to brass, but looked like dull zinc, and the screwed portions could be crumbled off by rubbing with the hand. An investigation showed this water to be strongly impregnated with ammonia.

In another instance, a boiler in a hotel was being opened for inspection, the engineer was taking out the manhole plate, the inspector standing just behind him. As the plate was taken out, the torch in the engineer's hand ignited a rush of natural gas, which painfully burned both men. Investigation showed that gas was pumped into the boiler from a well, and as the whole house got its supply of water from this well, the gas was distributed throughout the piping. As there was danger of many accidents this well was abandoned.

One engineer was killed in a factory due to an accumulation of sewer gas in his boiler, which had a blowoff pipe leading directly into the sewer. The boiler was blown off on Saturday night, and on Sunday morning the engineer went down to clean it. On taking out the manhole plate above the tubes [illegible] back and his torch set fire to the gas which evidently blew him against the brick wall in the rear of the boiler, crushing his skull. He was found lying across the [illegible]

The theory was that as the boiler was blown empty and, cooling over night, a vacuum was created inside and the sewer gas sucked in through the blowoff pipe.

[illegible]

[illegible]

Knock in Engine Crank

Regarding the knock in the crank of J. W. [illegible] [illegible]

[illegible]

[illegible]

or three thicknesses of paper to allow for future adjustment. We then sweated a thin piece of brass on the side of the brasses, filing them down to a fit, after which we put them together and tried the engine out again. After making a few changes, as regards taking out or adding more paper packing, the pound disappeared and has not appeared since.

In some cases where the collar on the outer end of the pin is a part of the pin itself the brasses may be taken out and a piece of sheet brass sweated onto the sides and then fitted as stated.

CHARLES H. TAYLOR.

Bridgeport, Conn.

Relative Rate of Heat Transfer to Water

The article in the issue of January 12 on "Relative Rate of Heat Transfer to Water at and below the Boiling Point," by W. H. Sawdon, is a good illustration of the very erroneous conclusions that are liable to be drawn from rough and ready experiments. My reasons for thinking that the conclusions the author comes to are erroneous, are as follows:

The temperature of the air on the day of the "bare" test was about 10 degrees lower than when the test with hair-felt covering was made, which of course will account for a large amount of radiation.

That the experiment was very carelessly carried out is evident from the following results:

Bare Test.		Covered Test.	
Time.	Rise of Temp.	Time.	Rise of Temp.
3 min.	31.5° F.	3 min.	18.5° F.
6 min.	30° F.	6 min.	42° F.
9 min.	31° F.	9 min.	31° F.
12 min.	27.5° F.	12 min.	25° F.

In the covered test the rise of temperature in 3 minutes varied from 18.5 degrees Fahrenheit to 42 degrees Fahrenheit. Comment is needless.

The heat capacity of the vessel, the stand and the iron rods, etc., was neglected, which would seriously affect the result and render the test absolutely worthless.

The bunsen burner was sending up a large volume of hot gas, which in passing upward surrounds the vessel to be heated and forms an inclosing wall from which heat will be radiated *to* the vessel during the tests, but the writer of the article assumes that the radiation will be the same when the gas is turned off and heat is being radiated *from* the vessel instead of to it.

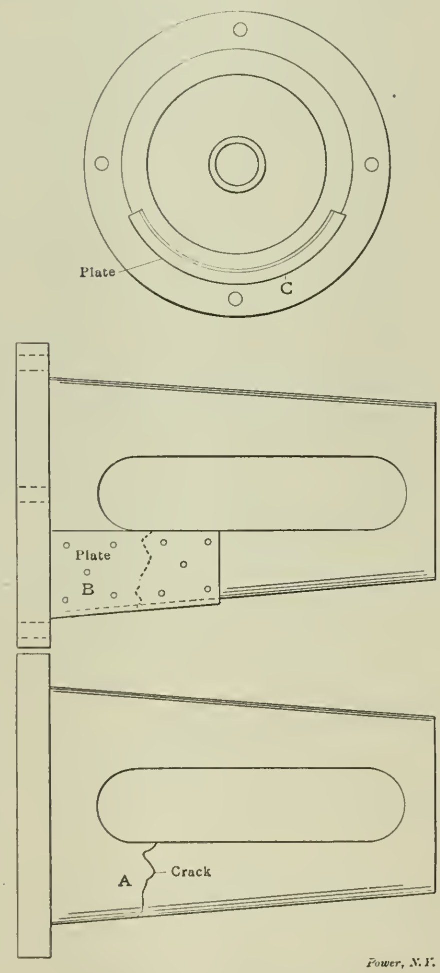
It may interest the writer of the article to know that when very careful tests of this character are made, in which every precaution against error is taken, the rate of transmission during heating of the water is only 2 or 3 per cent. lower than when the water is boiling.

JOHN GOODMAN.

Leeds, England.

Repairing a Broken Bracket

One morning while starting up a large Corliss engine the head-end dashpot became stuck in some manner, and as the trip rose the steam bracket was cracked at *A*. Of course it was necessary to shut down to repair the break, as the bracket was very shaky and liable to crack off at



REPAIRING A BROKEN BRACKET

the top at any moment. Upon telephoning to the representative of the builders of that particular style of engine we were informed that it would be at least four days, and possibly a week, before a new bracket could be obtained. We therefore decided to repair the old one.

The bracket was taken off and carried to the machine shop, where a sheet of iron, about 5/16 inch thick, was found. A piece about 4 inches square was cut from this and bent to fit and inclose the portion of the bracket that was cracked, as shown at *B* and *C*. The plate was then doweled onto the bracket, 10 pins being put on each side of the crack. After this, the plate was smoothed down, polished, and the bracket replaced. It has been run for three years and appears to be in as good condition and as strong as a new bracket, if not stronger.

WALDO L. WHITMARSH.

Phenix, R. I.

Difference in Economy in Large and Small Engines

On page 602, of the March 30 number, William E. Snow gives a graphic illustration of the difference in economy of a large and a small engine for the same work.

Mr. Snow carries the conditions to extremes, but there is one point that is usually lost sight of and that is the resistance to the piston in noncondensing engines to which I understand he refers.

Assume that we had an engine with 160 square inches piston area and 500 feet piston speed. With 33 pounds mean effective pressure it will give 80 horsepower.

An engine having the same piston speed and mean effective pressure would require 50 inches of piston area to do 25 horsepower. Suppose the larger engine should be loaded to 25 horsepower, it would require but 10 pounds mean effective pressure. Add the back pressure, which would amount to 16 pounds, and we have 26 pounds, and

$$\frac{26 \times 160 \times 500}{33,000} = 63$$

horsepower. If, to the 33 pounds we add the 16 pounds to the smaller engine we have 49 pounds, and

$$\frac{49 \times 50 \times 500}{33,000} = 37$$

horsepower. This shows the effect of atmospheric resistance, and is one reason why the small engine shows up so well, everything else being equal.

When it comes to a condensing engine the same thing, but in a different form, enters into it. Previous to 1870, the independent condenser was almost unknown, and the most ordinary engines were run noncondensing.

A man had an engine with 24-inch cylinder and at about this time a barometric column, known as the Ransan condenser, came out and this manufacturer attached one to the 24-inch cylinder and it showed up a saving of nearly 30 per cent.

He reasoned that if the vacuum would show such a result with a 24-inch vacuum, a much larger saving could be effected with a 30-inch cylinder with so much larger area, so he replaced the 24-inch cylinder with a 30-inch one and lost on economy instead of gaining.

This was not caused by any extra cylinder condensation, although that may have helped a little, but it so happened that with the 24-inch cylinder, the terminal pressure was at about atmospheric pressure and he had the benefit of the vacuum the full length of stroke, while with the 30-inch cylinder the cutoff was shortened so much as to reduce the terminal pressure and cut out the effect of the vacuum for a portion of the stroke.

The same thing is done in many cases on a compound engine by carrying a high receiver pressure with a short cutoff in the low-pressure cylinder and cutting out the effect of a large amount of vacuum. It also adds resistance to the high-pressure cylinder and does not get the highest efficiency from it.

Many engineers have learned that the highest economy in a compound engine is obtained by carrying the receiver pressure so that full atmospheric pressure shall be carried as near full stroke as possible in the low-pressure cylinder.

W. E. Crane.

Broadalbin, N. Y.

Oil Frothing Test

In carrying out an oil frothing test a small amount of mercury was placed in a test tube and heated slowly, stirring with a thermometer until the temperature of the steam was reached. See Fig. 1. A drop of oil was then allowed to run down the side of the tube. See Fig. 2. If it frothed, the oil was rejected as containing volatile elements which would be vaporized and which could not therefore be arrested by the oil separator. It was found, however, that if the oil should

FIG. 1

FIG. 2

contain a small amount of water this test would be misleading since the water produces a similar effect. Where the oil froths, therefore, the frothing tests are supplemented by the more complicated flash test.

This matter of testing cylinder lubricants is something well worth knowing by the operating engineer, as it occasionally happens that cylinder oils are used which make the complete separation of oil practically impossible. An oil which is vaporized at steam temperature is to that extent valueless for cylinder lubrication, since the oil gas has no lubricating value, and it would be better economy in every respect to buy the more suitable, although perhaps more expensive oils.

George H. Gibson.

New York City.

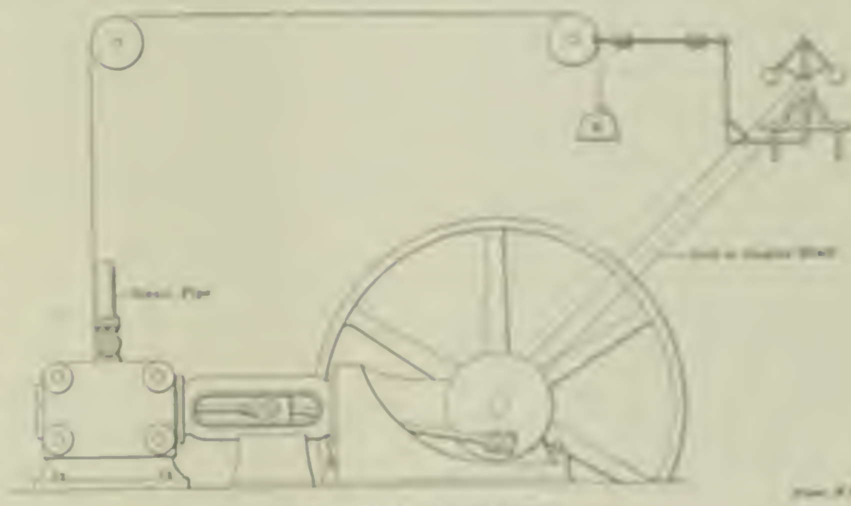
Homemade Engine Stop

Some time ago the writer happened to be in the engine room of a manufacturing plant when his attention was attracted to a rather ingenious device in the way of a homemade engine stop. The engineer explained that from some cause the engine had run away several times and in each instance disaster was narrowly averted. Accordingly, he had set about to produce an automatic engine stop at small cost. The accompanying sketch gives an idea of his apparatus. It is said to have fulfilled its function faithfully several times.

There is a detachable drum secured to the throttle of the engine with enough soft cord wound on it to correspond with the threads on the stem of the valve. The

cord is run over pulleys and connected with a weight of sufficient size to unwind the cord from the drum as it descends, thus closing the throttle. Ordinarily the cord is wound on the drum and the weight suspended at sufficient height to allow the engine to run at its full speed. The drum comes off for starting and stopping and is placed on a hook out of the way.

The scheme for releasing the weight is that of a sliding bar, the end of which is caught under a pin on one edge of the pulley directly over the weight. As it is loosely caught, an inward movement of 1/4 inch will release the weight. The other end of the bar is connected to the upper end of a bell crank which is hinged at the elbow. The longitudinal arm of the



A HOMEMADE ENGINE STOP

bell crank is in contact with the arm of an ordinary flyball governor, which in turn is connected by a belt to the engine shaft. The stud of this governor is adjusted so that it will not act until the engine has reached a speed beyond the range of the regular governor, at which time the arms is passed downward, causing the weight to be released and a prompt shut-down is the result.

Edward T. Brown.

Philadelphia, Penn.

Rope Drive

In commenting on Mr. Myers' "Rope Drive" with which the Wisconsin Central engine is equipped, I was not surprised of "knocking" the rope drive. For the one reason, I think it is a good thing, but of it is an effort to insert a more reliable governor, belts, who will go farther and make it better still. Either you consider the strength of a rope drive you don't stop knowing how its strength is a weakness.

If a governor would not be equipped with a rope drive there is going to be something wrong and then something will be a belt or broken governor shaft.

I believe this risk could be avoided if the friction could be eliminated and I believe a roller bearing would do the trick. If Mr. Myers wishes to do a good act, let him get hold of the "badger's" ear while the animal is in a receptive mood and suggest a roller bearing as a team mate for the rope drive and then he will have something to talk about.

R. McLaren.

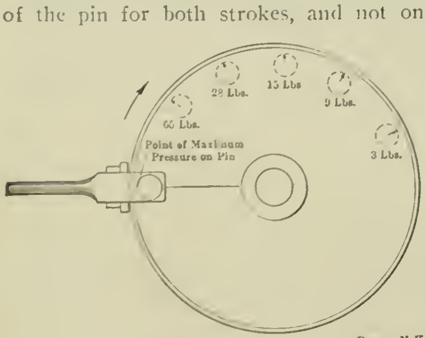
Berlin, Ont.

Flat Crank Pins

Crank pins, in my opinion, always wear more or less flat, according to the amount of pressure exerted on the pin and the material of which the boxes are made. This may be better illustrated by referring to the circle representing the path of travel of the crank pin. Steam is admitted while the piston is at the end of its stroke and carried, presumably, to one-fourth stroke before cutoff is obtained. Consequently, during this period of pin travel, it is subjected to the maximum pressure. After cutoff has occurred the remaining force acting on the pin is produced by the expansion of the steam imprisoned in the cylinder, and as the piston nears the opposite end of the cylinder this propelling force becomes correspondingly smaller until the point of absolute release is reached. This would seem to me to prove that the most wear must be at the point of maximum pressure.

Crank pins fitted with babbitt-lined boxes will not wear as fast as those constructed of bronze, owing to the fact that the babbitt, being of a softer nature than the pin, will more readily wear away. But even in this case, in time a flatness, however slight it may be, will be found at the maximum point of pressure on the pin.

Another point is that the maximum wear on the crank pin is on the same side of the pin for both strokes, and not on



PATH OF TRAVEL OF CRANK PIN

opposite sides, as is very often supposed. This may be understood in a better manner by referring to the pin travel in the illustration and following the supposed travel of the crank pin from one center to the other.

Charles H. Taylor.

Bridgeport, Conn.

Locating Ground in Line with an Ohmmeter

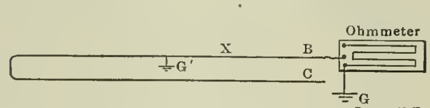
The accompanying sketch shows how to use an ohmmeter for locating a ground on line circuits. The B and C represent the ends of a circuit which is grounded at G', the distance of ground from B being unknown. To determine the distance from B to G' connect the ohmmeter across the line from B to C and get the total resistance of the line which, for example, we will call 4 ohms. Connect one side of the ohmmeter to the ground and the other side to one side of the line B, as shown in the sketch, and read the resistance, which will be the resistance through the line B to ground G' and through to G; call this 11 ohms. Then disconnect the line B from the ohmmeter, connect the line C and take the resistance through the line C to the ground G' and through to G; call this 13 ohms.

The formula for resistance of the line to G' from B, or X, is:

$$11 - \frac{11 + 13 - 4}{2} = X,$$

or 1 ohm.

This resistance divided by the resistance



LOCATING A GROUND WITH AN OHMMETER

of the line per foot gives the distance in feet from B to ground G'.

R. L. Mossman.

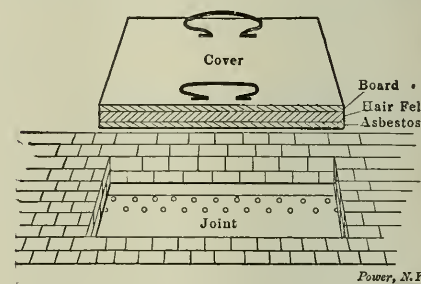
Fremont, Ohio.

Uncover the Joints

In view of the large number of boiler-joint troubles of late, I think it should be made a United States law that in all boilers, whether lap-seam or butt-strap, there should be some convenient way of inspecting the outside of the joint, and especially is this necessary with the butt-strap joint, as it is utterly impossible to detect a crack along the outer row of rivets, which are in single shear, because the inner strap covers a wider area on the inside, and a crack from one rivet hole to another is entirely hidden except from the outside.

Three years ago I was told by an inspector that the company had no record of a triple- or quadruple-riveted double butt strap having given trouble, but from recent reports published in Power, three cases were reported from one company alone. In these cases steam was seen coming up through the brickwork and after removing the bricks a long crack was found. It is singular that all of these cracks have been about 18 inches long, and it is reasonable to believe that these cracks start by degrees.

With the idea carried out as shown in the sketch, the joint can be looked at as often as desired by lifting out the covering with the handle. There are scores of boilers in operation today that are twenty years old and the joint has never been



MR. WALDRON'S SUGGESTION FOR UNCOVERING JOINTS

seen; if uncovered, I have no doubt they would disclose longitudinal cracks.

A. C. Waldron.

Lynn, Mass.

Engine Stopped by Rat

In a large tannery a rat took lunch from the rope-transmission line. The engineer blew the whistle for starting in the morning, but the rat failed to get away and became caught in such a way that his tail extended beyond the rope like a strand.

The rope was protected by a telltale wired to an automatic engine stop so that should the rope strand, it would operate it, and the rat's tail, operating the automatic stop, shut down the engine.

F. S. Palmer.

Chicago, Ill.

A Cause of Engine Wreck

In the letter, "A Cause of Engine Wreck," published in the March 23 number, page 563, by W. E. Crane, the question is asked: "If the long rod of the governor be lengthened and the short one shortened what will be the result?"

The result will be according to the mechanism of the valve gear. Take for instance one type of Corliss engine; to lengthen the long rod and shorten the short one will shorten the cutoff, and if changed enough, the engine will not take steam at all, as the trip collar would be forced under the disengaging hooks.

The proper and only right way to change the speed of a governor of this type of engine is to change the size of the pulley. A weight arm can be attached and a weight added to it, but this makes the engine sluggish. The thing to do is to set the cutoff at the proper point for the load to be carried, and the governor will do the rest.

JOSEPH F. SUMMERS.

Duranga, Colo.

More Frequent Internal Inspection

In answer to H. E. Gansworth's letter in the March 9 number, under the heading, "More Frequent Internal Inspections," I wish to state that there are two sides to this story.

He starts to say there are inspectors and inspectors, etc., but all through his letter he condemns them generally. He may or may not have a grudge against boiler inspectors, or perhaps he sells boiler-cleaning devices. No doubt there are inspectors who do not do their full duty, but there are plenty who do.

In the case he cites where ten wheelbarrows of scale were taken out of the boilers, the inspector was at fault if he did not order a cleaning, but the other case where four 150-horsepower boilers were pushed to their utmost and, after cleaning, three boilers did the work, shows that these boilers must have been in pretty bad shape, due to scale, and no inspector worthy of the name would have called them clean. These three boilers are certainly wonders, as in preceding numbers of Power authorities have shown that experiments with scale showed that a boiler would be in a very dangerous condition due to thickness of scale, without showing perceptible increase in the use of fuel.

I know of one case in particular where the boilers had a slight covering of scale, and the inspectors so reported. These boilers were in good hands, and the scale was kept down to a small amount, and no recommendation was made by the inspectors for better cleaning; in fact, these boilers were in a good general condition, and no fault could be found with them. An "enterprising salesman" came along, induced the manager to buy his tube cleaner, with the usual guarantee, etc. The engineer objected to using it, but the manager insisted. One boiler was experimented on, with the result that all the tubes were loosened in the back head, and as the boiler was 18 years old it had to be retubed, and the owner paid the bill. The cleaner was thrown under the bench.

As to taking out 265 pounds of scale, a large boiler can easily contain that amount without one calling it a dirty boiler, as the scale might be plastered very thinly over the surfaces.

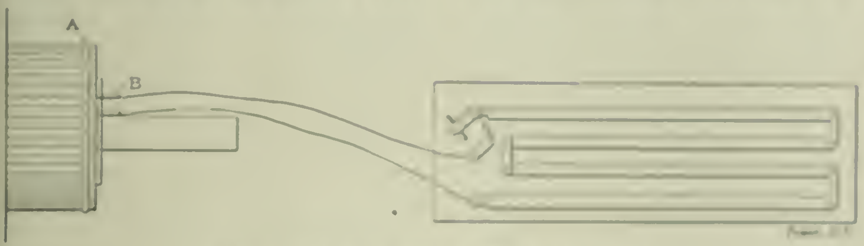
Another phase of this question is that a great many owners, managers and superintendents become very indignant when told by an inspector that the boilers need better cleaning, maintaining that they have a good engineer, who knows his business, and that the boilers have never given trouble from being dirty; and there it ends. I know of many cases where the insurance was promptly canceled until the boilers were cleaned, and kept in a less dangerous condition. I also know that insurance companies are always willing to make suggestions, analyze feed water, and in other ways try to help the owner keep his boilers in good condition.

MILTON HELLER.

Cincinnati, O.

Using the Ohmmeter for Testing Armature Coils

The accompanying sketch shows how to use the ohmmeter (described in a



TESTING ARMATURE COILS WITH AN OHMMETER

late issue), for locating faults in armature coils.

Two small copper clips *B B* are connected to the ohmmeter as shown, these clips being held to each segment of the commutator by a rubber band *A*. Mark the segment as the starting point and take the resistance of the coils between each segment. If the readings show the same all the way around, the coils are in good condition. If one coil is short-circuited its resistance will be less than the others. If a coil is open the resistance will be higher. By connecting one clip to the armature shaft and the other to the commutator the resistance to the shaft can be measured.

In testing the armature coils the lowest resistance in the ohmmeter [illegible] be plugged in as the resistance of the coils is very low. In testing the grounds [illegible] the coils and shaft plug in the highest coil in the ohmmeter. I have [illegible] this one to [illegible] armature [illegible] and [illegible] the commutator.

E. L. [illegible]

[illegible], O.

A Case of Bagging

Some months ago I saw a boiler in a repair shop that had given an unusual history. The sheet over the fire was bagged down 2½ inches over a fairly [illegible] section.

The boilermaker had an order for three [illegible] foot boilers of the return-tubular type. The engineer of the firm from which the order was received directed that the blowoff pipe be inserted in the rear head, 2 inches from the bottom. The engineer stated that he had had 25 years' experience in handling steam plants, and that they could install them as he wanted or some other firm would get the job. In addition he directed that the boilers be set with the front ends 2 inches lower than the back ends. The result was that, in course of time, all three boilers bagged.

EDWARD T. [illegible]

Philadelphia, Penn.

Repairing a Worn Guide

Mr. McCauley's letter in the April 13 number, about a worn guide, particularly interested me as I am a crank on that part of [illegible].

If Mr. McCauley would cut oil [illegible] of both ends of the lower guides, the guide would never wear concave, and if he got it just right, it would not wear enough in years to need taking up, much less re-scraping.

Engineers [illegible] the advantage of [illegible] but they will not listen to the [illegible] and cut off the guides. When I was [illegible] people [illegible] me [illegible] they will do so.

Engineers have [illegible] "How much should I cut off?" Keep cutting them off until they stop wearing concave. [illegible] the surface of the guide. If the [illegible] [illegible] were cut in the [illegible] the guide [illegible].

[illegible]

[illegible]

[illegible]

[illegible]

Will the Load on the Bolts Change?

Referring to G. A. Glick's problem appearing in the March 30 number, I should say that the stress on the bolts in either cylinder would be exactly the same, provided the elastic packing was cut to the exact size of the cylinder, so that there would be no recess between the cylinder and head owing to the packing being cut larger at the inside edge than the diameter of the cylinder, or so that the steam would have the same area to work.

Each of the twelve bolts is placed under an initial stress of 1000 pounds, consequently the head is held against the cylinder by a force of 12,000 pounds and the initial stress on the bolts would not be increased until the total pressure of steam on the head exceeded 12,000 pounds.

One hundred pounds steam pressure per square inch, in this case, would neither increase nor decrease the stress on the bolts, since a pressure of 100 pounds on an area of 120 square inches is 12,000 pounds, and as long as the pressure does not exceed 100 pounds per square inch there would be the same stress on the bolts without the steam pressure as with it, or 1000 pounds on each bolt.

If in this case, however, the pressure should exceed 100 pounds per square inch, more stress would be put on the bolts, as the total pressure of the steam would then be in excess of the 12,000 pounds with which the head is held against the cylinder by the bolts.

RALPH F. BLANCHARD.

Fitchburg, Mass.

We will first consider the case with the ground joint. When the flanges are pressed together they are far less yielding than the studs, and can therefore be considered as noncompressible, and the studs, due to their elasticity, can be considered as springs. In the case of a ground joint with the substitution of springs for bolts, the total area of the cylinder is, as given, 120 square inches and the pressure per square inch as 100 pounds.

Then

$$120 \times 100 = 12{,}000$$

pounds, the total pressure acting against the cover from the inside.

The initial tension on the 12 studs or springs is 1000 pounds each, hence the total pressure holding the cover against the cylinder is 12,000 pounds. This pressure acts in an opposite direction to the internal pressure. To increase the tension on the springs or studs, they must be subjected to a further elongation, and to do this the total internal pressure must be greater than the total initial pressure. Since the external force applied equals the initial stress, the tension on each stud for the ground-joint case is 1000 pounds.

With the packing between the cover and cylinder, we have a different state of affairs. Here we have the flanges and packing in compression and the studs in tension. Substituting springs in place of the elastic packing, the total initial tension on the studs is 12,000 pounds, hence the total stress in the springs acting against the cover is 12,000 pounds, or 1000 pounds per stud. The total internal pressure is the same as in the first case. The direction of the initial and internal forces is the same, hence the total stress on the studs (considering that relatively to the packing the stud is inelastic) will be the sum of the initial and internal stresses, therefore:

$$12{,}000 + 12{,}000 = 24{,}000$$

pounds, or 2000 pounds per stud.

JOHN B. SPERRY.

Aurora, Ill.

Replying to G. A. Glick's problem, we find that the total pressure of the steam is

$$120 \times 100 = 12{,}000$$

pounds. Each of the twelve studs carries 1/12 of 12,000 pounds or 1000 pounds of the steam pressure. This 1000 pounds will be called the external load. Under the conditions of a ground joint, there is practically no elasticity of the parts held together, the stud is comparatively elastic and there is a certain elongation due to tightening up. It is evident that the initial stress, due to tightening the nuts, holds the head in contact with the flange of the cylinder. There can be no separation of the parts until the internal load per stud exceeds the stress due to tightening up, and until the parts separate there can be no additional stress in the studs. Therefore, a load up to and including the pressure due to the stud nuts puts no additional load on the stud. Any load beyond the initial stress will cause a stress in the studs equal to this load. For any pressure less than 100 pounds per square inch, no stress beyond the initial stress is induced in the bolt. As soon as the pressure exceeds 100 pounds per square inch, the surfaces of the cylinder and head will separate.

Consider the parts with a packing between, compared to the elasticity of the gasket, the studs may be considered inelastic. In this case, there is an initial stress due to screwing up, and any additional pressure in the cylinder will act directly on the stud causing an additional stress, and at 100 pounds pressure, there will be a stress of 200 pounds in each stud. The load on the studs is intermittent.

HARRY ANDERSON.

New York City

There are 12 studs from the flange of the cylinder through the head, and the nuts are tightened until there is a tensile stress of 1000 pounds in each of them; there would, therefore, be a force between the head and flange exerted mechanically through the wrench and nuts of

$$12 \times 1000 = 12{,}000$$

pounds, which we will call the "mechanical force."

When a charge of steam is admitted to a cylinder it acts similar to a spring under compression, and tends to separate the head from the cylinder. This has the effect of decreasing the mechanical force, for the simple reason that it takes a part of the stress on the studs remaining constant. And if the steam acts upon an area of 120 square inches on the head and a charge is admitted at 100 pounds pressure, then the mechanical force would be entirely removed because a force of

$$100 \times 120 = 12{,}000$$

pounds, would be exerted against the head and the mechanical force neutralized, leaving the same stress on the studs as before. Therefore, the stress on the studs would be constant for all steam pressures above atmosphere up to 100 pounds. But if there were an increase of steam pressure above 100 pounds, then the stress on the studs would increase an amount proportionate to the increase in steam pressure, and if the steam pressure were below atmosphere, or a partial vacuum within the cylinder, the stress on the studs would decrease a corresponding amount.

CHARLES F. CLARK.

Hartwick, N. Y.

I should say that the strain on the stud bolts is exactly the same when a pressure at 100 pounds per square inch is admitted into the cylinders. As there are twelve studs and each is under 1000 pounds strain we have 12,000 pounds.

This 12,000 pounds is exerted against the end of the cylinder when there is no pressure in the cylinder. When pressure is in the cylinder at 100 pounds per square inch, it gives a total pressure on the cylinder head of 12,000 pounds, which is opposed by 12,000 pounds on the studs. This relieves the pressure between the cylinder head and the end of the cylinder, and I should expect the packing to blow out of cylinder No. 2. The load in pounds per bolt is the initial strain in both cases.

FRANK W. CERNY.

Mesa, Ariz.

I should say that the stress on the studs of each cylinder will remain the same regardless of the style of joint, ground or otherwise; as any stress due to the elasticity of the packing is included in the initial stress of 1000 pounds.

For either cylinder, the stress per bolt due to the steam in the cylinder at 100 pounds pressure would be 100 times 120, divided by 12, or 1000 pounds. The total stress per bolt would be 1000 plus the initial pressure of 1000 or 2000 pounds.

ANDREW B. DURYEE.

New Rochelle, N. Y.

Some Useful Lessons of Limewater

More about the Chemistry of Carbon; Its Connection with Gas Producer Work; A New and Simple Oxidation Table; What a Heat Unit Is

BY CHARLES S. PALMER

In the study of chemistry, go as far as you will, you will never get beyond the chemistry of carbon. We have seen that it has its simple series of compounds, from reduced to oxidized extremes, in which it is imitated by many of the other elements, and several minor but large series of compounds, from reduced to oxidized extremes, in which it is not imitated by any other element. Indeed, in a sense, the compounds of this one element, carbon, are more in number than all the compounds of all the other elements put together. This looks like a large and extravagant statement, and like most large statements it has its qualifying clause, which is that when one speaks of the "compounds of carbon," he implies its compounds with oxygen and hydrogen, and also with certain other helpers, such as sulphur, nitrogen and the like. No element can have compounds without borrowing the union of itself with other elements, and so carbon must borrow the help of other elements to count up its really enormous list of series of compounds.

In these elementary lessons we shall quickly go on with the natural study of nitrogen, sulphur, chlorine, sodium, potassium, calcium, iron and so forth, but one must remember that just around the corner stands carbon with its almost infinite possibilities. If one were asked how one little mind of common students like yourself or myself can hope to master even a small part of all that, the answer is plain and easy. When you are ready for it—not now, but later—just pick out one or two of the simplest hydrocarbons, such as methane and ethane, and master these fairly well, paying attention to the others and higher ones only just enough to see what complexities they offer which are not illustrated by methane and ethane. Then the great subject becomes fairly easy and intelligible. But before we do that we should get some notion of the chemistry of the more important things, such as the common acids and bases, the common reducers and oxidizers, the common water absorbers or "dehydrators," and so on. Also, one must know something of analysis, which is the finding out what are the ingredients of common things.

Analysis is called "qualitative" if it aims simply to find out what ingredients are in any special compound; analysis is called "quantitative" if it aims to find out how much there is of any ingredient in any compound. Thus, one might attack common limestone to find out what elements are in it. One would soon find out that limestone carries only calcium, carbon and oxygen—that would be "qualitative" analysis. But if one should go farther and find out how much there is of each ingredient, calcium, carbon and oxygen, in the limestone—that would be called "quantitative" analysis. As a matter of fact, quantitative analysis does not usually really go on to the exact quantity of the elements themselves, but stops short at certain compounds of the elements. Thus, the composition of limestone is usually not stated in terms of calcium, carbon and oxygen, but simply in terms of carbon dioxide and lime or calcium oxide, thus: One hundred per cent. of pure limestone is made up of some 56 per cent. of calcium oxide and some 44 per cent. of carbon dioxide. That is to say, it acts as though it contained these things in these proportions, for the carbon dioxide is so firmly "fixed" with the oxide of calcium and the calcium oxide is so firmly bound to the fixed gas that they act like one pure substance which is like no other thing in the world. One can easily calculate from the per cent. of carbon dioxide and calcium oxide in limestone or marble how much there is of each, carbon, calcium and oxygen, and if the results of the analysis are calculated out to that point, then the analysis is called an elementary or "ultimate" analysis. But there is another reason why the analysis is usually stopped at the halfway house of calcium oxide and carbon dioxide, rather than at the terminus of carbon, calcium and oxygen, and that is that the substance, limestone, actually falls to pieces in analysis, and the pieces picked up are much like carbon dioxide and limestone; and the results are so stated. If heated strongly, limestone falls into the gas, carbon dioxide (which is collected in a solution of strong caustic soda), and lime (which is weighed as lime). The carbon dioxide unites with the caustic soda to make sodium carbonate, but one does not stop to separate the soda carbonate from the rest of the caustic soda, but simply weighs the caustic before and after the absorption of the carbon dioxide, thinking all the while of the carbon dioxide as an acid anhydride, which it is. The gain in weight of the caustic soda is the carbon dioxide which the heated limestone has given off, and that taken from the original weight of the limestone gives the weight of the lime which is left.

All this appearance of come-happy-go-lucky analysis is all right, if one has first proved by careful "qualitative" analysis that the limestone contains nothing else in it but calcium, carbon and oxygen. If these points are first proved, then the subsequent reasoning as to the carbon dioxide and the lime is all right. But there are some peculiar things about common analysis. One of these strange things is that there is no simple, easy and sure test for most of the oxygen that is contained in the many things about us. It is odd that this thing, oxygen, which makes up one-fourth by weight and one-fifth by volume of the air, which makes up about one-half in weight of the rocks, clay, sand, etc., about us, which makes up about one-half of such things as wood, paper, cotton, bread, etc., it is odd that there is no certain and direct way of testing for this thing, oxygen, except by indirect reasoning and showing that other things are not present in amounts sufficient to explain all the weight of the thing being analyzed. But if this careful searching for other things is once done, and if the reasoning about them is well done, then the inference that the rest of the per cent. not accounted for must be oxygen; this is certain and reliable.

However, the history of chemistry has some good stories to tell about how some good chemists made mistakes in their first analysis and reasoning. The great Liebig once neglected to search for sulphur in a compound which he was analyzing; I believe it was taurine or some similar organic compound, but at all events it was an object lesson for lesser lights to go slowly in their preliminary work of proving the presence or absence of oxygen in things examined. A similar thing happened in reference to the composition of the atmosphere over a century ago, when the great Cavendish tried to absorb a tube of inclosed air by electric sparking of the oxygen and nitrogen over strong caustic soda. He noticed that he could never get complete absorption of the tube of common air, and also noted that there was always a small bubble of what he called "nitrogen" left in his measuring tube or eudiometer. But this small bubble was really argon, the "lazy" gas in the air, which imitates nitrogen in some of its properties and which makes up about one pint in 100 pints of the air. This argon is peculiar in that it makes no real compounds with any other element; and it took a hundred years and some of the best measuring ever done to get on the track of the fact that there is such a thing in the air as argon. It was the English physicist, Lord Rayleigh, who found a funny little decimal, way out in the third or fourth place, in weighing his samples of nitrogen from various sources, which put him wise to the clue. Rayleigh called in the help of Ramsey; the two together discovered the inactive argon, common as air, making 1 per cent. of common air, to the glory of science and the humiliation of the centuryful of chemists who had overlooked it.

The Gas Producer

There are other romances in the history of chemical analysis, but we will go on with the chemistry of carbon, and one matter which you probably are right on the point of asking yourself about is regarding the new-fangled gas producer around the corner. You know something of the burning of coal under your own boiler. You know that you get good combustion, without many calls from the smoke-nuisance officer, and with approval from the "Old Man" at the way you save his coal. But you hear wonderful and almost incredible stories about the large horsepower and the small coal consumption of the new furnace (whose only chimney seems to be the exhaust of the gas engine), which needs to be fired only once or twice a day. Certainly there is something here which is worth noting, and it comes right out of our oxidation tables.

For example, look at the first table which gave carbon, carbon monoxide and carbon dioxide at one end of the table. All that was not for nothing. When carbon burns in the two stages, first to the one-oxide, and then to the two-oxide, it does it work with perfect regard to two things: The exact amounts of carbon and oxygen concerned, and the amount of heat given off; these two conditions of the burning of carbon with oxygen are fixed. Now when carbon first burns to the one-oxide, and later to the two-oxide, it is as though a definite weight has fallen down—first to one precipice, and then to another—just as though the fall of carbon to one-oxide and then to two-oxide were a two-step waterfall. Now in the first step of this chemical waterfall, the heat given out is about 4450 heat units for every one pound by weight of carbon concerned, whereas, the heat given out by the chemical fall of carbon monoxide to dioxide is some 10,050 for every one pound of carbon concerned.

Now, it takes oxygen to let the carbon perform its two chemical falls, and if the furnace is closed then the carbon can get only enough oxygen to make the first fall, namely, to the one-oxide. Then this heat is given off in the furnace, the "producer" it is called, and this heat might be wasted if it were not used in a shrewdly economical way. The heat is used to heat the carbon molecularly next door to the partly burnt carbon; this unburnt carbon is supplied with steam, and this second part of carbon acts with the steam much like a miniature water-gas plant. It makes water gas, carbon monoxide and hydrogen, just as shown in the last lesson. But this tearing apart of the hydrogen and oxygen in the watery steam takes up heat or energy, and this heat is supplied by the first carbon which tumbled down its first step of the two-step chemical waterfall.

The whole of this part burning of one carbon and the water burning of the other carbon is that two parts of carbon have gone over to one part of hydrogen and two parts of carbon monoxide. As far as the heat given out by one carbon and taken up by the other carbon is concerned, that is a case of one hand washing the other. As far as the part burning of two carbons is concerned, which must be set down to the debit side of the chemical account, for coal burned is coal burned, one cannot eat his cake and still have it—all that is true. But, now, just look at the credit side of this double-entry bookkeeping: We have the credit of one part of water decomposed by the extra heat of the first carbon; this is not stolen, but simply taken from one pocket and put into another. As a result, we have the power of two carbons, put into the gas form—note that—the gas form, at the expense of only one carbon burning part way; it figures out about 15 per cent. theoretically used from the total 100 per cent. in the coal.

This coal has got into the gas form, and there is where the economy of the gas engine stands ready to use what good chemistry has produced. It is not our plan to go into the physics or mechanics of the producer-gas engine, but simply to stop here and explain this two-stage chemical waterfall until you see the chemical side of it. I have nothing but hearty encouragement to give to all honest and earnest students of the gas engine. If you have your troubles, so do steam engineers. If the gas engine is sometimes wanting in reliability, so is the steam engine. It took a century of steam practice to get you where you are now, and it may take a few years to get the producer-gas engineer where he wants to be; but one thing is clear, you have got to understand this oxidation table of carbon so that you can see it in your mind's eye at any time.

A Simple Oxidation Table

Now we are ready for a new and simple form of the oxidation table of carbon, that is, the heat table of carbon. Here it is: If the other tables of carbon were worth noting, this one is simply indispensable to you. The one thing that you ought to know about coal is what heat you can get from it. Heat is the one thing that the old world needs, of the material things. Coal is practically heat energy stored up. Here is the problem right up against you. That boiler, that furnace, that engine, with steam waste, with steam economized, may not be the most useful form of saving what Mother Nature has stored up. Note this table. When carbon burns to the first oxide, it gives off some 4450 heat units. Learn that. When this first oxide of carbon burns to the second, it gives off about 10,050 more of heat units. Well, if you put your first oxide into the producer-gas cylinder, which is only a sort of a

HEAT OXIDATION TABLE OF CARBON.

C (1 lb. Carbon) → + O → CO (Carbon Monoxide) + 4450 B.t.u. Heat. + O → CO_2 (Carbon Dioxide) + 10,050 B.t.u. Heat.

Two Stages.

One Stage. → 14,500 B.t.u.

gas cannon, you have all that extra 10,050 heat units to use where it gets in its work. But if you put *two* carbons, in the monoxide form, into the producer-gas engine cylinder for the heat cost of only one carbon, that is, two for 4450 heat units, then the average for each carbon is only some 2225 heat units used, leaving, theoretically, the other 85 ($2 \times 14{,}500 = 29{,}000$; $29{,}000 - 4450 = 24{,}550$; $24{,}550 \div 29{,}000 =$ 84.76 per cent.) per cent. of the heat to be used where it can do its work. Can you beat it?

When a small engine, of some 50 or 100 horsepower can reach an economy which is reached in steam work and practice only by the very largest and most complicated engines, what do you think of this oxidation table? There is a chemical as well as a mechanical side to the burning of coal. Indeed, there are both sides; but I am talking about the chemical side, because it is the side that you need most. You can learn the facts, get them right; the figures are approximately correct. You can figure the ways and means of this wonderful story of the two-stage burning of carbon. One thing to which I want to call your attention is what a "heat unit" is. If we are talking about the B.t.u.

(British thermal unit), that refers to the heat taken up in raising a pound of water 1 degree in temperature Fahrenheit. If you are talking about the French heat unit, the calory, that refers to the amount of heat taken up by one kilo (kilogram, a little over two pounds) of water, in raising itself 1 degree of the thermometer Centigrade (or Celsius, the inventor) and marked C°. In the figures given above, the heat units are of the B.t.u. sort; but whichever way one takes to tell the story of the energy squeezed out of the coal in its degradation from carbon to carbon one-oxide, and then to carbon two-oxide, there is the same chance for economy; and the producer-gas problem has started one of the most interesting possibilities which has appeared in recent times.

All this is the text for much similar study of heat units which will come in from time to time. It is only recently that chemists have realized that the study of compounds and neglecting the heat or energy connected with them is like saving the shells of nuts and throwing away the meat. But now that we are well started, we will be ready to look at either side of the game as it comes on the field. One begins to see that the chemist must not only have his fumes, his balance and all the other suitable apparatus, but also his thermometer. We weigh stuff or matter on the balance. We cannot weigh heat or energy on the balance, but there is one way by which one can measure heat or energy, that is by his thermometer and pocketbook. Coal costs money, because it stands for stored-up energy, and energy, "the power of doing work," is something which we all want. The reason for the great importance of these oxidation tables is that each compound, in its way, stands as a marker of energy lost, used, given out or absorbed. So, after all, one cannot get away from the chemical side of matter and things. We will go right on the next time with the study of sulphur, because it concerns the best of the "king of chemicals," sulphuric acid.

The ninth session of the summer school for artisans of the University of Wisconsin begins June 28, continuing for six weeks. Courses are offered in steam and gas engines, electricity, machine design, mechanical drawing and allied subjects. There are no entrance requirements, the purpose of this school being to offer practical instruction by lectures and laboratory practice to young men in the trades. Certain advanced engineering courses are offered for those having the requisite preparation, and the general university summer session held during the same period allows opportunity for a wide choice in subjects of instruction. Information may be obtained from F. E. Turneaure, dean, College of Engineering, University of Wisconsin, Madison, Wis.

General Electric Company's Report

In his annual report to the stockholders, President C. A. Coffin, of the General Electric Company, states that for the year ending January 31, 1909, the net profits of the company, exclusive of dividends, amounted to $4,802,252.07. There was paid in dividends during the year, $5,214,025, leaving a deficit, to be charged to the surplus account, of $411,773.13, thus making the total surplus on January 31, 1909, $16,102,062.81. The net profits for the year of manufacturing and other companies controlled by the General Electric Company, other than the affiliated companies, in excess of dividends paid by those companies during the year, amounted to about $900,000. Of this amount $750,000 has been taken on the books of the General Electric Company and is included in the foregoing figures.

President Coffin also states that 1908 was marked by severe and continual depression in the business of the company and in consequence since the last report the business has depended largely upon current renewals and supplies, with occasional additions to plant on the part of the older and more prosperous companies. The result has been that the orders received during the year were only 7 per cent. of those received for each of the two previous years, and the shipments were only 63 per cent. of the shipments of 1907.

Vice-President Lovejoy reported total sales billed of $44,540,676, and total orders received of $42,189,017. Orders received during the first half of the year were the smallest since 1904. The outlook for the ensuing year is encouraging, however.

Boiler Defects Due to Bad Feed Water

In the January issue of the *Locomotive*, published by the Hartford Steam Boiler Inspection and Insurance Company, it was stated that of [illegible] boilers examined internally by the company's inspectors during 1908 the following defects, among others, were discovered, all traceable to bad feed water:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment	24,879	1,342
Cases of incrustation and scale	47,[illegible]	1,[illegible]
Cases of internal grooving	[illegible]	[illegible]
Cases of general corrosion	[illegible]	[illegible]
Burned plates	[illegible]	[illegible]
Leakage around tubes	[illegible]	[illegible]
Leakage at seams	[illegible]	[illegible]

The available iron-ore supply of the United States is estimated at [illegible] long tons, and the production of iron ore from the mines of the country in 1907 was [illegible] tons, the largest total ever produced in a single year.

Cost of Installation and Operation of Electric Plants

The cost of the Greenwich station of the London County Council Tramways is given by John Hall Rider, in a paper recently presented to the Institution of Electrical Engineers, as follows:

	Cost.	Per Kilowatt.
Land and buildings	$1,028,920.00	$47.0[illegible]
Piers and river work	200,875.40	8.8078
Engines, turbines, alternators and condensers	[illegible]	26.[illegible]
Boilers and economizers	[illegible]	14.[illegible]
Main and auxiliary switch gear, accumulators, station wiring, lighting, tools, etc.	174,[illegible]	[illegible]
Steam, exhaust and condenser piping, pumps, [illegible] and tanks	167,[illegible]	7.[illegible]
Coal and ash conveyors and [illegible]	22,[illegible]	1.[illegible]
Cranes, turntables, railway track, etc.	[illegible]	1.[illegible]

The operating costs for the year ending December 31, 1908, as given in the following, relate to the first half of the station only:

		Per Unit.
Coal (including unloading and removal of ashes)	$118,206.26	0.4751c.
Salaries and wages, running staff	48,019.20	[illegible]
Oil, waste, water and stores	10,[illegible]	[illegible]
Repairs to plant and buildings (labor and materials)	[illegible]	[illegible]
Management, insurance and [illegible]	8,281.[illegible]	[illegible]
Rents, rates and taxes	[illegible]	[illegible]
Total	[illegible]	[illegible]

Units delivered to substations [illegible]*
Maximum load in kilowatts [illegible]*
Station load factor 47.75 per cent.
Coal [illegible]
(Partly at [illegible] per ton, and partly at [illegible] per ton.)
Coal per unit delivered to substations [illegible]

*It is estimated that, for the year ending March 31, 1910, these figures will be, respectively, [illegible] units and [illegible] kilowatts.

In the answer to Question 2 of an Inquiry regarding "Angle of Deflection, etc., in Crank Shafts," published on page 793 of the April 13 number, there were two typographical errors. In the third column, "M_1 = C" should have been M_1 = C, and in the equation "M_1 = ½ M_2 + ¾," etc., the plus sign should have been used, making it M_1 = ½ M_2 + ¾, etc.

The twenty-seventh annual convention of the Street Railway Association of the State of New York, will be held at Fort William Henry Hotel, Lake George, N. Y., June 29 and 30, 1909.

POWER AND THE ENGINEER

DEVOTED TO THE GENERATION AND TRANSMISSION OF POWER

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During 1908 we printed and circulated 1,836,000 copies of POWER.

Our circulation for April, 1909, was (weekly and monthly) 153,000.

May 4 42,000
May 11 37,000
May 18 37,000
May 25 36,000

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

Contents PAGE

"Power" Sued for Libel and Acquitted

In the summer of 1907 one John E. Carroll, of Philadelphia, undertook the exploitation of an engine to run with carbonic-acid gas. There was no harm in this, for an engine will run with carbonic-acid gas as well as it will with air or steam—but no better. The half-page advertisements of the CO_2 Development Company, however, described the carbonic-acid gas which pours out of every chimney and arises from every fermenting tub as a vast "source of energy." So is water a source of energy, if it is elevated and free to fall. So is air a source of energy, if it is compressed and free to expand. But out of neither the water nor the air can more energy be got than has been expended in elevating or compressing it.

When, therefore, Mr. Carroll maintained that if he charged his engine with carbonic-acid gas under pressure it would continue to run forever if the gas did not leak out, and that under the ordinary condition of stuffing boxes it would continue to run and develop power in large and useful amounts for some thirty days, without any source of energy to draw upon, he stated what was opposed to all the known laws of physics and mechanics; something which, if true, would mean more to POWER and all that it represents than the invention of the steam engine; something which was so thoroughly revolutionary that its possibility could be admitted only after a demonstration positive and satisfying enough to warrant upsetting the principle of the conservation of energy, and all the sciences which are founded thereupon. The demonstration which we attended signally failed to fulfill these conditions. It was a farce. The inventor talked the most arrant nonsense and refused to make the simplest tests to prove that his "demonstration" was honest. The conclusion that the CO_2 engine was a clumsy trick for obtaining money by false pretenses was inevitable, and we did not hesitate to say so. The whole affair was too ridiculous for serious treatment, and so in a two-page article in our issue of September, 1907, we laughed it off the stage.

In consequence of the publication of this article, F. R. Low, its author and the senior editor of POWER, was arrested something over a year later, upon a charge of criminal libel made by Carroll, when Mr. Low was in Philadelphia testifying to what he had seen in behalf of officers and stockholders of the company who had been honestly deceived into lending their names and money to the enterprise and who were then suing the alleged inventor.

We waived examination and were in due course formally indicted by a Philadelphia grand jury. Right here we wish to extend our grateful acknowledgments and thanks to the many friends who have assisted and offered assistance in the matter, especially to Jay M. Whitham, M. E., and A. C. Wood, M. E., whose testimony that they had examined the device and advised clients against investing in it would have been particularly valuable had it been admitted. As it was, however, the judge, after having heard enough evidently to satisfy himself of the nature of the case, ruled out all of our expert testimony and instructed the jury to find for the defendant.

The outcome is a victory for technical journalism, and for the honest inventor and investor. Anything less than so prompt and complete an acquittal might have tended to make editors over-cautious and prevented the prompt and complete exposé of the various get-rich-quick schemes which it is the function of the technical press to investigate and inform its readers about. One can well accept some indignities, and be put to some trouble and expense, for the reassertion of the right of the editor to expose in the broadest and most positive terms what he concludes, after careful investigation, to be a fraud.

First Be Sure You're Right

Engineers of isolated power plants are in many cases seriously handicapped by the inability or unwillingness of their employers to recognize what is necessary or desirable in the way of plant improvements or conveniences. On the other hand, the owners of such plants are not always safe in following out the recommendations of their engineers. For example, a certain engineer, with the laudable desire to increase the operating economy of his plant, urged the owner to discard the existing boiler-and-engine equipment and put in a more modern class of equipment. The old plant included horizontal return-tubular boilers and simple single-valve engines, and his plan was to substitute water-tube boilers and four-valve compound engines, raising the boiler pressure from 100 to 175 pounds. The equipment which he suggested would have been admirably suited to the work and if it had been a question of installing a new plant his ideas would have been eminently practical. He failed to consider, however, that the interest on the net cost of making the change would have been considerably more than the saving in operating expenses. In view of this fact and the additional important fact that the existing equipment was by no means worn out nor seriously out-of-date, the owner refused to make the change. A regrettable result of the discussion was that the owner's confidence in the judgment of the engineer was greatly reduced, although the latter was a thoroughly competent and industrious operating man.

We have known of several similar instances of recommendations based on a conscientious desire to further the owners' interests but not sufficiently well thought out and analyzed before presentation.

The moral is, not to refrain from making any suggestions at all which involve additional investment, but to consider thoroughly *all* of the possible results of carrying out an idea, weighing the disadvantages carefully against the advantages and being prepared to show that the latter would surely predominate. After you are dead sure of your ground, make your recommendation and urge it as vigorously as circumstances will permit.

Boiler Inspections and Explosions

Boiler inspection which does not inspect is worse than none at all, for it issues certificates of inspections which have not been made and guarantees the safety of apparatus which may or may not be safe.

It has been stated on what appears to be good authority that in some localities the inspector walks into the engine room, takes from the wall the old certificates of inspection, replaces them with freshly written ones duly sworn to, and goes to the office to collect the legal fee without even ascertaining if there are boilers in the plant. This is not a report of an isolated case but is a statement of what is claimed to be common practice. In fact, in the report of a recent boiler explosion in one of the Western States the public prints boldly asserted that not only was this the method of "inspection" employed in that instance, but it was generally known to be the customary procedure, a statement which is corroborated by our own correspondence. Of course, hanging would be much too good a fate for a scoundrel who carries on such a conscienceless game. Equally of course, that sort of thing would be impossible without the connivance of someone in authority around the plant, and that someone is fully as culpable as the potentially murderous thief who issues the certificate.

So often has the necessity for competent boiler inspection been urged and so often has the enactment of suitable inspection laws been advocated that anything bearing upon this subject seems almost, if not quite, platitudinous. But it is not easy to sit silent while from Maine to Texas and from Florida to Washington there come almost daily reports of loss of life and destruction of property from boiler explosions that in a majority of instances would have been prevented by intelligent inspection. Boilers have been found operating without safety valves or gage cocks and in one case because the safety valve leaked to such an extent that the fireman could not maintain the required pressure, a plug was screwed into the outlet.

In the territory of absent-treatment inspection for revenue only, where the combined certificate of inspection and perjury is nailed to the wall of the engine room and the fee collected in the office, mysterious boiler explosions occur, while in New York City failures are so rare as to be practically unknown, and in Massachusetts not a single boiler under the jurisdiction of the Massachusetts District Police has exploded.

There have been some boiler explosions in Massachusetts since the enactment of the inspection law, but by a peculiar construction given to the law not all boilers in the State were subject to State inspection and it was amongst the "exempts" that the explosions took place. On the other hand boilers which had been found unsafe and condemned by the State inspectors have been taken outside the State where there were no inspection laws and there erected, operated and burst.

Epidemics which annually cause much loss of life and cost practically nothing in the destruction of property are made subjects for national solicitude and special appropriations, while the dance of death in the inspectionless sections and in the wake of the incompetent or grafting inspector goes merrily on.

The Benefit of Reading

The engineering journal lay on the table unopened. The engineer sat in a discarded office chair, with his legs sprawled out in a manner denoting either laziness or a bad attack of "spring fever." Nothing seemed to trouble the serenity of his musings, not even the thumping of the engine twice at each revolution, nor the hissing of steam from several leaking valve stems and ancient flange packing.

This engineer has no time to read. He frankly said so, and more than that, "readin' an engineerin' journal didn't do no good anyhow."

Someone has said that most of us allow others to do our thinking for us, but here was a case where the engineer did not even go as far as that. He neither thought for himself nor allowed others to think for him, by reading what they had written.

The man who never reads will never amount to anything. If inventors had never read, there would never have been inventions. The greatest inventions known were not the outgrowth of chance, but the result of study, reading what others had to say pertaining to the subjects. If this were not so, the old stage coach would still be in vogue instead of flying machines, the old birch-bark canoe instead of the "Mauretania," the old Watt engine instead of the Corliss and steam turbines.

The clam, by shutting itself up in a shell, never gets anywhere unless "in the soup." It lies buried in the mud and is oblivious to all things. There is no sense in any engineer taking the part of the clam, shutting himself up, content with what knowledge has been drummed into his head. There is no good reason for being buried in the mud of ignorance because it is easier to doze in an arm chair. A man who will take the time to read for one hour each day will be surprised at the improvement that will be made in his knowledge regarding matters of which he was before ignorant.

The smartest man in the engineering profession does not know it all. There is always something coming up that either was not known before or was imperfectly understood. It does not, therefore, reflect any credit on the part of the man who comes to the conclusion that it is not worth his time to read the results of experience and experiments of others who are far above him in the work, and allows his engineering journal to remain unopened and unread.

In the average steam plant, the man in charge may claim, and truly think, that he knows all there is to know about everything in the place, but the chances are one hundred to one that in ninety-nine out of one hundred cases the engineer does not know how many heat units there are in each pound of coal he is using, nor the actual horsepower delivered per pound of coal day after day. Few are certain of the amount of water evaporated per pound of coal, or combustible, what the percentage of ash is, or how much moisture is contained in the coal that his company is paying good hard cash for.

Most engineers know a whole lot about a steam plant, but when they stop to analyze their knowledge they find that there are a good many things they do not know. If there is any doubt about it, take up a copy of your engineering journal, turn to the Question and Answer column and attempt to answer offhand the questions found there. The chances are that the reader will get a jolt that will open his eyes to the fact that there are yet a few things for him to learn. The better read a man is, the easier it will be for him to have a ready answer, but the man who is content to let his journal lie in its wrapper will find himself at [illegible] at all stages of the game.

Everyone is, or should be, looking forward to the time when his salary will be increased or a better position will be tendered him. To the well read man the possibilities are great, but to the ignorant man such times are few and far between.

On April 21 and 22 Florida electric-light men met at Orlando and formed a State electrical association with the following officers: President, H. A. Grant, Orlando; vice-president, W. H. Bostwick, Jacksonville; secretary and treasurer, G. F. Craig, Gainesville.

Boiler Explosion at Fond Du Lac, Wisconsin

On April 27, the warehouse and finishing plant of the Winnebago Furniture Company was totally destroyed by a boiler explosion and resulting fire, the estimated loss, including that to neighboring property by concussion, flying debris and heat, being $100,000. Nobody was hurt, the explosion occurring at 4 o'clock in the morning; had it taken place later in the day there surely would have been some fatalities. Only one man, the night watchman, who had been employed in this capacity but a few days, was in the factory at the time. He was in the boiler room and was blown clear of the building, landing on a pile of ashes, but escaping practically without injury.

Of the boiler room and setting not one brick was left on top of another, as shown in Fig. 1. The top half of the back head and the top part of the shell, supported by diagonal braces, shot up into the air, through the roof, completely over a five-story brick courthouse and down into the main street of the town, two block away, cutting in two like a straw a 10-inch telephone pole and burying itself in the sidewalk. Tubes were scattered in all directions in the courthouse yard, and nearly every window in the structure was broken by the concussion.

As is usual in such cases, the old story about pumping cold water onto the hot sheets of an empty boiler gained circulation as an explanation of the castastrophe. On the contrary, all indications point to the fact that there was plenty of water in the boiler at the time of the explosion, otherwise there could not have been let loose the tremendous amount of energy which must have been necessary to accomplish the destruction. An investigation of the conditions under which the boiler was operated, and an examination of the boiler itself, serve to indicate with considerable accuracy the reason for the disaster.

In the first place the boiler was used for heating purposes only, no power being used in the building, and has served this purpose for years. The boiler was 48 inches in diameter by 14 feet long, being built of ¼-inch iron plates, with ⅜-inch heads. The shell consisted of a large number of small plates, about half the longitudinal seams being double-riveted and the other half single-riveted. In Fig. 3 both types of joint can be seen. The size of plate was not uniform, probably no two plates having the same dimensions, and taken altogether the boiler was of a type commonly built 40 or 50 years ago when materials and manufacturing facilities were meager.

Examination of the metal showed that it was rotten through and through. This was shown not only by the parts of the boiler remaining on the ground and which passed through the fire, but also by the piece that went over the courthouse and

FIG. 1. SITE OF BOILER ROOM, AT BASE OF STACK

FIG. 2. TELEPHONE POLE CUT IN TWO BY PIECE OF BOILER

FIG. 3 FRONT HEAD AND BOTTOM OF BOILER

FIG. 4. PORTION OF BOILER, SHOWING SIZE OF PLATE AND RIVETING

which was not subjected to the fire. As far as could be ascertained, not a single seam let go; the rupture in all cases being in the sheet itself, showing that deterioration of the plates had made the seams the strongest part of the boiler.

When asked at what pressure the safety valve was set, the fireman who had charge of the plant in the daytime asserted that there was no safety valve of any kind on the boiler. A few pounds pressure was all that was necessary for heating purposes, but in order to pump up the boiler it was customary to throttle the stop valve down, so that the pressure would raise high enough easily to operate the duplex feed pump. It is known that the boiler carried 60 pounds pressure by the gage on the Sunday previous to the explosion.

The Rice Roller Relief Bearing

This is something decidedly novel in the bearing line, differing both in construction and application from the usual methods employed and, while not supplanting the regular roller or ball bearing in its legitimate field, has the advantage of being applicable to any overloaded bearing in a very few minutes, such as at noon or night.

These bearings can be applied at either side of an engine flywheel and by the use of calibrated springs can be made to sustain the weight of the flywheel, which would greatly relieve the duty of the journals as commonly applied. They can be applied to any idler having heavy duty at either side of a main driving pulley, carrying both the weight of the pulley and opposing the stresses of the belt.

The bearings can also be placed progressively, trailing from a central power station outwardly to the shafts of lesser duty and at each important point, i.e., where a subdrive exists and as far as may seem feasible in any given case. They are made in three sizes, and in their proportions bear no fixed relation with the diameter of a shaft; size No. 1 is calculated to carry a maximum pressure load of 2000 pounds, size No. 2, 4000 pounds, and size No. 3, 8000 pounds at any reasonable speed. They can be applied in sets of one, two or four, four of the larger ones being necessary in some cases, such as at an engine shaft and wherein the flywheel load might equal or exceed their combined rated capacity, the set of four giving a safe carrying capacity of 10 tons.

FIG. 2. COMPLETE BEARING

In the application of these relief bearings none of the regular bearings is in any way disturbed but simply aided in the performance of its work so that in almost every case the relief bearings could be displaced in a moment's time and without a shutdown, simply throwing the full duty back on the regular journals. These bearings have been tested for three years in one factory, where they are applied to both ordinary shafting and on heavy engine and flywheel duty, as shown in Fig. 1.

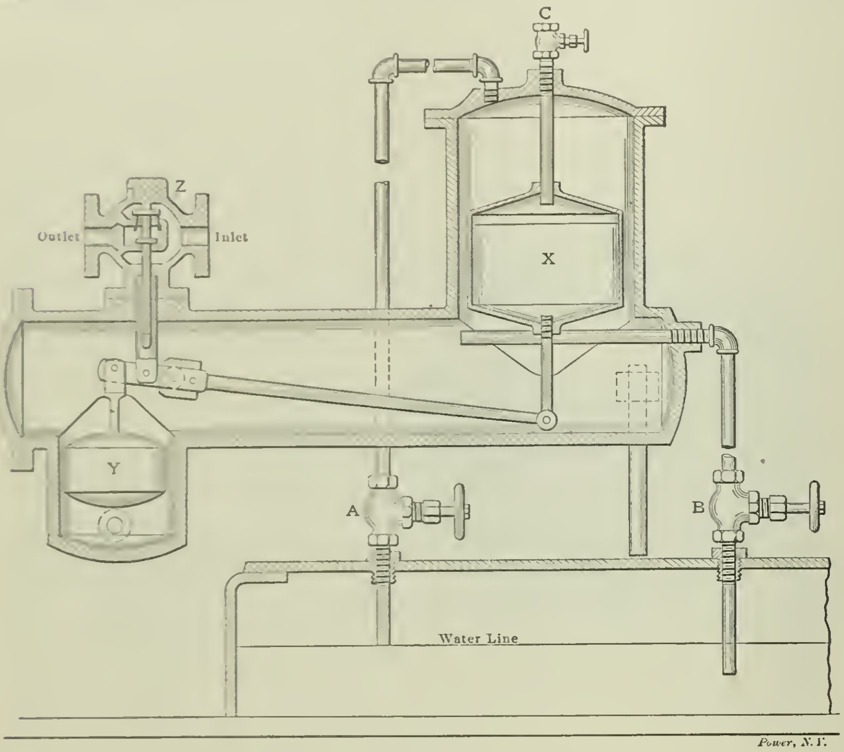
The friction relief bearing is made up of a cast-iron housing, an outer steel roll and a central main roll pin which is stationary in the housing. Between the main roll and the main roll pin are 16 rolls, eight upon each end of the housing and carried in a cage. At each end of the main roll are eight hardened-steel balls. These balls bear upon two hardened-steel washers, one at each end, and take care of the end thrust in the main roll. The smaller intermediate rolls have also at each end a hardened steel washer which takes the end thrust. The main roll pin is hollow, is partially filled with felt and forms an oil reservoir which lubricates the inside of the bearing. One end of this main roll is provided with a series of holes and a stop pin which permits of the oil tube standing in a vertical position, no matter at what angle the roll may stand. All of the other materials with the exception of the intermediate roll cage are of hardened steel and ground to fit.

In service the housing is carried upon a tiller rod, the outer end of this being carried to an overhead support on the upper end of which there is a heavy spring which is calibrated so that by measuring the compression, or giving it a certain amount of compression, a certain load will be carried by the relief bearing. In locating the relief bearing in relation to the shaft upon which it runs, it is so placed on one side or the other of the journal bearing that its action upon the shaft is directly opposed to the forces acting upon the shaft, that is to say, the weight of the pulley and the direction of the belt pull. It is made by the Pickering Governor Company, Portland, Conn.

FIG. 1. APPLICATION OF THE RICE ROLLER RELIEF BEARING

The Senter Feed Water Control

This device consists of a cast-iron body shaped as shown in the accompanying illustration located at some convenient point above the water line in the boiler



SECTIONAL VIEW OF SENTER FEED-WATER CONTROL

and connected thereto by means of the pipe *A*, known as the siphon pipe, extending to the water line, and also with the connection *B*, or gravity pipe, extending somewhat below the water line.

In starting, the gravity connection *B* is opened first, allowing water to fill the apparatus, the air escaping through the vent *C*. As soon as the water reaches the top of the open bucket *X* it will flow into the bucket and fill it. The vent may then be closed and the siphon connection opened, when no farther attention will be required.

Assuming that the level of the water is below the siphon pipe, the water will run back into the boiler by gravity. This empties the housing down as far as the gravity pipe, as shown, and leaves the bucket completely filled with water, exerting a downward pressure on the end of the long lever. Owing to the long leverage, the bucket is much heavier in this filled condition than the weight *Y* on the short end of the lever; consequently, the balanced valve *Z* is opened, allowing feed water to pass to the boiler.

When the water line has been raised until the siphon pipe is sealed by water, the steam in the upper part of the housing condenses and water again fills the space, rising around the bucket and neutralizing the weight of its contained water. As the counterweight *Y* is considerably heavier than the bucket itself, the weight naturally drops and the bucket rises when both are submerged, thereby closing the feed valve.

A blowoff is provided in the drop leg under the weight *Y* and means are also provided for blowing sediment out of the bucket, the vent *C* being continued down by a pipe which acts as a guide when the bucket rises and falls. Blowing out when at its topmost position thoroughly cleans the bucket.

The balanced regulating valve may be reground by removing the top guide plug and inserting a screwdriver in the slot made for that purpose on the top disk. This device is not attached to the water column in any way, but directly to the shell of the boiler as indicated. The regulating valve has an area considerably larger than the feed pipe, and all parts of the control are designed to operate with the minimum amount of attention for long periods. It is made by the Senter Manufacturing Company, Chattanooga, Tenn.

"Firma" Compound High Pressure Water Glass

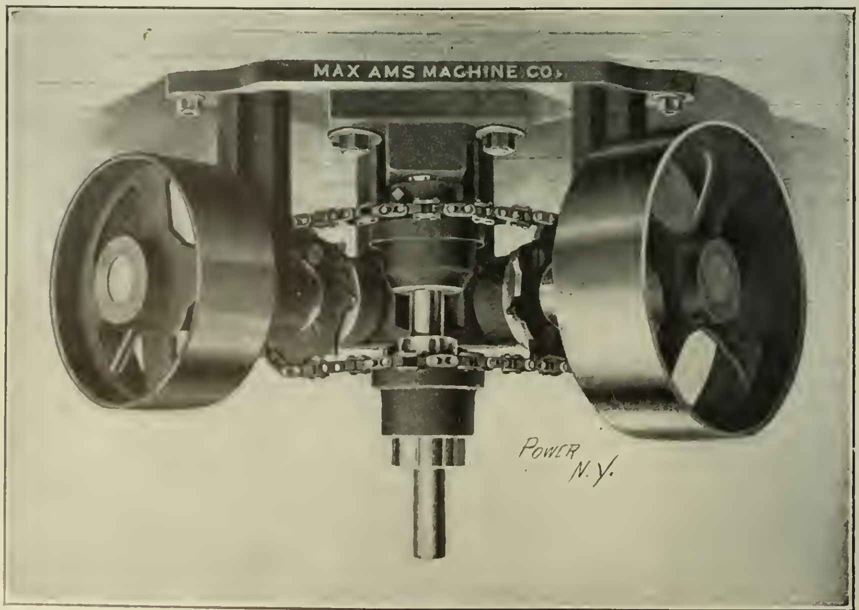
The "Firma" compound high-pressure water-gage glass is simply a glass tube which comes in various diameters and lengths. In appearance, it is a tube of clear white glass, the walls of the tube being about 3/32 inch thick.

The superiority claimed for it is because it is a double tube; that is, one glass tube is drawn over another, the whole being fused into a solid mass. While this junction cannot be seen in the glass, the result is that the inside tube will expand in proportion to the temperature of the water or steam and the outside tube will contract according to the sudden change of temperature which water-gage glasses are called upon to withstand in boiler rooms, locomotives, etc.

This gage glass is manufactured by the Advance Packing and Supply Company, 123 Franklin street, Chicago, Ill.

A Chain Angle Drive

The driving of shafting at right angles is often a serious problem, the latest solution being that of the Max Ams Company, Mount Vernon, N. Y., and illustrated herewith. It consists of four sprocket wheels and a special chain, built with link openings in both directions. This is neces-



NOVEL ANGLE DRIVE

sary to mesh with the idle sprockets on the short vertical shaft and at the same time mesh with the driving and driven sprockets. It is a very simple device and is built to transmit various amounts of power.

American Society of Naval Engineers

The American Society of Naval Engineers held a banquet on Friday evening, May 7, at Rauscher's, Washington, D. C., in celebration of the twenty-first anniversary of the organization of the association. Covers were laid for about 150. While the dinner was attended by all branches of the naval service, the engineers predominated, and among them were many representatives of the American Society of Mechanical Engineers, who were in convention at Washington. The formal toasts were: "The President," Senator M. E. Clapp; "The Navy," Rear-Admiral C. S. Sperry, U. S. N.; "Naval Engineering," Rear-Admiral Richard Wainwright, U. S. N.; "The Navy and the People," Hon. W. E. Roberts. The following also spoke informally: Albert Dawson, representative of Iowa; Prof. F. R. Hutton, of Columbia University, and honorable secretary and past president of the A. S. M. E.; Robert Patchen, newspaper representative, U. S. N.; Hon. Beekman Winthrop and Hon. L. A. Coolidge. The general trend of the addresses seemed to favor concentrated action and harmony between the line and staff. The speeches were all most emphatic and frank and were enthusiastically received.

After the addresses, J. W. Armour entertained with songs and recitals. Rear-Admiral J. K. Barton, president of the association, presided, and Commander W. S. Smith was the toastmaster.

"Power" Editor Acquitted on Libel Charge

The libel suit brought by John L. Carroll, of Philadelphia, against F. R. Low, senior editor of Power, was tried before a Philadelphia grand jury on May 13 and the editor was acquitted, the judge instructing the jury to find for the defendant. Carroll, it will be remembered, is the inventor of the CO_2 motor, which was described in Power for September, 1907, as being a "mechanical fake." This week Carroll himself is to be tried on several counts for obtaining money under false pretenses.

Hans Holzwarth, the inventor of the Holzwarth steam turbine, has perfected a gas turbine which has been tried at Hanover, Germany, with such results that the proprietors have been encouraged to undertake a 1000-horsepower unit.

Ohio Society of M., E. and S. Engineers

The nineteenth annual meeting of the Ohio Society of Mechanical, Electrical and Steam Engineers was held Friday and Saturday, May 21 and 22, at Canton, O., headquarters being at Hotel Courtland. Besides the business sessions, entertainment features, inspection trips, etc., the program included the following papers: "Heat Insulation," by L. O. Hoag; "The Interpole Motor," by Prof. H. B. Dates; "Hot, Soft Water for Steam Boilers," by G. H. Gibson; "Lubrication of Steam Cylinders by Grease," by B. F. Fisher; "Some Practical Points on Power Plant Piping," by Justus Roesser.

Passaic Association's Ladies' Night

Passaic Association No. 15, N. A. S. E., of Passaic, N. J., held a ladies' night in honor of the twelfth anniversary of the founding of the association. Harry Clark, the president, in a few brief remarks, introduced Mayor Fred R. Low, who made an effective address of welcome. An entertainment, which was greatly enjoyed, was given by the "bunch," after which refreshments were served. The members of the arrangement committee are to be congratulated.

BANQUET OF AMERICAN SOCIETY OF NAVAL ENGINEERS, WASHINGTON, D. C., MAY 7

Keystone Association's House-warming

Keystone Association No. 50, N. A. S. E., of Buffalo, N. Y., held a housewarming Wednesday evening, May 12, in observance of the opening of new and beautiful headquarters on the ground floor of the Mutual Life Insurance Company's building. There were fully 400 in attendance and No. 50 should feel justly proud of the success of the event.

Walter McKnight made the address of welcome and Joseph N. Gregory presented the hall to the association.

The following musical program was rendered: Charles Morton, baritone solo; Ethel Smith, piano selections; Arthur Smith, tenor solo; Gertrude Rumage, piano selections. Miss Mary Crage was accompanist. At intervals the following past presidents of No. 50 made brief addresses: William Eskin, John Sturnor, B. C. Miller, Joseph Bubach, Frank Desett, John Hager. Edward Lawler and Winifred Graham, of No. 16, also spoke. Dancing closed the festivities.

Business Items

The third edition of the Smooth-On instruction book No. 7 has recently been printed by the Smooth-On Manufacturing Company, 752 Communipaw avenue, Jersey City, N. J., and a copy will gladly be sent to any engineer or other interested person on application.

The Electro-Mechanical Engineering Bureau has opened offices in the Monadnock Block, Chicago, Ill., for consultation, inspection and tests along mechanical, electrical and chemical lines and is in a position to give expert attention to any technical subject, including the development and design of devices, processes and patentable ideas.

The Fred M. Prescott Steam Pump Company, Milwaukee, Wis., has established a district sales office in the Chandler building, Atlanta, Ga., in charge of R. L. Radcliffe, who has been connected with its sales department for some time. The establishment of the new office was necessary on account of the large volume of business emanating from the southeastern and southern portions of the country.

McEwan Brothers Company Whippany, N. J., has ordered from the Hewes & Phillips Iron Works, Newark, N. J., an 18x34x42 tandem compound-condensing Corliss engine with condensing apparatus. The Bernheimer & Schwartz Pilsener Brewing Company, New York, has ordered one 18x30 heavy-duty tangye-type direct-connected engine to run at 150 revolutions and to be equipped with the new "Franklin" valve gear.

John J. Harman has become a member of the Harman Engineering Company, of Peoria, Ill., the other member of the company being Jacob A. Harman. The company will give particular attention to mechanical-engineering problems, including examinations, reports, designs and tests of steam-, hydraulic- and gas-driven electric-generating plants and determination of mechanical efficiencies of manufacturing processes and machinery.

The Wisconsin Engine Company, of Corliss, Wis., recently put into service the second engine sold to the Oliver estate in Pittsburg. This engine, which is installed in the central power plant, is a 900-horsepower vertical cross-compound Corliss engine, operating at 120 revolutions and direct-connected to a 600-kilowatt direct-current generator. A Wisconsin-Corliss engine of the same capacity, but of the horizontal cross-compound type has been in very successful operation in the same engine room for several years. This company also recently put into service smaller engines sold to the J. M. Kohler Company, of Sheboygan, Wis., and to the Racine Manufacturing Company, of Racine, Wis.

What might be called a pocket-edition general catalog has just been got out by the Joseph Dixon Crucible Company, of Jersey City, N. J. This lists the company's principal products, such as crucibles, facings, lubricating graphite, greases, pencils, protective paint, etc., giving brief descriptions and prices. It is of value to the purchasing agent, engineer, contractor, superintendent and anyone, in fact, who uses or specifies graphite in any form. The booklet is of commercial-envelop size, and will conveniently go in the pocket or desk pigeonhole. It is substantially bound in tough cover stock and attractively printed. If you want a copy address the Dixon company at its home office.

Plans for a new power plant for W. T. Stevens & Sons Company, North Andover, Mass., have been completed by Charles T. Main, of Boston. The plant is to consist of turbine-generator, boiler and pump rooms, with a coal pocket in the rear. The walls are to be of brick. In the 25x50-foot turbine room will be installed a 360-kilowatt Westinghouse turbine generator with two exciters and a motor-driven Le Blanc condenser. The boiler room will be 40x50 feet and equipped with two 72-inch Bigelow horizontal return-tubular boilers with forced draft. Space is provided for a duplicate boiler installation. The pump room is to contain both boiler-feed pump and a 1000-gallon fire pump. The stack is to be of brick, 150 feet high, with a 6-foot flue.

James Beggs & Co., of New York City, manufacturers of the Blackburn-Smith feed-water filter and grease extractor, announce that an increasing demand for this specialty has made it necessary to appoint sales agents in all the principal cities. This filter may now be obtained through the following agents, all of whom have competent engineers to explain its operation and the advantages obtained by its use: Boston, Mass., Walter G. Ruggles Co.; Watertown, Conn., M. J. Daly & Sons; Buffalo, N. Y., Buffalo Mill Supply Co.; Pittsburg, Penn., National Valve and Manufacturing Company; Cincinnati, O., Murdock Manufacturing and Supply Company; Detroit, Mich., A. Harvey's Sons Manufacturing Company; St. Paul, Minn., R. B. Whitacre & Co.; San Francisco, Cal., Plant Rubber and Supply Company; Montreal, H. W. Petrie, of Montreal, Ltd.; Toronto, H. W. Petrie, Ltd.; Vancouver, B. C., H. W. Petrie, Ltd.; San Juan, Lebedjeff & Co.; Georgetown, British Guiana, W. G. Harry & Co.

Among the orders recently booked by the Crocker-Wheeler Company is one for two 1000-kilowatt, 6600-volt, 3-phase, 25-cycle alternating-current generators for the Nordberg Manufacturing Company, Milwaukee, Wis. These machines will be used for supplying light and power to the Miami Copper Company, Globe, Ariz. The Houston Electric Company, Houston, Tex., has purchased an 800-kilowatt, 575-volt direct-current generator. Two 3-phase, 2300-volt, 60-cycle alternators, having a combined capacity of 550 kilowatts, are to be added to the equipment of the municipal plant at Pasadena, Cal. A motor-generator set consisting of a 3-phase, 60-cycle, 2300-volt, synchronous motor and a 575-volt direct-current generator, having a capacity of 300 kilowatts, was sold to the Boise Valley Railway Company, Boise, Idaho. The National Tube Company, McKeesport, Penn., has added to its 22,800 horsepower of Crocker-Wheeler motors to the extent of 275 horsepower for the operation of saws and various rolling mill machinery.

New Equipment

The Michigan Buggy Company, Kalamazoo, Mich., is building an addition and will install new engine.

The San Antonio (Texas) Gas and Electric Company, it is said, will build a new power house to cost $200,000.

The Hill Manufacturing Company, Lewiston, Me., is erecting a new mill. A 700 or 800-horsepower engine will be installed.

The Ark Gravette Cold Storage, Canning and Packing Company has been incorporated with $50,000 capital. Incorporators, E. M. Gravette, J. T. Oswalt, E. L. Chatfield, etc.

The North Carolina Electrical Power Company is to erect a plant near Marshall, N. C., which is to cost about $400,000. C. E. Waddell, Biltmore, N. C., is engineer in charge.

The Original Ice Company, Middletown Township, N. J., has been incorporated with $20,000 capital to manufacture ice. Incorporators, Chas. A. Tantum, W. W. Tamlyn, B. F. Allen.

Plans are being prepared by J. D. Atkins, Department of Public Buildings, Treasury Department, Washington, D. C., for the installation of an auxiliary power plant at the San Francisco mint.

The East St. Louis, Columbia & Waterloo Railway Company will soon start work on construction of proposed electric railway. H. Reichenbach, Columbia, Ill., is secretary and treasurer.

The Cleveland Technical High School

Heating, Lighting, Power and Ventilating Systems in the $400,000 Building Devoted to Cleveland's New Departure in Technical Education

BY H. W. WOODWARD

The Cleveland technical high school, while a part of the public-school system of Cleveland, is in many essential respects unique in educational scheme, as well as in material equipment. The newness of this type of school and the magnitude of the undertaking presented many intricate problems, both educational and material, to those concerned in formulating its plan and in working out the details of construction. The courses offered differ radically from those in other high schools in the city, and are not molded to conform to college entrance requirements. It is intended that this shall be in itself a finishing school, with an atmosphere of manufacture and industry, and steamfitting, clay modeling, pottery, mechanical drawing, leather and art metal work and bookbinding. The department for girls in domestic science has courses in cooking covering the preparation and analysis of foods, the study of food values and the preparation and serving of complete meals, home decoration, physiology and hygiene, home nursing, household accounts, plain sewing, dressmaking and millinery. The full course may be completed in either four years of three terms each or three years of four terms. Night classes are carried on throughout the year in three sections meeting alternate nights. The same equipment and instruction used during the day is available for ments for class rooms, of one square foot of glass to five square feet of floor, although the measurement given includes corridors, basement and all portions of the building. The cost of the building complete, exclusive of shop tools and laboratory apparatus, was $[illegible], or about 15½ cents per cubic foot, a very low price for so complex a building with such elaborate equipment.

The completeness of equipment in drafting rooms and shops is evident from the illustrations. These rooms accommodate from 20 to 30 students each, and the arrangement of schedules keeps the rooms in service most of the day and evening. In the drafting room the designs are pre-

FIG. 1. CLEVELAND'S NEW TECHNICAL HIGH SCHOOL

whose graduates shall be prepared to enter a vocation. In the class room, studies are chosen which have the most immediate and direct bearing on life work, and during the last two years pupils are allowed to specialize in lines where tastes and talents run. The school year is divided into four terms of twelve weeks each, with one week intermission between each term. The school day is divided into two equal parts, one for class room and recitation work, and the other in shop, foundry, kitchen or sewing room. Full courses are given in woodworking, pattern-making, machine shop, foundry, forge and blacksmith shop, bricklaying, plumbing the evening classes. A two years' course in evening work warrants the issuing of a certificate as an evidence of character and workmanship.

The Building

The building contains 63 class and shop rooms besides offices, lunch, rest and toilet rooms, auditorium, gymnasium and power plant, and accommodates 1400 students. The total content is about [illegible] cubic feet, the floor area 125,000 square feet, the exposed wall area [illegible] square feet and the window surface [illegible] square feet. The window area for the entire building is nearly equal to the standard require- pared from which shop work is executed. Drafting tools and shop tools of every description are furnished by the school, and a system of hourly checking guards against loss and misuse. In all of the shops demonstrations of the work to be done are made before the tools are put into the students' hands.

Power Plant Equipment

In Fig. 2 the power plant of the building is shown in plan view. The boiler room, Fig. 3, contains three horizontal tubular boilers, 72 inches by 18 feet, built for 150-pound pressure, and Detroit automatic stokers, with draft-area outtings. The two automatic driving engines are so arranged that either engine will operate any or all of the stokers. A McDonough automatic damper regulator controls the stack damper, as well as the speed of the stoker engines. The stack, which is 150 feet high by 4 feet inside diameter, is octagonal in form and built of brick of the same color and quality as that used in the building.

In the engine room, Figs. 9 and 10, are one 17x10-inch center-crank and one 20x20-in side-crank Skinner engines, each equipped with an automatic oiling system. The engines are direct-connected to 125-kilowatt and 200-kilowatt Burke three-wire generators and run at 250 and 200 revolutions per minute, respectively.

The feed-water heater, Fig. 11, is of the Webster horizontal cylindrical type, with receiving, purifying and heating tank having 40 cubic feet of water storage capacity, and piped as an induction heater. The two boiler-feed pumps, 6x4x8 inches, furnished by the Platt Iron Works, are adapted to pump hot water and are so connected that they may be run separately or together. They are equipped with ratchet-drive lubricators, Squires pump governors, and have a Bristol thermometer in the discharge line. The oiling system consists of storage tanks for cylinder and engine oil located in the boiler room, and each is piped to a funnel on the outside of the building, so placed that an oil barrel can be emptied direct from the wagon, and to faucets on the wall of the engine room. A gage board with a full set of nickel-plated gages connected to the high-pressure steam lines and heating system, a switchboard and the auxiliary apparatus for the Power's temperature control and the Webster vacuum system complete the engine-room equipment.

Heating and Ventilation

The system of heating and ventilating is a combination of direct radiation and mechanical ventilation, the direct radiation being proportioned to supply the heat losses through walls and windows with steam circulating at or below atmospheric pressure. The ventilating system is designed to supply fresh air at a constant temperature of 70 degrees Fahrenheit to each room. The direct radiation for each room was figured from outside wall area, window area and exposure to wind and points of the compass. The formula used was developed during the progress of design, being a modification of one generally employed, and results have proved its correctness.

Assuming an outside temperature of zero degree Fahrenheit, a room temperature of 70 degrees Fahrenheit, steam in the radiators at atmospheric pressure, and cast iron radiation emitting 250 B.t.u. per hour per square foot,

$$R = 0.28 \left(G + \frac{W}{4} + 0.02\ NC \right),$$

where

R = Radiation required in square feet,
G = Area of glass in square feet,
W = Area of exposed wall in square feet,
C = Contents of room in cubic feet,
N = Number of air changes per hour, due to leakage around windows =

$$\frac{G}{W} \times \frac{1}{(\textit{number of protected sides})}.$$

N has values varying from 1/2 to 1/7 depending upon window area and number of exposed sides. The radiation in rooms having a northern exposure and open to a free sweep of the wind was increased about 10 per cent. above that given by the formula. The direct radiation totals about 15,000 square feet in 265 units. Except in the auditorium, locker rooms and corridors, wall radiators of ornamental cast iron are used. These are tapped at the top for steam and at the bottom for returns, and are set with a pitch of 1 inch in 10 feet. Floor radiators are two-column cast iron and tapped for a single pipe connection. All cast-iron radiation was furnished by the American Radiator Company. In the gymnasium locker rooms are coils of 1-inch pipe, supported from the ceiling on roller hangers.

For the heating system the steam piping is laid out for overhead distribution and for downward flow both of steam and condensation, and is graded to 1 inch in 10 feet. Piping is of standard weight, National Tube Company's make, and fittings and valves were made by the Crane Company. Excepting risers, all piping is covered with 85 per cent. magnesia put on by the Philip Carey Company. A 6x12-inch Kieley pressure-reducing valve with a 2½-inch bypass connects the high-pressure steam line to the heating system, and a Davis 10-inch vertical back-pressure valve is placed on the exhaust beyond the point where connection is made to the heating main. The exhaust head is a Swartwout 10-inch cast-iron head, and the steam separators at the engine throttles are Swartwout vertical separators. A Webster 10-inch horizontal oil separator connects the engine exhaust to the heating mains, and this is drained by a Webster low-pressure grease trap. The steam lines are drained by Anderson traps.

The ventilating system was designed to supply to each room by means of blowers, 30 cubic feet of air per minute for each occupant, at a constant temperature of 70 degrees Fahrenheit, and to remove air from the rooms with exhaust fans. The horizontal ducts from the blowers to the risers are built of brick and concrete under the basement floor, and the risers, both supply and exhaust, are of galvanized iron. Each supply riser has an adjustable deflecting damper at the bottom to insure proper distribution of air, and starting at the floor level of the room which it serves, the riser is widened till it reaches the outlet, in order to secure a low velocity for the air delivered. The riser is coved at the top and has a coarse horizontal screen below the outlet, but the opening, which is about 7 feet above the floor, is not covered by a register face. On account of the large amount of air

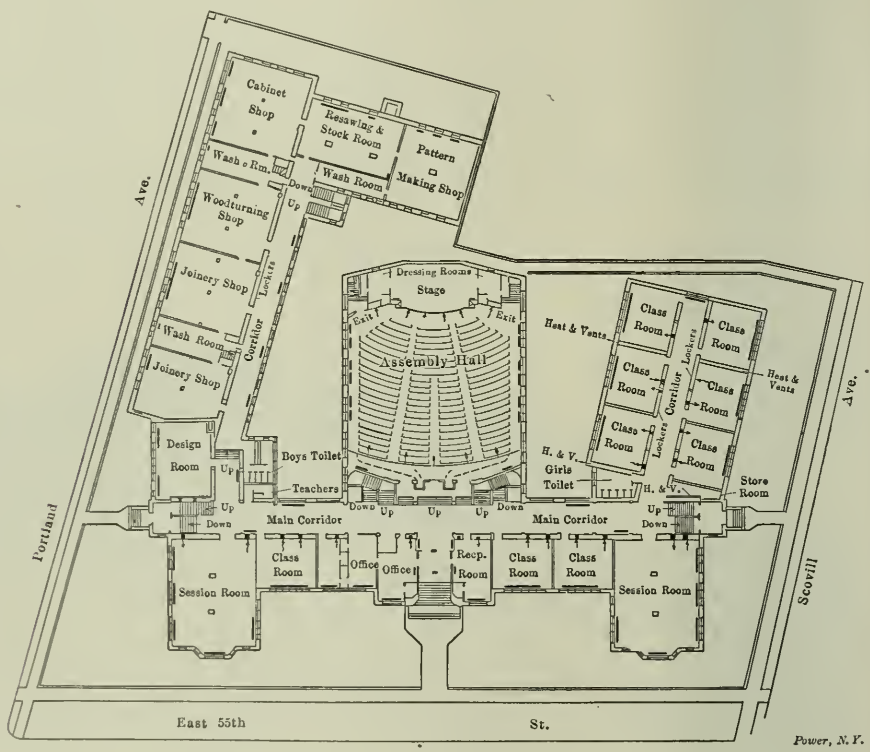


FIG. 2. PLAN OF FIRST FLOOR

FIG. 3. PATTERN SHOP

FIG. 4. MACHINE SHOP

required for the auditorium and the gymnasium, special plenum chambers are provided at the entrances to those rooms. The vent flue in each room starts from the floor level, and the opening is covered by a register face, just inside of which is placed a curtain of light aluminum flaps hanging horizontally and overlapping each other by about 1 inch. This acts as a most effective check valve on the vent system, allowing the air to pass freely from the room, but preventing any backward flow. Vent flue outlets for the auditorium extend across the full width of the stage and open into a special vent chamber under the stage floor. The vent flues discharge into the attic spaces, and at the upper ends have volume dampers to regulate the amount of air drawn from each flue. The tiers of closets on either side of the building, and the chemical laboratory have each its special exhaust system.

Air is supplied by three 8-foot and one 9-foot steel-plate single-inlet bottom horizontal discharge fans with housings specially designed to suit the conditions of the building. Each 8-foot fan delivers 41,000 cubic feet of air per minute at 160 revolutions per minute, using from 15 to 20 horsepower, and the 9-foot fan delivers 54,000 cubic feet per minute at 160 revolutions per minute with 20 to 25 horsepower. Three of the fans are belted to Burke motors, while the one supplying the shops is direct connected to an 8x10-inch horizontal center-crank engine with automatic throttling governor, designed to run at 200 revolutions per minute on a steam pressure of 100 pounds. The exhaust fans comprise four 60-inch electric propellers running at 200 revolutions per minute and delivering 30,000 cubic feet of air per minute; two 45-inch steel-plate exhausters, with a capacity of 4500 cubic feet of air per minute at 1100 revolutions per minute, connected to the closet exhaust system; and a No. 3 Monogram exhauster with a capacity of 1500 cubic feet per minute, on the exhaust system of the chemical laboratory. All fan motors are provided with Cutler-Hammer standard fan regulators with automatic overload release, which are capable of reducing the speed of the fan to one-half of the normal rating. The tempering coils for the 8-foot plenum fans contain 5000 lineal feet of 1-inch pipe, and those for the 9-foot fan contain 7200 feet. The plenum and exhaust fans, direct-connected motors, steam engine and tempering coils were furnished by the B. F. Sturtevant Company.

The Webster vacuum system is applied both to direct radiation and to the tempering coils, each unit of radiation and each drip point having a Webster water-seal motor which prevents the escape of steam while permitting the discharge of air and water. An 8x12x12-inch Webster vacuum pump brings all condensation back to the engine room, and a vacuum governor controls the pump speed and maintains any desired degree of vacuum in the return lines.

Every important room in the building is provided with the Powers system of automatic temperature control. In the larger class and session rooms, automatic control is applied only to part of the radiators, while the balance have hand control. In shops, gymnasium and auditorium, the radiators are grouped on submains, each group having automatic control. The tempering coils at the fans are divided into three sections, each section with an automatic valve adjusted for a different temperature range, and under the coils

FIG. 5. FORGE SHOP

FIG. 6. DRAFTING ROOM

are the air bypass dampers. The diaphragm valves for radiators and tempering coils, numbering 120, have graduated control maintaining a partially open position and supplying just steam enough to do the heating required; the diaphragm gymnasium and apparatus rooms, carbon lamps are used. The shops have individual drop lights over each machine, and in the drafting rooms the adjustable lamps are wired from the floor. The gymnasium is lighted by ceiling clusters sential to match colors and fabrics at night. In the boiler and engine rooms are Cooper-Hewitt mercury vapor lamps. Sixty electric motors, ranging in size from ½ to 30 horsepower, are in use for shops, ventilating fans, elevators, etc. The

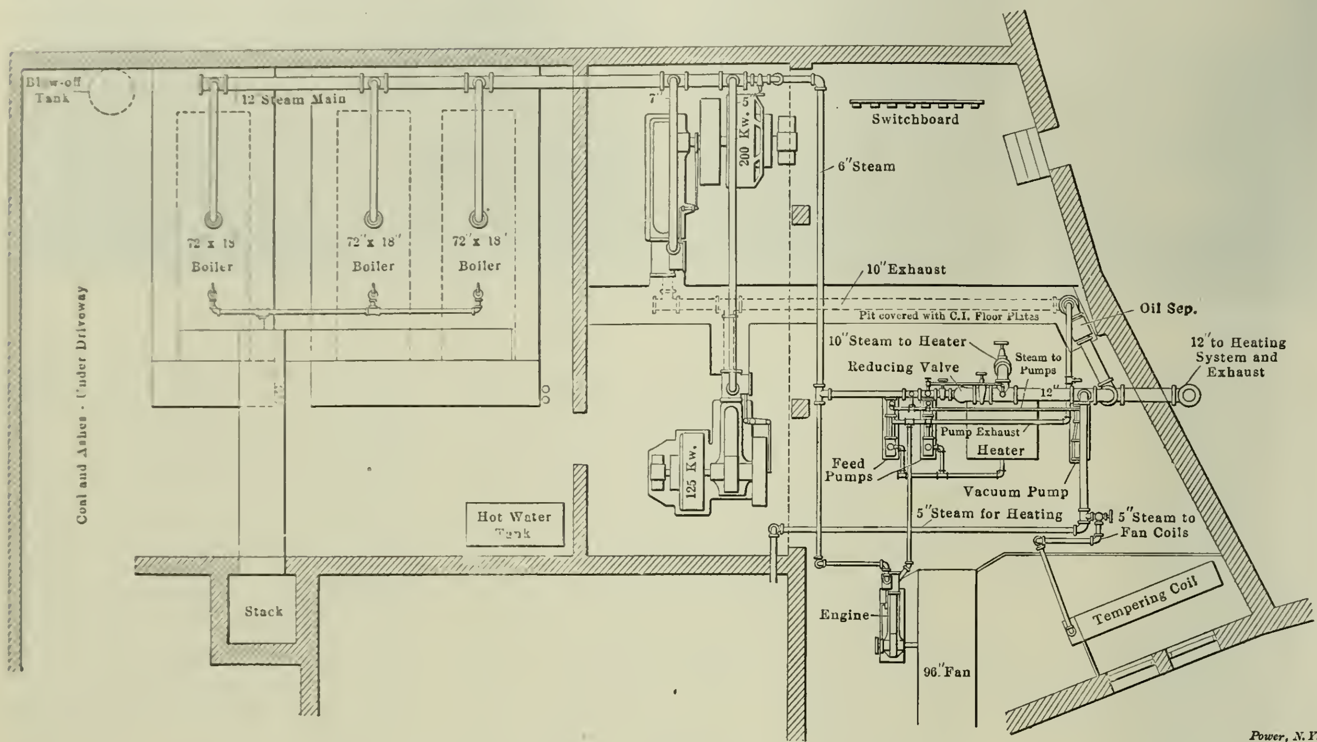


FIG. 7. PLAN OF ENGINE AND BOILER ROOMS

motors on bypass dampers operate with a graduated motion maintaining any intermediate position required. The thermostats controlling the direct radiation, numbering 70, have for a sensitive element a hollow corrugated-metal disk containing a highly volatile liquid, and operate the valves with a temperature variation of one degree. Compound-duct thermostats near the fan delivery control the diaphragm valves on the tempering coils and the diaphragm motors on the bypass dampers. At the delivery of the disk fans in the attic are doors operated by diaphragm motors controlled by air cocks. The air compressor, which furnishes the motive power for the system, the driving motor and automatic switch made by the Powers Regulator Company, the switchboard with air cocks for attic damper control and the storage tank under pressure of 15 pounds are located in the engine room. Piping of galvanized iron and armored lead tubing connects with each thermostat, valve and diaphragm motor.

FIG. 8. BOILER ROOM

Lighting

The scheme of lighting conforms to the specific requirements of the several rooms. For general illumination in class rooms, corridors and auditorium, there are 530 60-watt tungsten lamps. In shops, drafting rooms, locker and toilet rooms, of carbon lamps protected by metal cages; the auditorium by tungsten lamps in ceiling clusters with holophane globes and carbon lamps at the sides; the stage by carbon lamps. There are 34 single-glower Nernst lamps used in the art, millinery and dressmaking rooms where it is es- lighting system has three-wire distribution, with both two- and three-wire circuits for shop motors. Seventeen distributing cabinets for light and power are located at convenient centers of distribution and so wired that a very close balance is maintained on the lighting cir-

FIG. 9 SMALL GENERATING SET

FIG. 10 THE 200-KILOWATT UNIT

cuits; all lights not controlled direct from the cabinets are operated by Hart single-pole flush snap switches. The neutral is thoroughly and permanently grounded at the switchboard, and the neutral of the feeder circuits is not brought up to the feeder panel. All wiring throughout the building is in metal conduit, and the cables from the generators to the switchboard are lead covered and laid in vitrified tile.

Switchboard

The switchboard, Fig. 12, comprises two generator and two feeder panels, with the necessary switches, I. T. E. circuit-breakers and instruments, and provides for 21 circuits. The ammeters and voltmeters are Weston round-pattern back-connection instruments, the ammeter on the feeder panel being a two-way instrument with a 100-0-300 dial. On the end feeder panel are Sangamo 1500-ampere shunt total-output wattmeters. The first feeder panel contains voltmeter and ammeter switches of special design, by means of which the voltage can be read across the terminals of each generator, across the outside busbars, and from each outside bus to the neutral, and the current in any circuit can be determined. Shunts are placed in each circuit, and each feeder switch is labeled and numbered corresponding to the number on the ammeter switch. Fuses and cutouts for the feeder circuits are mounted on separate marble blocks at the back of the board. The board is of blue Vermont marble 2 inches thick by 7 feet high, and the ends are closed in by a heavy-mesh wire netting with oxidized copper finish. The switchboard and panel boards were built by the Cleveland Switchboard Company.

Test Data

During the winter of 1908-9 a series of tests were made on the heating and ventilating system and the power-plant equipment. The air supply to each room was found to be very close to the calculated amount. The plenum fans under normal running conditions handle 120,000 cubic feet of air per minute, and during the 9 hours' run deliver 3200 tons of air. The power required to drive them is 55 horsepower, and to drive the exhaust fans, about 20 horsepower. The air is delivered at a temperature of 70 degrees Fahrenheit and with outside temperature at 30 degrees Fahrenheit, 120 pounds of steam per minute is condensed in the tempering coils, requiring 200 boiler horsepower and 4½ tons of coal a day to heat the air for ventilation alone, with a correspondingly greater amount for a lower temperature. A chart from the recording thermometer is reproduced in Fig. 13. From 6:30 to 7:30 a.m., while the building was being warmed, the temperature regulation was out of service and the air heated to 130 degrees Fahrenheit, but during the rest of the day the temperature was maintained very close to the 70 degrees. During the month of January, 1909, 270 tons of coal were burned, 3,150,000 pounds of water evaporated and 17,000 electrical units used, and at no time was the exhaust from the engines sufficient to heat the building. Tests on boilers, engines and generators were made at intervals, of which the following are average results:

BOILER TEST.

Kind of boilers	Horizontal tubular
Size of boilers	72"×18'—72—4" tubes
Heating surface, each	1800 square feet
Type of stoker	Detroit automatic
Fuel	Bituminous slack
Number of boilers in test	2
Duration of test, hours	8
Average steam pressure, pounds	95
Average temperature feed water, degrees	[illegible]
Average draft in uptake, inches of water	0.28
Average per cent. of moisture in steam	2.2
Average draft over furnace, inches of water	0.17
Average CO_2, per cent	11.7
Average oxygen, per cent	7.8
Calorific value of dry coal, B.t.u.	11,000
Total horsepower, rated at 12 square feet per horsepower	400
Average boiler horsepower developed	[illegible]
Apparent evaporation per pound coal as fired, pounds	7.31
Equivalent evaporation per pound coal as fired, pounds	7.96

FIG. 11. AUXILIARY APPARATUS

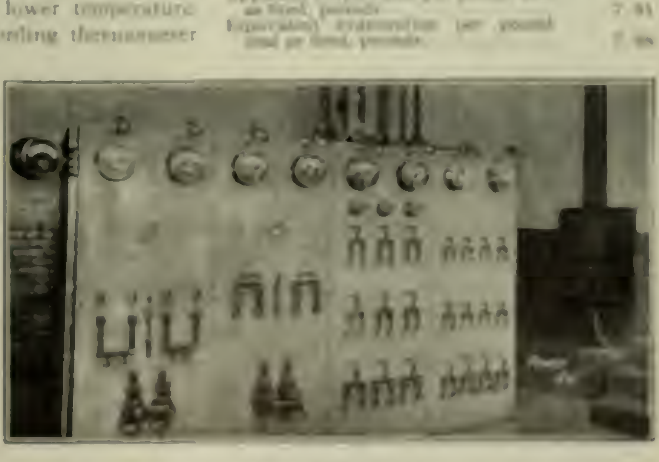


FIG. 12. SWITCHBOARD

Equivalent evaporation per pound dry coal, pounds	8.35
Equivalent evaporation per pound combustible pounds	10.13
Efficiency of boiler furnace based on dry coal, per cent	67.3
Percentage of steam used by stoker engine, per cent	2.25

ENGINE TEST.

Make	Skinner simple, noncondensing.
Type	Side crank.
Cylinder dimensions, inches	20x20
Average steam pressure, pounds	96
Average back pressure, pounds	1.33
Average speed of engine, r.p.m	196
Average indicated horsepower	306
Dry steam used per kilowatt-hour, pounds	46.8
Dry steam used per electrical horsepower-hour, pounds	35
Dry steam used per indicated horsepower hour, pounds	30.2

GENERATOR TEST.

Make	Burke direct-current, three-wire..
Rating at 250 volts, amperes	800
Average voltage	235
Average amperes	840
Average load, kilowatts	198

James F. Barker, under the general direction of Superintendent of Schools William H. Elson. The operation of the plant is in charge of the engineer, William C. Clark. The building was formally dedicated by the Board of Education and delivered to Director of Schools Charles Orr on April 15, 1909.

The Growth of the High Speed Engine

On Tuesday evening, May 11, an abstract of a stenographic report of a lecture on "The Growth of the High Speed Engine, or The Straight Line Engine in Particular," by Prof. John E. Sweet, was

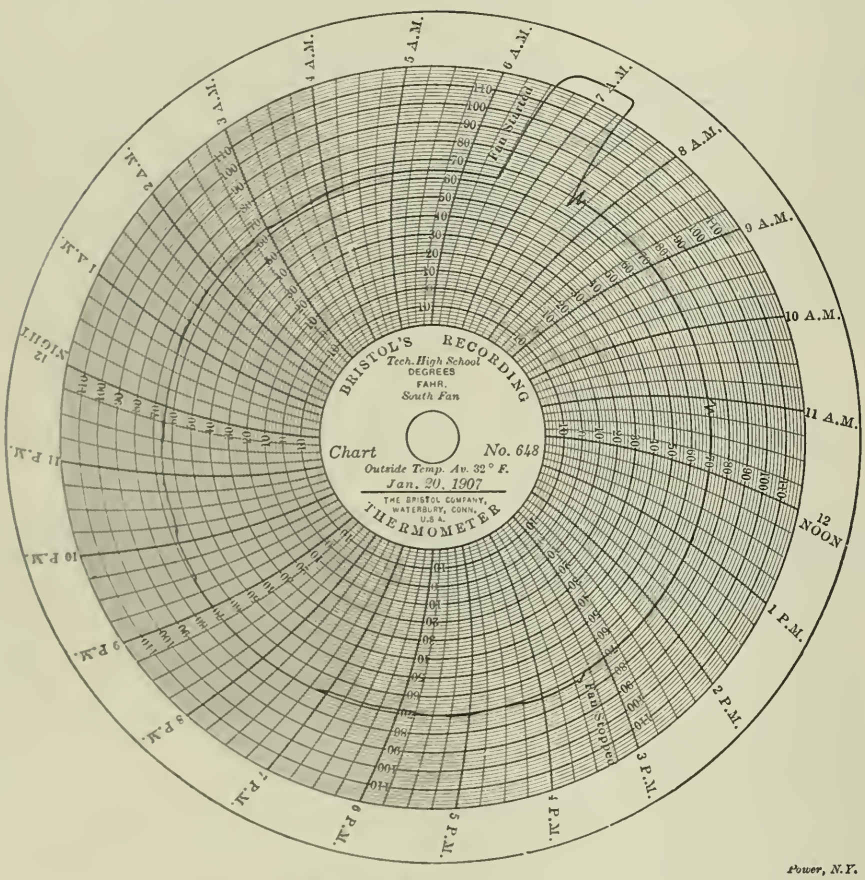


FIG. 13. CHART FROM RECORDING THERMOMETER

Temperatures at end of run, deg. C.	
Room	28
Commutator	53
Armature	49
Shunt field	41
Series field	56

The educational scope and material features of the school were outlined by a commission of prominent Cleveland men appointed for that purpose. The designs for the building were prepared by Architect of Schools F. S. Barnum, and the details of the heating, ventilating and lighting systems and power plant were worked out by Charles A. Cadwell and H. W. Woodward of The Cleveland Engineering Company. The administration of the school is in the hands of Principal

read before the Modern Science Club, of Brooklyn, N. Y. Thirty-five lantern slides were used. Professor Sweet was not present. An animated discussion followed the reading of the paper, which was in part as follows:

Professor Sweet's Paper

In treating of this subject I shall, both from necessity and choice, rely entirely upon my memory. Just who built and ran the first high-speed engine would be hard to determine, because it turns upon what we call high speed in revolution and what we now know as high speed originated in about this way:

At the time when Charles T. Porter was building steam-engine governors, Horatio T. Allen, who was later associated with Mr. Porter in building the Porter-Allen engine, conceived the idea that he wanted an engine with a positive valve motion that would give the results of the Corliss engine.

In their natural intercourse, Mr. Porter suggested to Mr. Allen that with his valve motion the engine could be run at a much higher speed. Mr. Allen had not thought of this, nor taken to it very enthusiastically. Mr. Porter worked out the idea, and among other things had built and exhibited one of their engines at the London exhibition of 1862, where he astounded the English engineers by the speed at which it ran, although it was

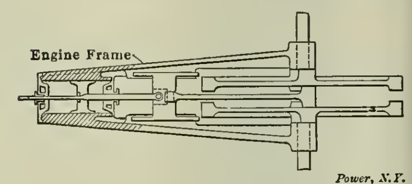


FIG. 1. FIRST PENCIL SKETCH, LATE IN 1869

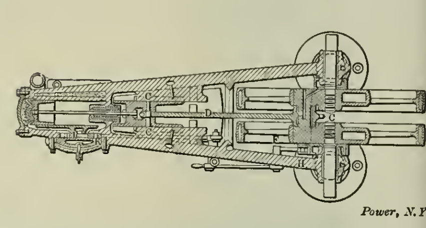


FIG. 2. HORIZONTAL SECTION OF FIRST ENGINE

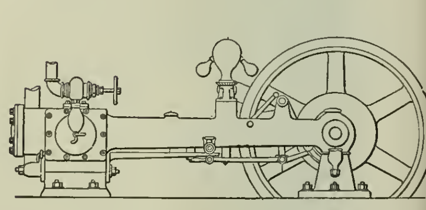


FIG. 3. ORIGINAL ENGINE, FLYBALL GOVERNOR

what we would now call moderate speed.

At that time I was a draftsman in the international patent office, London, and traced on parchment the drawings of the Richards indicator (of which Mr. Porter had charge). I believe I saw Mr. Porter, although I did not make his acquaintance. However, we met at the Paris exhibition, where Mr. Porter exhibited five engines built at the Whitworth works in England. The largest one, 12x24 inches, ran a portion of the machinery, and at the speed of 250 revolutions per minute, if I recollect correctly. This engine had a condenser of Mr. Porter's design, in which the pump plunger was connected directly to the tail end of the piston rod, and although running at that high speed, which no engineer but Mr. Porter believed could be made serviceable, the engine worked quietly and successfully. The secret was in making the end of the plunger pointed and running it under water.

Of the four other engines, all I think 6x12, one ran at a terrific speed. The attendant told me that they were going to run it at 1000 revolutions, although I do not know what Mr. Porter expected to

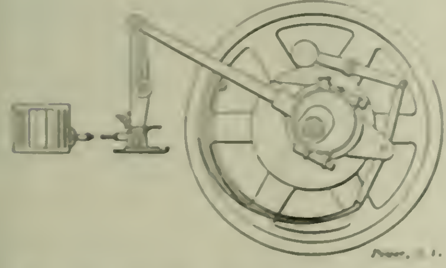


FIG. 4. CENTRIFUGAL GOVERNOR WITH ROCKER

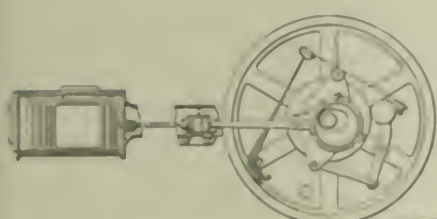


FIG. 5. GOVERNOR WITHOUT ROCKER

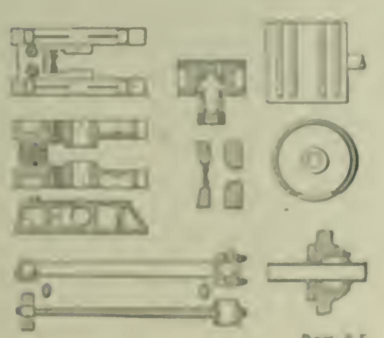


FIG. 6. PISTON, CROSSHEAD, ROD AND LONG SLEEVE

do, or did do, but anyway it went fast enough. Mr. Sprague says 1500 or 1600 but I don't believe it. Two were running dynamos for lighthouses, and another was a complete engine with one-fourth of the cylinder and steam chest cut away, driven by a belt to show the action of the valves, piston, etc. This was repeated by the Buckeye Engine Company many years later.

On Thanksgiving Day, 1870, I started on the drawings for the first Straight Line engine (Figs. 1 and 2), and finished and started the engine on the first day of April, 1871.

This engine had a varied experience, and for the last nineteen years has adorned, or disfigured the present Straight Line engine works. See Fig. 2. In the meantime Mr. Porter had come to New York, built a shop at Harlem, and was in the engine business, building and selling the Porter-Allen engine.

While at Cornell, in 1875, with only student labor, we built the second Straight Line engine and had it on exhibition at the Philadelphia Centennial. This engine had a shaft governor which was then, perhaps, the second or third one ever shown in this country. Mr. Hoadley's and Mr. Tabor's were earlier, and the Hartnell, of England, earlier still. Patents had been secured before, but I do not recall that any were so far advanced as to call general attention to them.

In the fall of 1879 the third Straight Line engine was built. See Fig. 3. In February, 1880, the Straight-Line Engine Company was organized, a name given to the engine, and the first one built by the company was started the first of July of that year. This engine is still running at the Lakeside power house in Syracuse, N. Y.

FIG. 7. PACKINGLESS VALVE STEM

At the Centennial there were shown three or four electric generators or "dynamos," as they were called then, and the one we had built at Cornell, the first Gramme machine built in this country, was shown driving an electric light, but such only as could be used for a lantern. Electric lights up to that time had been used only in lighthouses and lanterns. That fall electric lights were placed on the campus at Cornell, and others, to some extent, in the East.

The growth of the electric light and the growth of the high-speed engine came on together. The electric people have often claimed that the electric-light business built up the high-speed engine, but there are two sides to that story.

In the early days there was a good deal of flicker in the lights and the electricians claimed that it was all due to the unsteady speed of the engine.

We furnished an engine for the Brush people and after Mr. Brush and his superintendent worked a half day testing out a forty arc-light machine, Mr. Brush decided that the greatest variation was one turn in two minutes, and that led them to "sit up and take notice" and settle that the flicker was due to imperfect carbons. The better-governed engines helped out the electric people.

The slow-speed Corliss engines varied so at each revolution that the speed of the engines could be counted anywhere the lights were in view.

The next engines that bid for favor among the electric people were the Armington & Sims and the Ball. I think the Armington & Sims first, as they seemed to have a pull with Edison and were the first to make great progress.

The Ball builders made great claims for their governors, but they have changed them three or four times, while ours is

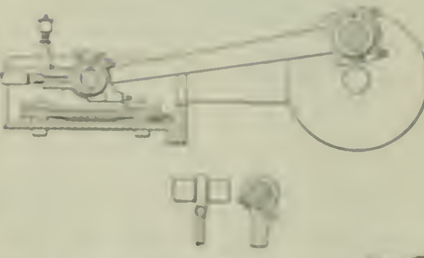


FIG. 8. LONG CROSSHEAD AND SHORT GUIDE

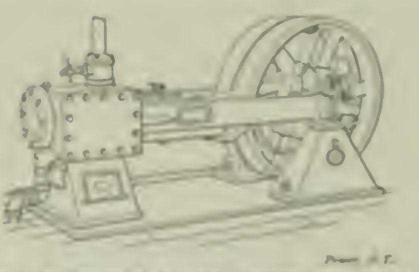


FIG. 9. PRESENT ENGINE, CENTER THROTTLE, ABSENCE OF FOUNDATION BOLTS AT CYLINDER END

FIG. 10. COVER PLATE AND RIBBING ON BASE

practically the same as that used on the first engine built by the company, twenty-nine years ago.

The Straight Line, Armington & Sims and Ball engines were center-crank, shifting-eccentric shaft governors; mine a single ball; the Armington & Sims two balls and in the Ball the governing was partially centrifugal and mainly by an ingenious arrangement whereby the eccentric was shifted by the load.

Soon after the four engines mentioned came the Porter, Ide, Westinghouse, Skinner and others.

The Porter-Allen and the Straight Line valves were mechanically fitted flat valves, depending on the mechanical fit for tightness. The Armington & Sims and Westinghouse piston valves and the Ball used a partially balanced valve.

At the Centennial the Buckeye Engine Company exhibited a small engine, such as they coupled direct to a circular saw, and ran it at a terrific speed. I think they said 400 turns a minute. It was something like a 6x12 or larger, and the saw of such size as is used for cutting lumber.

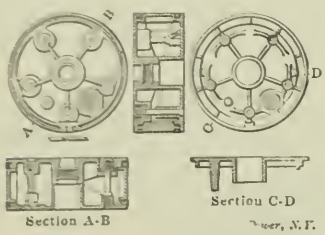


FIG. 11. POP PISTON

The Westinghouse two-cylinder single-acting engines were short-stroke, and ran at high speed, likely faster than any of the others, and as far as numbers were concerned the Westinghouse people turned out twice as many as any other builder, although possibly not as far as electric lighting was concerned. They were the first to adopt the inclosed crank case and splash oilers, and the first to introduce compounding. The continuous systems of oiling with pump and filter was introduced later, and I think by steps, but by whom first I do not recall.

J. C. Hoadley, who was the first, no doubt, to introduce the shaft-governed shifting single-eccentric in this country, determined by experiment that to have the engines run quietly from 10 to 14 per cent. clearance was necessary, and Bourne and Auchincloss that it was not possible to use the shifting eccentric and maintain a constant lead to the valve at both ends of the cylinder. This led me to "monkey" with the rocker arm and design the corrected valve motion which did maintain a constant lead at both ends of the cylinder.

Experimenting with our earliest engines showed me that a constant lead was exactly what we did not want, but a variable lead; and when we got the variable lead I became convinced that the constant lead was not worth the distorted rocker arm that it took to get it. See Fig. 4.

By the change from the original form of approximately constant lead to the variable lead, we were enabled to reduce the clearance to one half of the amount Mr. Hoadley had established, and as the clearance is one of the sources of loss, the new arrangement not only enables us to run quietly at a wide range of load, but much more economically. See Fig. 5.

While great stress has been laid on the superiority of the Corliss engine, and justly so, this gain in economy by the change in the valve motion did not give our engine the trade; and this, perhaps, because of a lack of able salesmen.

But there are in the small electric-light business three essential things that come in before economy. The most essential of all being that the engine must go, and with the briefest possible stop—when a stop is imperative. The engine must govern on the widest variation of load, and the engine must be quiet and in many cases practically noiseless. The question of steam consumption sometimes does not come in at all, on account of heating the place.

This history has extended over a period of about forty-five years. No one can realize the amount of study and experimenting that has been given to the development of the subject. The experiments we have tried, and found to fail, far exceed the successes and, as Edison says, "No failure is a loss, because you learn something;" so we have learned a lot of things that don't work as well as we could have hoped.

We tried long pistons (Fig. 6) which all said was right, but they did not do well; too many got to cutting. We tried various kinds of piston rings which had limited expansion stays. Mr. Porter's four-opening double valves with very short travel have eight chances for leakage, aggravated by the small lap. We cut it down to one valve, with two chances for leakage and long travel and wide lap, which is better, but none too good.

The compensating-pressure plate is too complicated. For the various steam-chest and cylinder-head joints, the narrow band, metal-to-metal, is the thing; also, the round rod in a reamed hole for piston and valve rods; the bushes, from wood to cast iron. Babbitt is best in some places, and lead bronze in others (Fig. 6).

Six or eight kinds of crossheads and guides; two or three different kinds of attachments of crossheads to rods; three

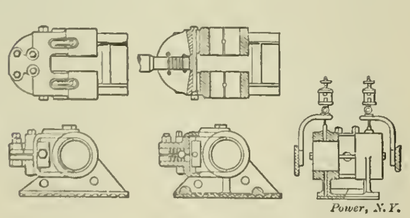


FIG. 12. PRESENT CROSSHEAD

or four kinds of takeups on crosshead pins; three or four crosshead pins; three different styles of frames; solid and bushed cylinders; three or four modifications in the design of the governor; three kinds of governor, before the final design (Fig. 5); three kinds of main boxes; two or three throttles before John Coffin's (Fig 9); two distinct forms of cross-section of the various parts; and a half hundred direct-connected bases; certainly as many, if not more marked departures from general practice on the part of other builders.

The original characteristic features of the Straight Line engine were the straight two-arm frame, three-point support, ring oilers (Fig. 1), flywheels on the throws of the crank (Fig. 2), single-ball governor (Figs. 4 and 5), absence of packing on piston and valve rods (Fig. 7), end play to all journals, long crossheads (Fig.

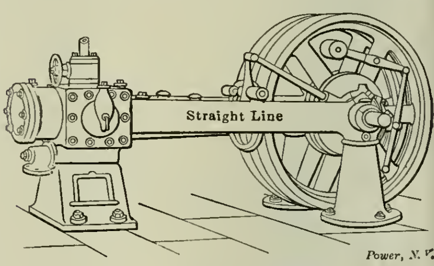


FIG. 13. ENGINE WITH ROCKER ARM FOR CONSTANT LEAD

8) and short guides, limited expansion piston rings, the absence of foundation bolts (Fig. 9), baffle plates in valve (Fig. 10), Coffin throttle and pop piston, balancing pockets in rim of flywheel (Fig. 2).

It is for us, whose shadows are growing fainter and fainter, to anticipate what is to be the final outcome of our fighting this battle for the high-speed engine. Grass grows up and dies down; trees grow and die; dogs grow and die; and man suffers the same fate. Countries spring up and flourish and fade away, and astronomers tell us that the moon is dead, and that there are dead stars. Each and every one of the old slide-valve engines has had its day, a thousand rotary engines have died "a-borning" and the glory of the Corliss engine is waning.

The high-speed and gas engines started together. The gas engine has matured much more slowly, and is about to have its innings. The high-speed engine is changing its coat, and must share the fate of everything else. It has served its purpose, proved its right to existence, been useful, and if it goes down with the Corliss engine it will die in good company.

Steam-turbine semi-portable units are built by the Allgemeirne Dampfturbinen Gesselischaft in Nuremberg. The turbine is above the boiler and direct-connected with the dynamo. The boiler has corrugated flue tubes, internal furnace and smoke tubes, and comparatively big water and steam spaces. The superheater, for 750 degrees Fahrenheit, is in the reversing chamber. It has surface condensation for getting warm water free from boiler scale. The boiler seat is constructed as a pump-case for the condensation pump. Portable units have jet condensation. For small work, pressure turbines are used, for larger work, overpressure turbines. At 700 horsepower a consumption of 1.3 pounds of high-grade coal is guaranteed.

Development of the Surface Condenser

The Surface Condenser before and after the Advent of the Steam Turbine. Factors Influencing Surface Efficiency and Condenser Design

BY GEORGE A. ORROK

The surface condenser owes its invention to what Neil Dow denominated the "Demon Rum," for wherever distilled liquors have been manufactured the "worm of the still" is known and its uses well understood. It may be considered certain that, as the still was introduced into Europe from Arabia before the ninth century of our era, it is a most ancient piece of mechanical apparatus being antedated only by the boiler, the invention of which must have been developed at some earlier time.

The earliest distilling apparatus probably consisted of a vessel of clay or glass for containing the liquid to be distilled and a pipe or receiver with cooling apparatus for condensing the distillate, or condensed vapor from the boiling liquid. Later the pipe or receiver was developed

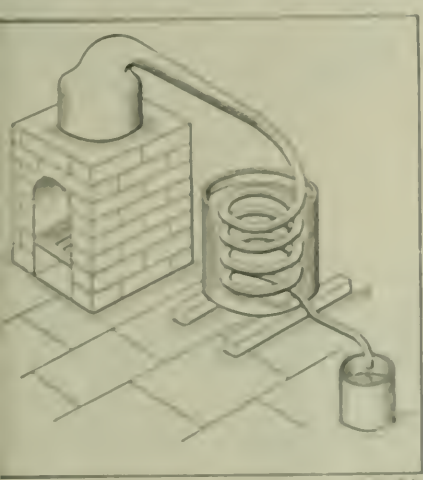


FIG. 1. THE HELICAL WORM

into the form of the helical worm so often used in the stills of a few years ago. It is said that a perfectly preserved glass worm was found in the excavations made at Tyre in Syria some forty years ago, the Tyrians being famed as glassblowers. The city was destroyed by Alexander in 332 B. C. With the introduction of Arabian learning in Europe, the science of alchemy was disseminated and the "retort and alembic" or chemist's still came to be well known. In later years Liebig modified the form of the alembic, or condenser, so that it consisted of a glass tube surrounded by a second glass tube, provided with means for circulating a stream of cooling water between the inner and outer tubes, thus producing the tubular condenser of modern form.

While alchemy had been developing into chemistry the art and science of engineering had come into being. Papin, Savery and Worcester had changed the retort into a boiler. Newcomen had applied the boiler to an engine, and in 1765 James Watt took out a patent for a steam engine with a separate condenser in which the steam was condensed by contact with a metallic surface cooled by a stream of water flow-

FIG. 2. CHEMIST'S STILL

FIG. 3. LIEBIG CONDENSER

ing over the outside, as well as a jet of water inside, a combination of surface and jet condenser. In [illegible] Cartwright patented a condenser in which the steam was condensed in the annular space between two cylinders, the cooling water flowing through the inner one and around the outer one. Brunel in [illegible] patented a surface condenser using groups of small tubes for cooling surface. Finally in 1831,

Samuel Hall took out his patent covering the surface condenser, properly so called, claiming among other things the use of the condensed water for boiler feed water and the distilling of fresh water for make-up feed. In his condenser the steam passed through the tubes and the water around them.

One of the first ships fitted with Hall's condenser was the "Sirius," which in 1838 made the first passage under steam from England to America. Hall's condenser was not a success, partly because of the low steam pressure carried (about 15 pounds gage) and partly on account of the use of tallow as a lubricant. The tallow, partly decomposed by the heat of the steam, volatilized and coming in contact with the tubes, which were made of copper, formed soluble copper salts which

FIG. 4. HALL'S CONDENSER

rapidly attacked the iron plates and tubes of the boilers. The change to brass tubes for the condenser did not help matters very much and besides, the tallow not decomposed frequently hardened in the tubes. Hall did not think of passing the water through the tubes instead of the steam, and his condensers were soon replaced by the ordinary jet condenser. In [illegible] John Bourne patented the counter-current principle for the steam and circulating water, used separate circulating and feed pumps, and passed the water through the tubes instead of around them.

Surface Condenser in 1880

It was not until 1880 that the increased boiler pressures made the surface condenser a necessity. Up to about this time the pressure carried did not exceed 30 pounds gage, and sea water was used for feed water. The amount of salt in the boiler water was tested from time to time by the salinometer, and when too concentrated the boiler was blown down and fresh sea water was added, the concentration always being kept below the point at which the calcium sulphate commenced to be deposited. When the pressure was increased to 45 pounds gage, the calcium sulphate was deposited at the ordinary concentration of sea water, so that it could no longer be used for feed.

About this time the surface condenser was tried by many shipbuilding firms with success and soon became the standard apparatus. The necessary makeup was at first carried in the ballast tanks, but evaporators were soon installed, and at the present time are an indispensable part of the outfit of every ship.

On land the surface condenser was not taken up by designers and manufacturers to such a degree as in marine work, for the incentives were lacking. Good feed water was usually cheap and plentiful. The jet condenser gave the 23 to 26 inches of vacuum required with a much smaller expenditure of power and cooling water,

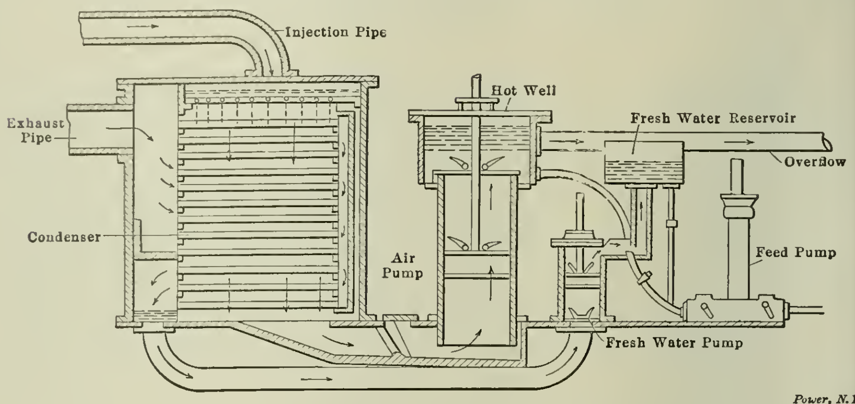


FIG. 5. PIRSSON'S SURFACE CONDENSER

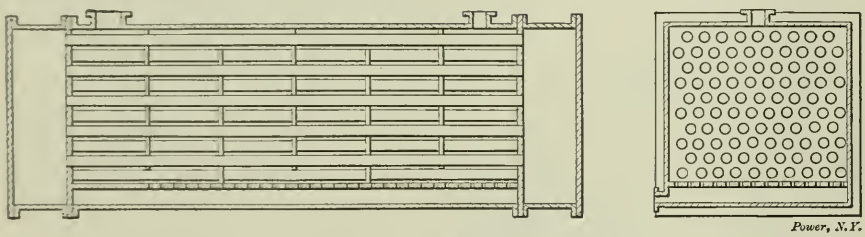


FIG. 6. LIGHTHALL'S STEAM BOILER CONDENSER

and withal the jet condenser was much less costly in first cost and maintenance. It was only where the feed water was bad or very costly that the surface condenser was used, and most of the large installations were near the seacoast or rivers.

As first built for land purposes the surface condenser followed closely the lines of marine practice. The shell, either circular or rectangular in section, was usually made of cast iron with end flanges. The tube plates were bolted to the flanges of the shell with sufficient bolts to hold them in place. The water boxes were placed on the tube plates and bolted through the tube plate to the flanges of the shell. From the lowest part of the shell the hotwell pipe led to the air pump. The circulating water was led into the water box at one end of the condenser and passed through the tubes and out through the water box at the other end. The exhaust steam entered the condenser through a nozzle at the top of the shell. The air pump was the usual bucket pump of the old jet-condenser type, or the horizontal piston type with flap valves developed in the sugar industry. Dry-air pumps were unheard of and not necessary. Most condensers had a provision for introducing a jet of cold water into the steam space, usually a rose nozzle at the steam inlet, in order to assist in the work of condensation, and to furnish the makeup feed. That this makeup water was warmed to the feed temperature was a well-known incidental saving, as shown by Bourne's patent in 1838.

By 1870 the surface condenser had attained the status of a standard machine differing but little from the description given above, and until the appearance of the steam turbine with its demands for better vacuum, only two additions of moment were made in the design of the apparatus. As early as 1850 it was known that the efficiency of the condenser depended on the velocity of the water in the tubes; the greater the speed the higher the efficiency, and the water was made to pass twice or three times through the length of the condenser by dividing the tubes into banks by means of partitions in the water boxes. This practice did not become general until after 1870. The better results obtained by this means and the bending of the upper rows of tubes by the force of the entering steam suggested the introduction of baffle plates and supporting plates inside of the condenser, these tending toward a better distribution of steam to the tube surface.

In navy condensers attempts were made to secure better steam distribution by providing steam passages into the tube banks, these passages being made by leaving out tubes. Although good results were obtained by this method, the manufacturers did not seem to take kindly to it. For this reason this method is rarely used although many condensers in actual service have been greatly improved by removing tubes to open a passage for the exhaust steam into the tube banks.

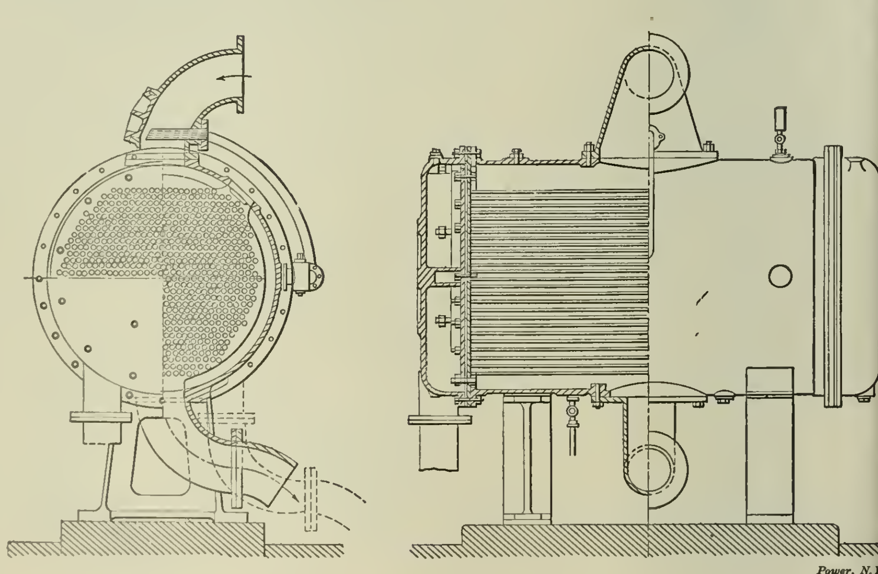


FIG. 7. SURFACE CONDENSER OF 1860

Wheeler, in 1883, patented a surface condenser making use of the Field tube principle. He made use of a double water box at one end of the condenser, the condensing water entering the outside tube and coming back by the inside tube. This condenser was not very successful, probably on account of the entering cooling water absorbing heat from the water on its return as well as from the steam.

The Air Pump

Since Newcomen's time, the air pump had made comparatively little progress, the single-acting bucket pump with three valve decks, one in the bucket and the others above and below it, being the most popular for use with the surface condenser, as it always has been in the case of the jet condenser. Occasionally either

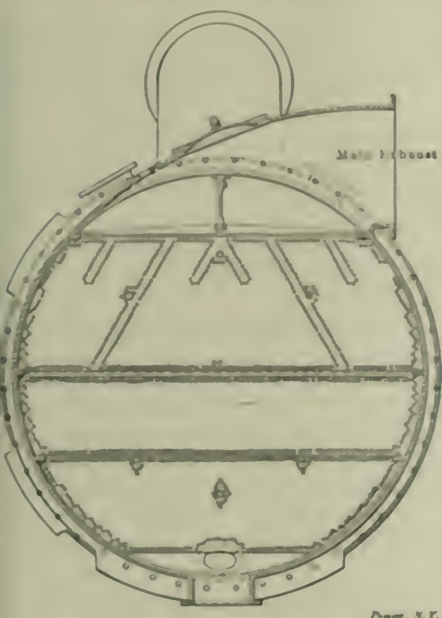


FIG. 8. PASSAGES IN TUBE BANKS

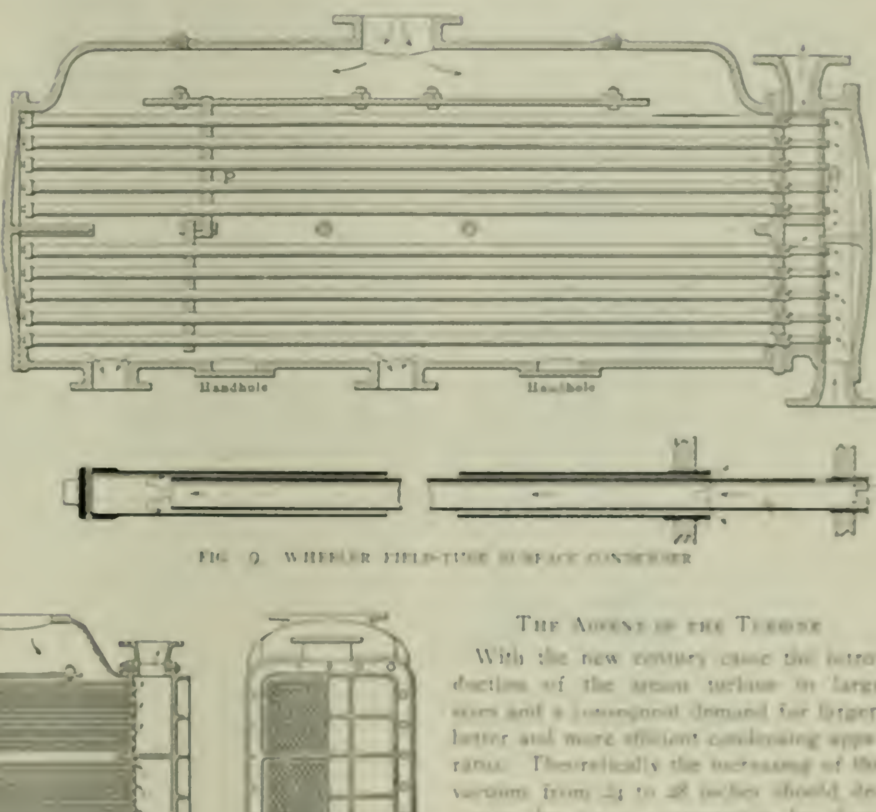


FIG. 9. WHEELER FIELD-TUBE SURFACE CONDENSER

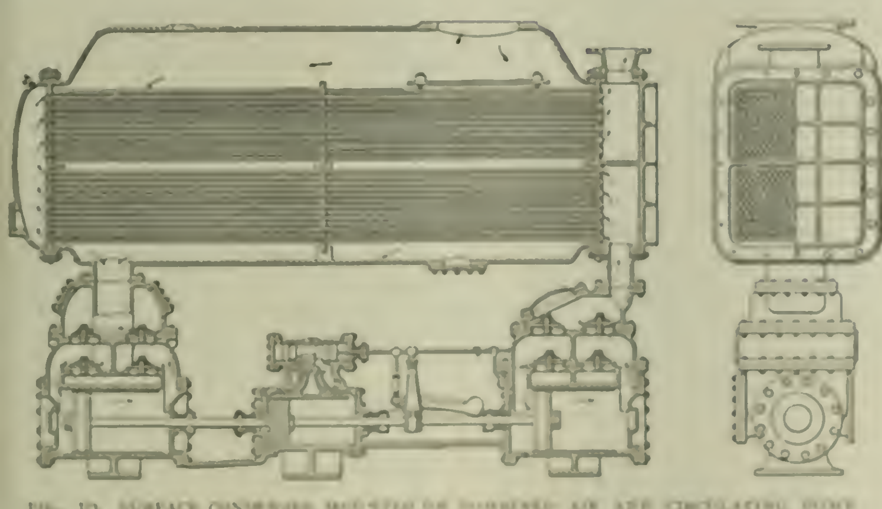


FIG. 10. SURFACE CONDENSER MOUNTED ON COMBINED AIR AND CIRCULATING PUMP

the upper deck of valves or the lower deck was omitted. These pumps were always built with vertical barrels, and for use with the ordinary vacuums of 24 to 26 inches are quite efficient when well designed and kept in proper repair.

The horizontal double-acting type, which had early been developed from the force pump as the bucket pump had from the ordinary house lifting pump, was also popular, especially in the sugar industry where indeed as much progress in condensation had been made as in marine work. This pump with its inclined flap valves and proper design was capable of exceedingly good work. It was also built with horizontal valve decks and vertical lift valves.

Generally the circulating pump was of this design also, and in marine work was uniformly driven from the crosshead along with the air, feed and bilge pumps. In land work the air pump was sometimes driven from the crosshead, but by this period the circulating and feed pumps were always independent where surface condensers were used. Some twenty years earlier, in 1850, Bodmer, the hydraulic engineer, had invented his single-acting valveless air pump, but it had not been largely used. The writer has as yet been unable to find when the horizontal double-acting valveless pump appeared, but it certainly was in use before this period in some few installations.

Such was the surface condenser in 1870. Such it was to remain except for small changes in constructive details. The condenser auxiliaries however had been materially improved. For circulating service the centrifugal pump had been introduced, found its field and was already well in the lead. Edwards and Brown had improved the Bodmer valveless air pump in England and Germany, where it had long been known, and it had been introduced into the United States. Brown had improved the horizontal valveless air pump and its use had spread both to England and the United States, where it has been known as the Bailey pump. The horizontal direct-acting pumps of the Blake, Knowles or Warren types had been developed and made considerable progress in displacing the single-acting bucket type for surface condensing work.

The Advent of the Turbine

With the new century came the introduction of the steam turbine in large sizes and a consequent demand for larger, better and more efficient condensing apparatus. Theoretically the increasing of the vacuum from 24 to 28 inches should decrease the steam consumption by about 15 per cent. With most types of turbine this theoretical increase is very nearly obtained and justifies the importance attached to high vacuums in steam-turbine work. With the reciprocating engine an attempt to approximate this saving would necessitate cylinder ratios greatly in excess of anything that has been employed, with the attendant initial condensation and friction losses. The attempt to utilize a vacuum higher than 26 inches on reciprocating-engine work has always resulted in no increase of commercial economy.

As the larger steam turbines were installed in electric-generating stations where the necessity for economy is always paramount, most of the condenser manufacturers approached the problem in the same way, i.e., by an increase of surface and then, not finding this sufficient, they had recourse to the dry-air pump which had been developed for the vacuum pan and triple effect in the sugar industry and later had been applied to the barometric type of jet condenser. The importance of the entrained air together with the additional air gaining access to the condenser through leaks in the shell and exhaust system, began to be understood and its effect on the efficiency of the condensing surfaces has been studied by many investigators. The difficulties of a few years ago may be better appreciated now that it is known that with a 5000-horsepower condenser, a hole of 1/32 inch diameter through the shell has quite a serious effect on a 28-inch vacuum.

Overcoming Clearance in Air Pump

The original dry-air pump was an air compressor with a rather large compression ratio. These pumps worked very well with compression ratios up to about

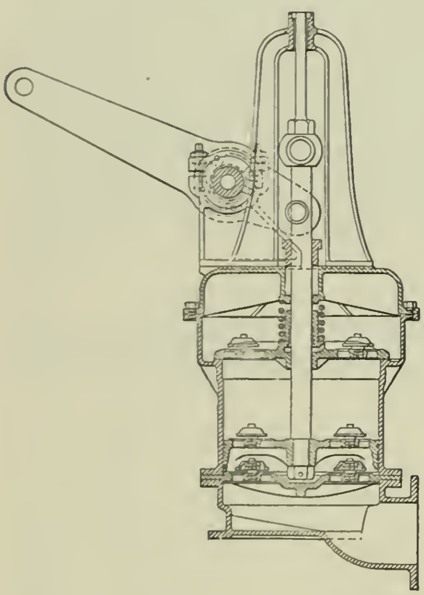


FIG. 11. STANDARD MARINE AIR PUMP

seven, but the clearance must be small. With higher vacuums than 26 inches the clearance becomes troublesome, and Weiss improved the pump by the expedient of bringing both ends of the cylinder into communication at the end of the stroke at the moment of valve closing. This allowed the air at atmospheric pressure in the clearance space to expand into a full cylinder of the air at condenser pressure, but shut off from the condenser, thus saving a portion of it and increasing the efficiency of the pump by that amount. By means of this expedient the pump will maintain a vacuum on a closed shell within 0.3 inch of the barometer without difficulty.

A second way of doing the same thing is by compounding, using a very low compression ratio in the first stage and performing the remainder of the compression to atmosphere with a larger compression ratio in the second stage. This method has not been used as much as the Weiss pump, but is equally as good except for the complication of the second cylinder with its stuffing boxes and the additional chance of air leakage.

Wet-air Pump

Of the pumps for handling both air and water, the Bodmer pump has been very successful in the hands of the American owners of the Edwards patents, and remarkably good results have been obtained by its use. This Bodmer pump has also been materially improved by the addition of a set of valves allowing the air to enter above the piston on its down stroke. This improvement has also been introduced in the Brown pump by Josse in Germany, and the horizontal Bailey pump in America has been adapted to the more efficient work made necessary by the higher vacuums; Tosi in Italy has also improved the valveless pump.

Another type of air pump for use with surface condensers is the Le Blanc pump. In this pump the air is removed by the action of a jet of water in an ejector, a device somewhat similar to the Parsons vacuum augmenter. The Le Blanc pump consists of an ejector of suitable size furnished with a partial-admission centrifugal pump similar to a reversed Girard turbine. The pump blades throw successive layers of water into the diffuser of the ejector, entraining the air between the water laminations as they pass into the ejector. Very good results are claimed for this pump. The Parsons augmenter consists of a steam ejector which pulls the air from the main condenser by the aid of a steam jet, passes it through an auxiliary condenser to condense the steam, and the mixture of water and vapor at perhaps twice or three times the absolute pressure of the main condenser is then removed by an ordinary wet-air pump.

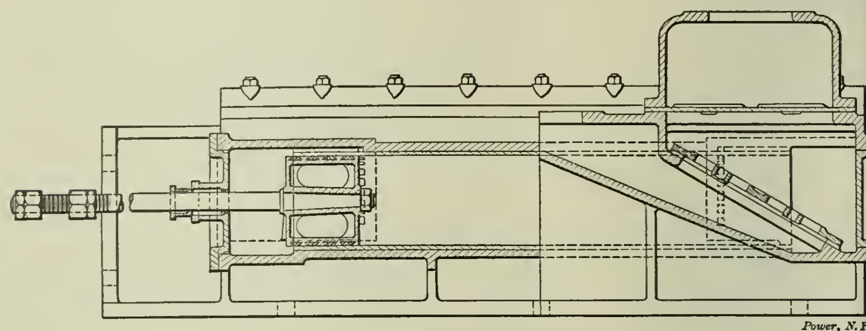


FIG. 12. HOLLIS WET-AIR PUMP

It had been observed that the vacuum fluctuated with the strokes of the air pump, and that this was more marked in those condensers, mainly of the counter-current type, in which the temperature of the hotwell water approached that due to the vacuum. Some condenser manufacturers correct this fluctuation by the addition of a dam or weir around the hotwell pipe, causing the flooding of the lower rows of tubes, thus insuring the cooling of the condensed steam below the vaporization point. Increasing the number of wet-air pumps to two or three of smaller size has also the same effect and has been largely used, but the most efficient and popular expedient is to use a centrifugal wet-air pump. These pumps are small in size, cheap in first cost even when made of bronze, and have been very successful when properly designed and installed. The double-stage pumps were most successful

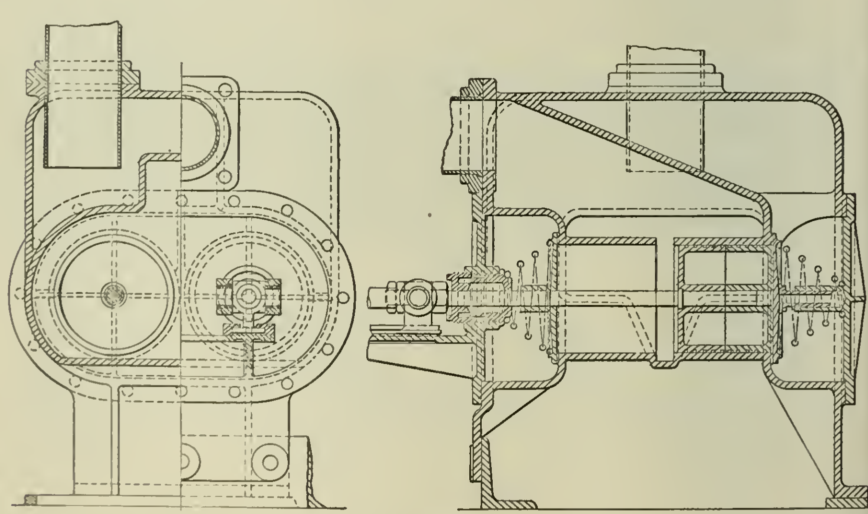


FIG. 13. BAILEY WET-AIR PUMP

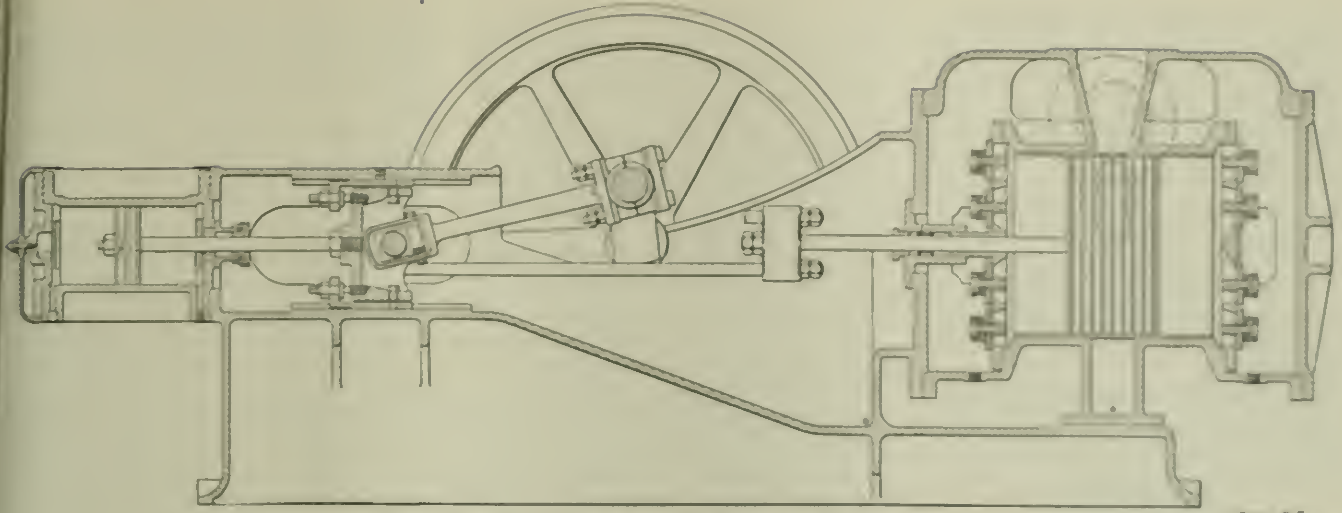


FIG. 14 MULLAN'S SUCTION VALVELESS AIR PUMP

at first, but, as the conditions for successful operation were better understood, the single-stage pump came into use and is equally satisfactory.

For success three conditions must be observed: the pump must be below the bottom of the condenser (no suction lift), the pump and hotwell pipe must contain no pockets for the collection of vapor, and the pump must always be submerged. With these precautions an even water line may be preserved in the condenser or hotwell at all loads within the capacity of the pump.

Small Steam Turbines to Drive Auxiliaries

Condenser auxiliaries for turbine work are always independently driven by engine, motor or steam turbine. Motor drives are not as common as formerly, and the excessive upkeep on high-speed engines is a drawback to their use. The small steam turbine has made a place for itself in this field and, as centrifugal-pump manufacturers have met the exigencies of the occasion by the development of pumps suited to turbine speeds, many of the later installations are provided with turbine drives for the circulating and hotwell pumps. The Le Blanc dry vacuum pump so far is the only pump for this service susceptible to a turbine drive, but without doubt others will be developed to meet the demand.

Factors Influencing Surface Efficiency

Notwithstanding the rapid and great improvement in condenser auxiliaries, the efficiency of the condenser itself was still quite low. The tendency was to increase the tube surface in the hope of getting a better vacuum. Since Rankine's time it had been known that 40 to 50 pounds of steam may be condensed per

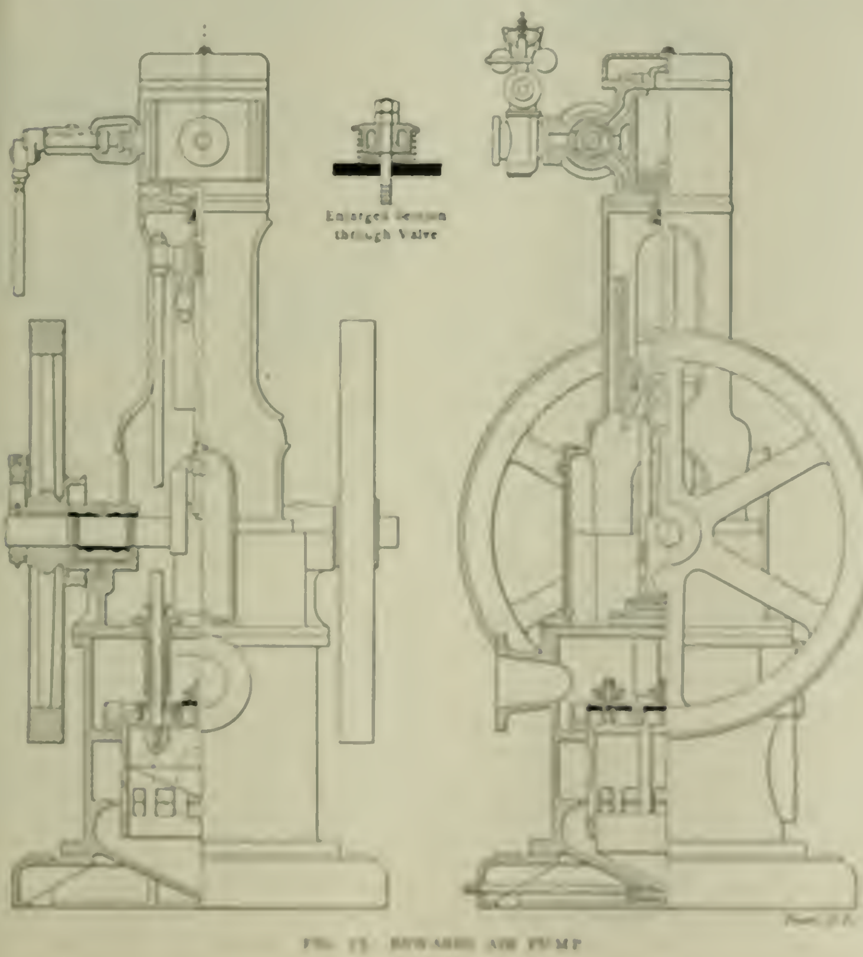


FIG. 15. EDWARDS AIR PUMP

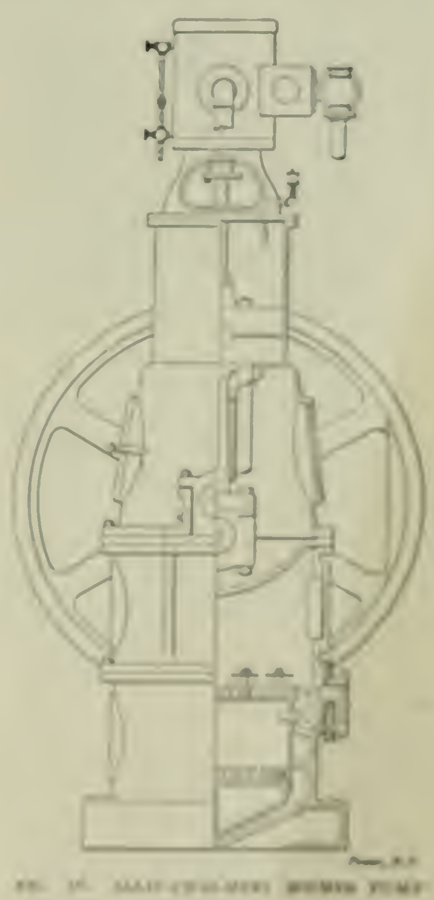


FIG. 16. ALLIS-CHALMERS [illegible] PUMP

hour per square foot of surface under condenser conditions, if proper arrangements are made, and in the face of this fact six pounds per hour was considered good practice with eight as a maximum. Purchasers were also in error in that they frequently specified the surface they required instead of the work to be done. In 1900 there were almost no condensers in which the heat-transmission coefficient U (B.t.u. transmitted per square foot per degree difference per hour) exceeded 300. In 1904 there were very few in which it reached 400.

The increasing difficulties and cost of maintenance of condenser tubes made the question of efficiency a subject of the

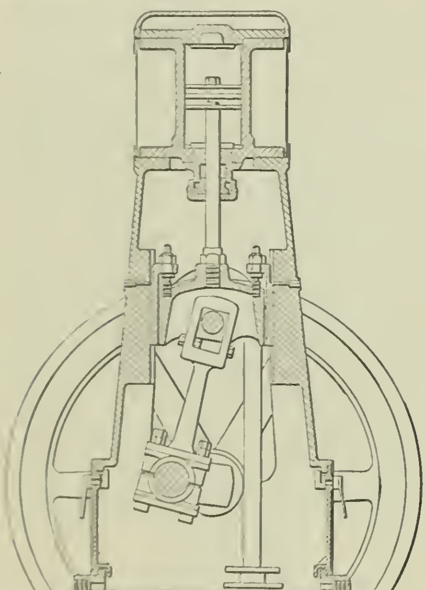


FIG. 17. MULLAN'S VERTICAL AIR PUMP

first importance. A 6000-horsepower engine usually had a condenser with about 9000 feet of tube surface and carried a vacuum of 26 inches. As these large installations are nearly always near the seacoast and use salt water for condensing, the deterioration of condenser tubes and consequent replacement, although a serious matter, was not a very costly one. The leakage of salt water into the condenser was not troublesome, as the condensed steam contained oil and was thrown away. But a 10,000-horsepower turbine with 25,000 square feet of tube surface was a more serious affair, particularly as 28 inches, or greater, vacuum must be carried with practically no leakage and the condensed water used for feed, this necessitating a much more frequent replacement of tubes. At the present time three years may be taken as the average life of condenser tubes, and in the condenser quoted above, about 8000 square feet of tube surface would be replaced every year. Such a condenser might have, say, 6000 tubes, and as Sunday is the only available time for maintenance work of this kind, an average of 40 tubes would have to be replaced each week when the water boxes were opened for cleaning. The question of tube deterioration has been investigated many times and the action proved to be chemical or electrochemical, but no satisfactory remedy has been found. Alloys approximating the "Admiralty" mixture of 70 parts copper, 29 parts zinc and 1 part tin, have refuse; third, flooding of the lower row of tubes with the water of condensation; fourth, the accumulation of air in the condenser drowning those tubes with which it is in contact. The second and third factors may be corrected by the designer, the first will not obtain if there is no oil in the exhaust steam, and the fourth concerns both the designer and builder. Careful workmanship and erection will reduce the air leakage to minimum limits and modifications of design have solved the air problem satisfactorily.

Among the most successful of these methods are the results of the experiments of Weighton and Morison which are illustrated herewith. The condenser has a circular or rectangular tube plate, the shell containing baffle or drainage plates which carry the condensed steam to the shell as quickly as possible and at

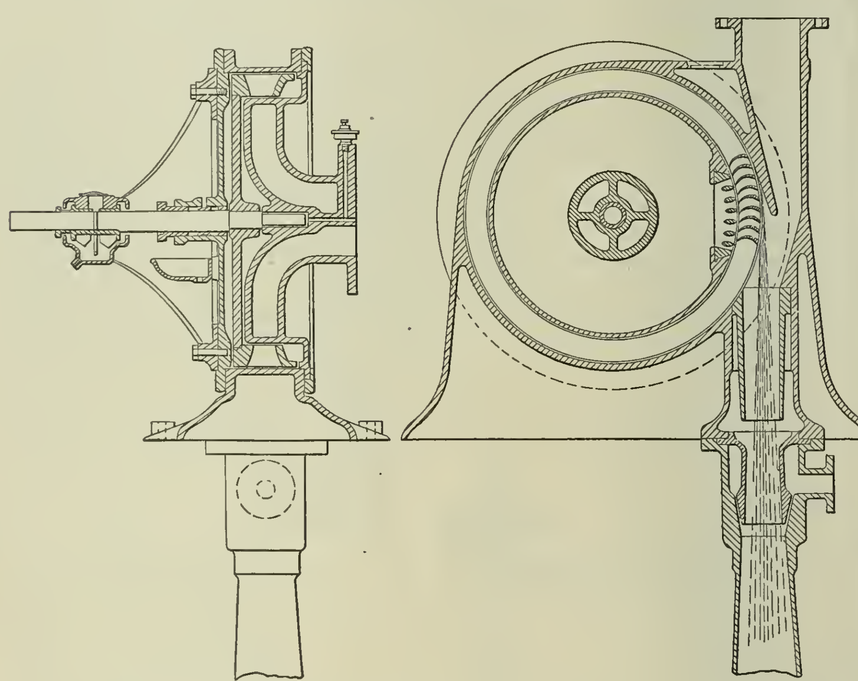


FIG. 18. THE LE BLANC AIR PUMP

been most successful when salt water is used for cooling.

These considerations have led to the investigation of surface efficiency, and many noteworthy experiments have been made leading to the increasing of heat transmission by a better distribution of the steam to the tube surface, a more rapid rate of flow of the condensing water and a more complete removal of the entrained air.

Maximum surface efficiency should occur when the tube surface is open in the most free and unrestrained fashion to the access of steam on the one side and the cooling water on the other. The factors influencing this freedom of access are, first, oily or greasy deposits on the steam side of the tubes; second, the choking of the water passages through the tubes with dirt, paper, straw or other

the same time control the direction of steam flow. The condensed steam is not allowed to collect on the tubes nor flow over more than a few rows before being led to the inner surface of the shell.

At the bottom of the condenser where the air must accumulate, a nest of tubes is set apart as a water cooler, the water level on the steam side of the tubes being held constant by a "dam" similar to that illustrated. The hotwell water is removed by an Edwards pump whose suction is taken off just above the lowest baffle plate or partition, and as the temperature of this hotwell water is very close to the vacuum temperature, the pump handles very little air. As the water collects in the lowest tube bank, it is cooled below the vacuum temperature and cools the air in contact with it. Another larger pump exhausts the cool air from this chamber nd also the excess water which flows into the pump suction over the dam. The discharge of the second pump is into a hotwell provided with a float actuating two valves, one of which allows a portion of the water to return to the cooling chamber; the other is connected to the inlet steam nozzle of the condenser and allows the excess to go through the condenser again, where it is warmed to the vacuum temperature and removed by the hotwell pump. A triplex Edwards pump is generally used, one cylinder acting as the hotwell pump and the other two as the air pump. It should be noted that the principle is similar to that of the Parsons vacuum augmenter, the auxiliary condenser being in the main shell and the lower temperature cooling the air to the proper point.

The draining of the condensed steam from the condensing surface has been a most successful way of improving the heat transference, and many of the later condensers have been designed with this in view.

In the August 11, 1908, number of Power and The Engineer, the writer summarized in brief the experimental work which had been done in the line of improving the surface condenser. The diagram showing heat transference under varying conditions gave the work of six investigators, and with these curves another was plotted from the formula

$$U = 17\sqrt{V_s} \cdot \sqrt{0.023 + V_w},$$

where

V_s = Velocity of steam in the condenser, usually taken as 625 feet per second,

V_w = Velocity of the cooling water in the condenser tubes.

The formula was taken from Hausbrand with modified constants to suit the results of the experiments, and quite a number of condensers have been designed on this basis. In service they have proved successful, showing heat transferences about as given by the formula.

The experiments of Professor Josse, published February 2, 1909, show even better results, and it may be that the constant 17 should be 20 or possibly 25. A chart adding Josse's curves to mine may be found on page 418, March 2, 1909, number of Power and The Engineer.

The "dry-tube" condensers shown in the accompanying illustrations are examples of the best modern design, and it is not too much to say that a value of U exceeding 800 may be obtained by good design with vacuums of 28 inches. It should be remarked that condensers seldom are tested to the limit of steam condensation, and the loss of vacuum is usually due to imperfect hotwell or dry-air pump arrangements, air leaks in the exhaust system, lack of sufficient condensing water, condensing water of too high a temperature or to failures of the circulating system due to dirt or rubbish accumulating in the tubes.

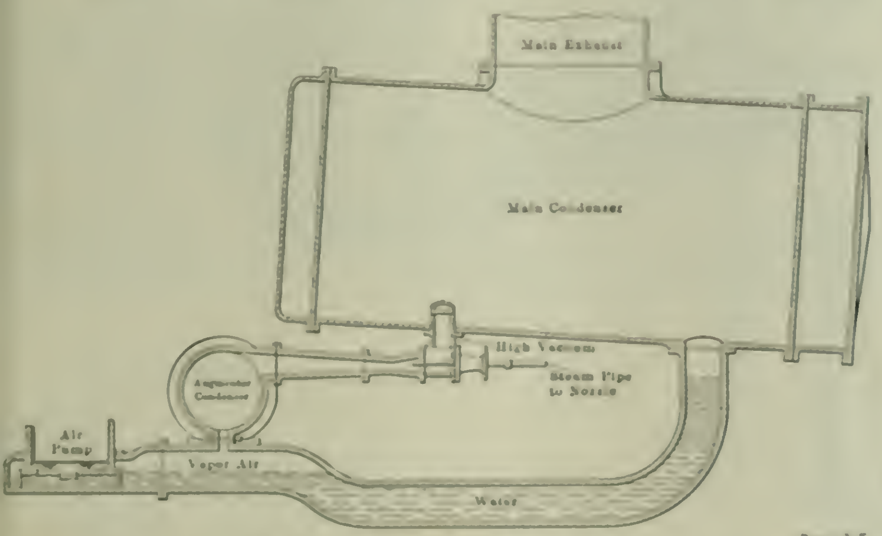


FIG. 19. PARSONS VACUUM AUGMENTER

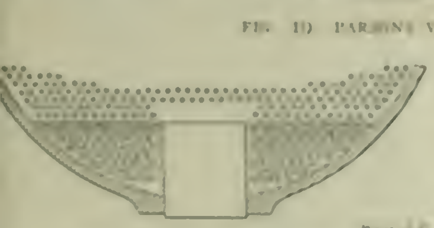


FIG. 20. THE ALLEN WEIR

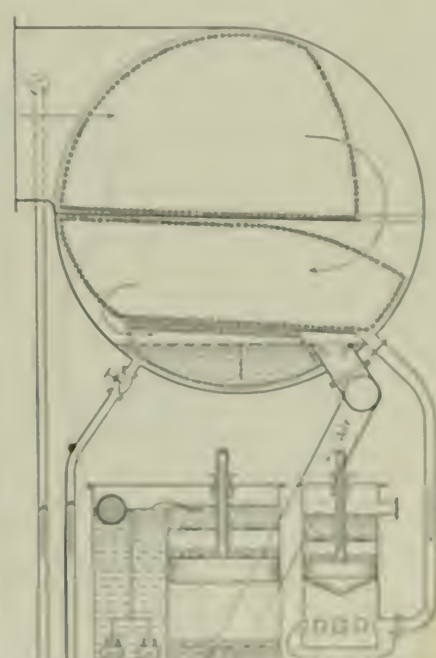


FIG. 21. WHEELER'S CONDENSER

CONDENSER DESIGN

In designing a condenser the following details should be considered:

Exhaust-steam System

The exhaust nozzle should be such a size that the steam velocity, computed upon the full weight at the volume due to the condenser pressure, should be around 600 to 700 feet per second.

The exhaust steam should enter from the top of the shell.

The shell should not be more than twice as long as the mouth of the exhaust nozzle where it enters the shell.

Sufficient steam space should be provided above the tubes to insure the entrance of the steam between the tubes throughout the whole length of the condenser.

Steam passages should be provided down through the body of the tubes so that every square foot of surface may be exposed to the steam flow.

Sufficient draining arrangements are required to prevent a film of water remaining around each tube.

A portion of the tubes near the hotwell and at the end of the steam travel should be protected from the water of condensation so that they may act as an air cooler.

A hotwell should be provided with a surface half as large as the exhaust nozzle area. The depth of the hotwell is not important but should be at least 18 inches.

The dry-air connection should be taken off about 3 feet above the hotwell water level, although 18 inches is usually successful.

The hotwell pump should be placed as close to the hotwell as possible with a direct connection and at least 3 feet below the hotwell water level.

Water Circulating System

Water should enter the condenser at the bottom and leave at the top. The lower edge of the discharge nozzle should be higher than the top of the upper tier of tubes to insure that the tubes will be full of water at all times. The circulating pump suction pipe should be large enough so that at maximum output the water velocity shall not exceed 10 feet per second and about 8 feet per second at normal output. The connection to the water box may be smaller and allow a flow of, say, 14 feet per second for maximum velocity.

Tubes may be of 1 inch outside diameter, never smaller in the neighborhood of large cities with salt water for cooling. With good clean water, fresh or salt, ¾- and ⅝-inch tubes may be economical.

water while properly holding the tubes.

The discharge pipe should be small enough to run full even when vertical, with 15 feet per second as maximum velocity.

A connection should be provided between the water box and the steam space and fitted with a valve so that the pump may be primed by the dry-vacuum-pump.

Condenser Shell

The shell should be tested by filling

that the water passage may be dry whe[n] not in use.

Gages and Thermometers

A final word may not be amiss regar[d]ing gages and thermometers. Vacuu[m] gages of the Bourdon variety are not[o]riously erratic. Use a good mercury co[l]umn of full length. A good thermomete[r] with a deep-winged well carried into th[e] center of the exhaust nozzle, with a me[r]cury column properly connected so as no[t]

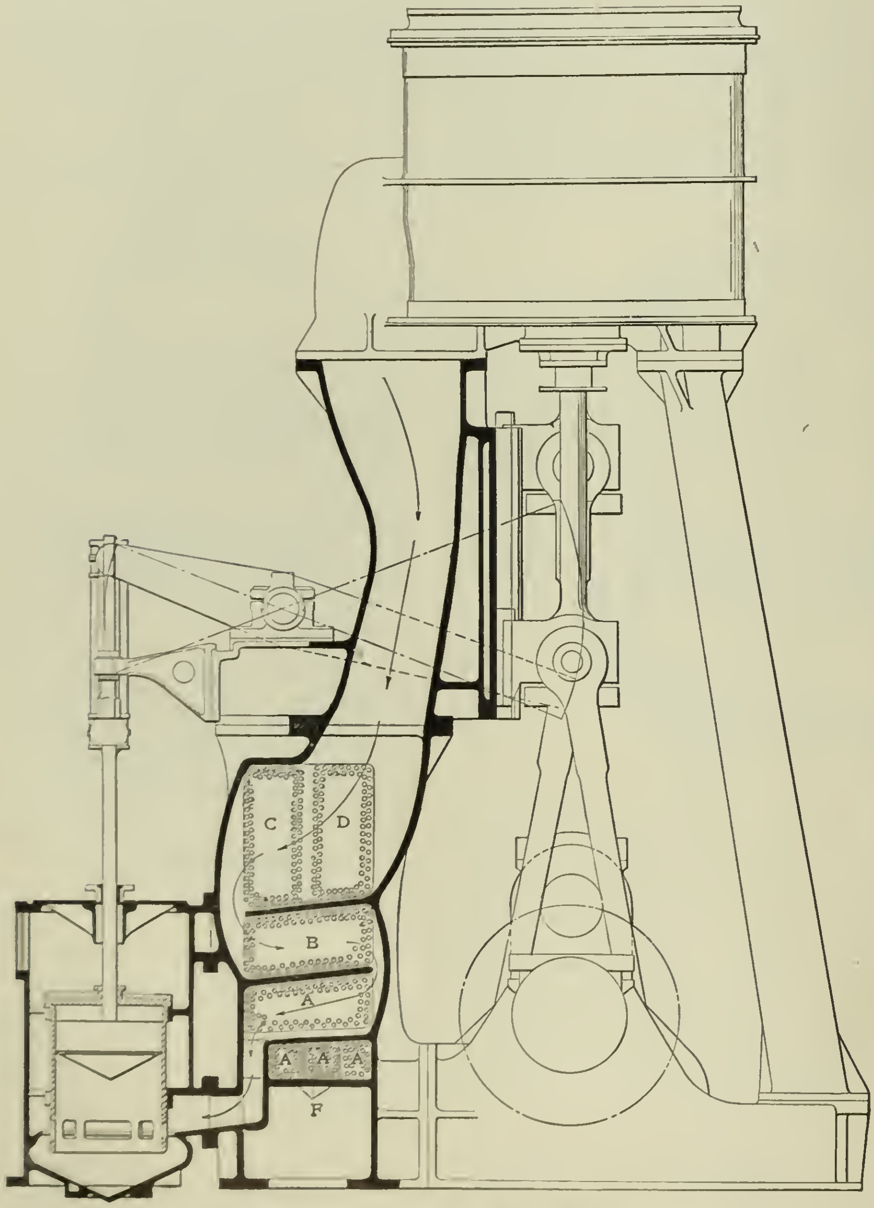


FIG. 22. WEIGHTON'S MARINE CONDENSER

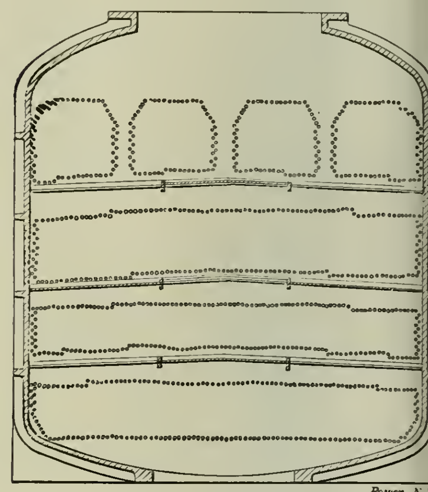


FIG. 23. WHEELER DRY-TUBE CONDENSER

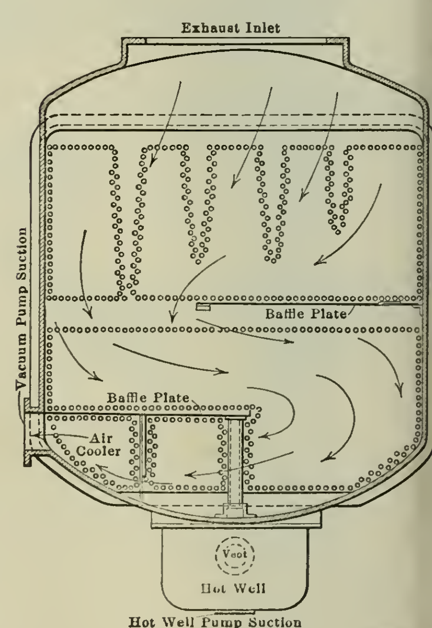


FIG. 24. WORTHINGTON IMPROVED TUBE PLATE

Tubes larger than 1 inch are rarely economical. Water velocities in the tubes should always exceed 4 feet per second, with 8 or 9 feet per second as a maximum. The length of tube and the number of water passes should be determined for each case from theoretical considerations.

Tube glands should be of such form as to add little obstruction to the flow of

with water under a head of 30 feet above the top.

The shell should be strong enough to stand a collapsing pressure of 10 pounds gage.

When in place the tubes should slope toward the pump end sufficiently to drain the tubes, and a ¼-inch hole should be drilled in each water-box partition so

to add the steam velocity head to the vacuum, will be the best index of the air leaks. Thermometers should also be placed in the circulating suction and discharge pipes, in the hotwell and the dry-air suction, and a second mercury column on the hotwell. With these instruments a very good idea may be obtained of what is going on inside the condenser.

A High-Pressure Turbine Operating at 30 Pounds Gage

It is not very often that a high-pressure turbine is required to operate at 30 pounds gage. This pressure, or slightly higher, is commonly used for ferry and river boats, and the "Robert Fulton," one of the new boats now being built for the Albany Day Line, is no exception to the rule. All machinery must, of course, be adapted to this pressure, and when it came to installing a ballast pump, the unit shown in Fig. 1 was chosen. This consists of a Terry turbine, of the same general design as the high-pressure machines, direct-connected to a 6-inch Alberger volute pump running at a speed of 1800 revolutions per minute. The duty of the outfit is to pump water from the river to either one of two ballast tanks of about 11,000 gallons capacity located on either side of the vessel.

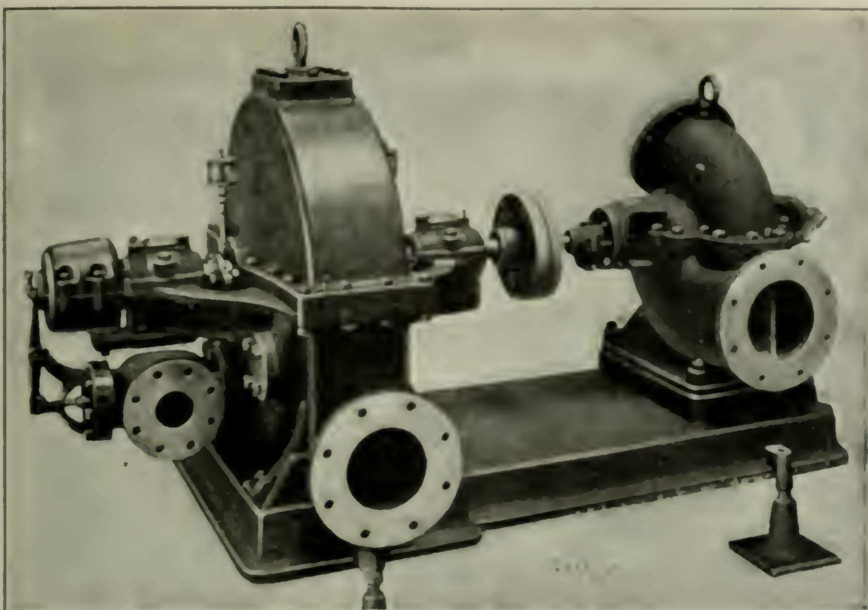


FIG. 1. TURBO PUMPING OUTFIT FOR THE "ROBERT FULTON"

When landing, passengers all move to one side of the vessel, and to keep an even keel, it is necessary to pump water in the ballast tank on the opposite side from the dock. This, of course, requires a large amount of water in a short period of time, and the pumping unit illustrated is guaranteed to deliver 1000 gallons of water per minute against a 25-foot head with the steam pressure as low as 20 pounds. Its range of operation is between 20 and 35 pounds gage. It is further guaranteed that after standing an hour, the turbine will clear itself of water and the 9-inch exhaust pipe rising to a height of 9 feet and will be running at full speed at a time not exceeding 30 seconds after the throttle is opened, and this without opening any drains to remove the condensation. The outfit is located in an inaccessible place in the hold and is controlled by a lever throttle valve at some distance from the turbine.

The construction of the turbine is shown to better advantage in Fig. 2, a sectional view showing the usual design, which is of the Reidler-Stumpf type. The jets of steam from the nozzles impinge tangentially on the buckets of the runner, and the steam is reversed by stationary guide buckets to be several times redirected upon the buckets of the same runner. The stationary buckets are mounted in the casing of the turbine in groups of four, and each group is supplied by a divergent nozzle, designed for a complete expansion of the steam between the initial pressure and the pressure of the medium in the case. With this subdivision of the process of abstracting the energy of the steam, the peripheral velocity of the runner may be kept down to reasonable limits and in the present case, with a speed of 1800 revolutions per minute and a single runner 2 feet in diameter, amounts to less than 200 feet per second.

FIG. 2. SECTION THROUGH TERRY TURBINE

With such a low steam pressure and a corresponding velocity of the steam, due to the less expansion, it was necessary to use a turbine which would ordinarily be rated at about 30 horsepower, and instead of using two nozzles, which is the number usually provided for this size, the turbine was equipped with four nozzles; the throat of the nozzle was also enlarged, and its shape changed to suit the conditions. These were the only changes necessary, and the turbine under existing conditions is capable of developing about 12 horsepower.

Before landing, it is usual to run the pump for about 8 minutes, which would mean 8000 gallons of water or over 60,000 pounds, and would be equivalent to the weight of nearly 500 passengers. The engineer, with his hand on the lever controlling the throttle valve, watches the telltale showing the list of the vessel, and to keep an even keel starts or stops the turbine as required.

On the "Hendrick Hudson," a boat of the same line, a similar outfit is installed, with the exception that the turbine operates on a steam pressure of 100 pounds. It is claimed to be giving the best of satisfaction, and as soon as the present installation is complete and in working order, it will be of interest to note its performance on a pressure as low as 30 pounds gage.

Supernatural Visitation of James Watt

How He Worked Out the Secret of Running an Engine Condensing; His Claim to Be the Father of the Rotary Engine Idea Substantiated

BY WARREN O. ROGERS

I have been considerably gratified by the recent publicity given the wonderful achievement of a photographer who succeeded in photographing a spirit from the other world. The photograph was published in a number of the leading papers of the country and, although the likeness resembled a potato, it is proof to some of us that spirits do surround us. I mention this merely to point out to those who are still skeptical regarding James Watt's visits to me that others have received supernatural visitations.

My third visit from James Watt was during one of the coldest nights last winter. I had settled down for a confortable evening with my books and, under the soothing influences of a "Perfecto" was rapidly forgetting the weariness of the day's toil. After a while I became drowsy; the half-consumed cigar fell from my fingers and I slept. How long I slept I know not, neither does it matter. When I awoke, it was with a start, as if my slumbers had been disturbed by some unusual noise. The room had grown icy and I could hear the house crack with the extreme cold. Other than this, not a sound broke the stillness of the night, except the occasional moaning of the wind as it was caught in an angle of the house and then whirled away.

Suddenly the silence was broken by a sound, as if the furnace door of the heating boiler in the basement had been opened forcibly, followed by the shaking of the grate, the unmistakable rattle of a shovel in the coal bin and the clanging of the furnace door, as it was slammed to. I listened in amazement. What could it be? Surely nothing mortal, for the doors and windows had been locked for hours. And certainly not a spirit, for a spirit would care little for fire or heat What, then?

As I remained motionless in my wonderment, the basement door creaked on its hinges, the click of the latch sounded and all was quiet again. As I arose to investigate, the portieres parted and James Watt stood before me, his phantom figure standing out against the curtain background. We shook hands, and with a sigh of intense relief I said:

"What in this world or the other possessed you to fire up that boiler?"

"Well," replied James, as he removed his mittens from his bony hands and carefully put them in his coat pocket, "from the feeling of this room the fire required attention. You make me think of that poem I wrote some years ago, 'Asleep at His Post,' or something like that. That is a strange kind of coal you use," went on James, as he removed his low-cut shoes and placed his transparent feet against the radiator; "has it been frozen, or what?"

"Oh no," I replied with a laugh. "That is a kind of coal known as anthracite. It is used extensively in the eastern States, burns without smoke and gives off considerable gas, which burns with a blue flame, something like brimstone."

"Ah!" said James, half to himself, "I knew there was something familiar about it—blue flame, brimstone—why, yes, of course."

As James thus soliquized he took a cigar and then remarked:

"This is the kind of a night no honest man should be abroad;" and he lit his cigar and began smoking in a manner that would put even the infernal regions to shame, I thought; "but I got lonesome, and having got into another circle, where I have greater liberty, I decided to come and talk with a fellow craftsman for a while."

James looked discontentedly at the table, on which reposed nothing but a few books, and rolled his tongue as if his lips were dry.

"Not tonight," said I.

James began to sulk.

"You had too much the last time you were here," I continued. "Tell me about your first attempt at running a condensing engine."

"All right," responded James, at once brightening up, and saying confidentially: "I *was* kind of soused wasn't I?

"My first condensing engine, as I told you at my last visit, was one of old Newk's model. Now, as you know, his idea wasn't worth a frozen tinker when applied as he had it. The idea of condensing the steam was all right, but it required a head to work the problem out so as to apply it to practical purposes. That is the way with a good many things nowadays, I fancy," and James nodded in a self-complacent manner as if he had a notion he could set a good many wrong ideas right if he only had the opportunity. As I thought of his achievements I felt that such a possibility would not be at all unlikely. Seeing that James was apt to become absorbed in meditation, I cleared my throat in order to attract his attention, whereupon he continued:

"Of course, you know that it was the hight of nonsense to put steam into an engine cylinder, turn in cold water and expect to get any economy. In those days we hadn't paid much attention to the conservation of natural resources, which you Americans seem to be making so much ado about. But I could see that if steam engines were to be a success, a different means of condensing the steam would have to be utilized."

"Not a very brainy conclusion," I said, just to "egg" James on; "but anyone could see that the idea was not brought out by Newcomen's method of condensing."

At this James straightened up with a gasp of surprise. "Brainy!" he roared, in his hollow grave-like tones; "Brainy! why, man, you may not think so, now that the problem of condensing steam has been solved. You just stop and think a moment and see if it wasn't brainy. Think of all the great engineers who have followed me; each and every one with the best of machinery and every facility for doing good work. And what do you see? What do you see?"

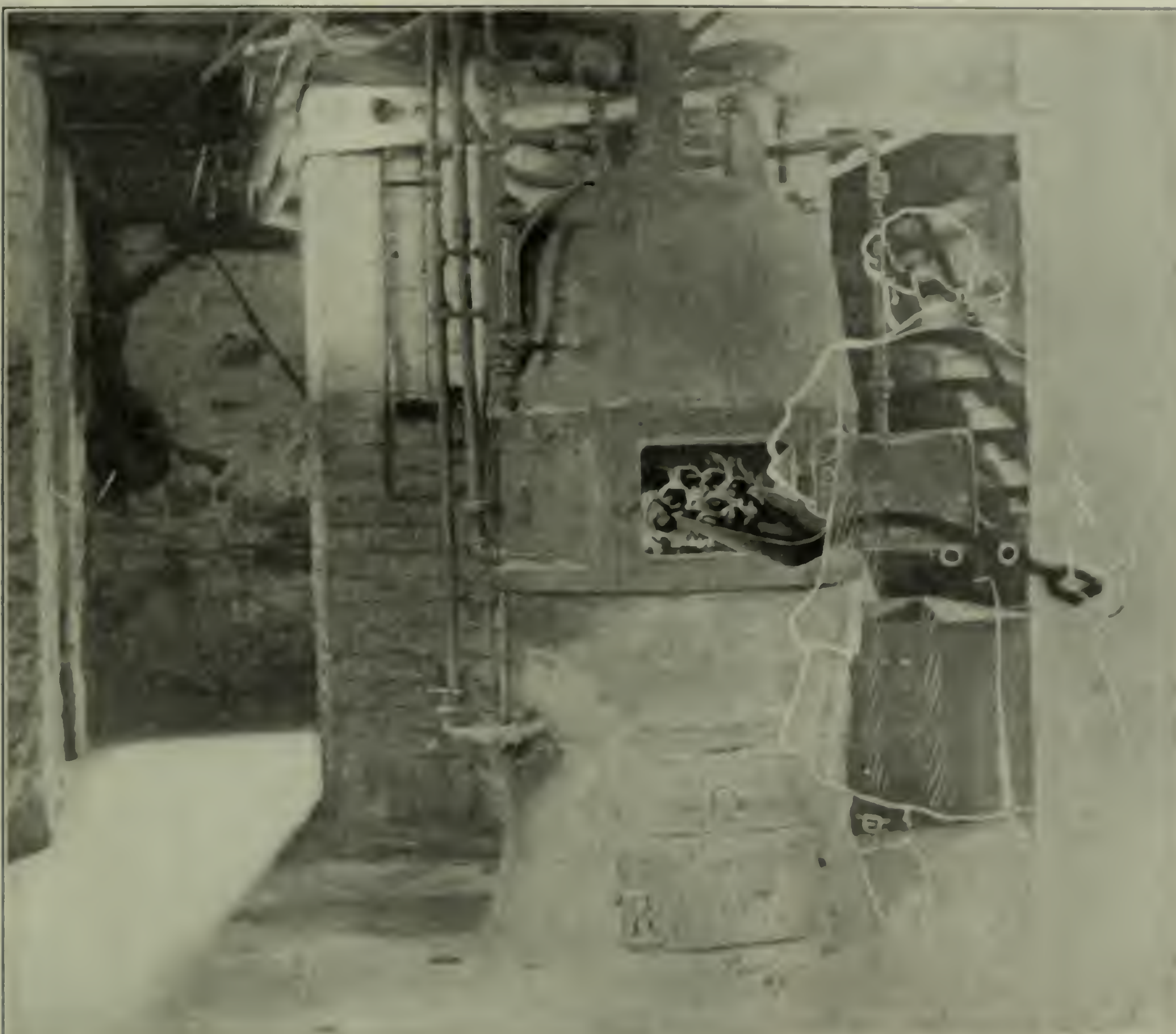
In his excitement James arose from his chair and cut the air with his fleshless arms, as he emphasized each word. His gumless teeth clicked together and a blue smoke that smelled like burning brimstone issued from his nostrils. The violence of James' resentment to my remarks regarding his thinking power alarmed me so much that I feared he might burst a blood vessel. Therefore, I assured James I had no intention of belittling his intelligence, but merely wanted to stir him up a little.

"Well," grumbled James in a mollified tone, "don't do it again. I am touchy about such things. The condenser has been improved somewhat since my day, but the idea is there, and if my patent hadn't run out I would prosecute every mother's son who is using the idea."

"That wouldn't do you any good," I replied; "it takes money to carry on a lawsuit. It wouldn't matter so much whether you were in the right or wrong, the party having the best lawyer would get the decision in the end."

"Yes, I know you are right," responded James. "I met some lawyers the other day, who were rather sociable chaps and told me considerable about the ways of making others believe that black was white, and that when you did, you didn't. St. Peter was for giving them a pass to the darker regions, but they began to argue the case in their peculiar jargon that nobody understood, and in less than half an hour had St. Peter so befuddled that he admitted it would take at least thirty years to decide their case. Then, I suppose, they will appeal his decision if it goes against them. If I had had such lawyers when I needed them, I finally came to the conclusion that I would about hit the nail on the head if I made a separate vessel and let the exhaust steam enter that to be condensed. I planned the thing out and had the condenser made according to my ideas. The first or second trial did not bring success, however; but I finally got the matter fixed so that the condenser was under the engine cylinder, with a very short connection between the two."

"What kind of a condenser did you first



THE SILENCE WAS BROKEN BY THE UNMISTAKABLE RATTLE OF THE COAL SHOVEL AND THE CLANG OF THE FURNACE DOOR.

I should have had money enough to invent things that would have made your engineers of today sit up and take notice."

"I don't doubt it," I replied in as conciliatory a tone as I could, as I saw the hair on James' head begin to rise. "It has always been a matter of wonderment to me how you carried out your many ideas in the manner you did. But go on about your condenser."

"Well," went on James, "I used to take my pipe and go out to some quiet place and sit down and smoke and think. experiment with," I asked as I passed the cigars, "a jet or surface?"

"Well, it was both; only it wasn't and it was. You see, I submerged the condenser body in a tank of water, so in a sense it was a surface condenser, seeing that the outer surface was acted on by the water surrounding it. Just how much steam was condensed by this means, I cannot say. The main feature of the condenser, however, was the jet, which condensed the greater portion of the steam. This jet was supplied with water from the tank, which was supplied by means of a pump connected with the beam of the engine. The condensed steam, injection water and air were removed from the condenser, through a foot valve, by means of an air pump and delivered to a hotwell. A boiler feed pump was piped to the hotwell and the water fed to the boiler. I calculate things haven't changed much since then, from what I can learn from new arrivals in our circle."

I was forced to admit that the idea of Watt had not changed materially, but did not say so, for James seemed to be developing a bump of self-admiration which was not doing him the least particle of good. Therefore, I said:

"Why, the condenser found in use today has no more resemblance to your condenser than the infernal regions has to a winter one. Condensers are now made not only with the aim of condensing the exhaust steam, but of maintaining a vacuum of not less than 26 inches for reciprocating engines and as high as now sible with steam turbines. Now, your condenser would be about as much use to a turbine as a dead skunk would be to a perfume manufacturer."

James did not like the observation, as I could see by the darkening brow and the way he bit his lip. But he mastered his feelings and said, in as natural a tone as possible:

"What do you mean by turbines? Is it a rotary engine? If that is what you are talking about, I want to tell you that I had a hand in that kind of a prime mover myself."

"You did!" I exclaimed in amazement, for James spoke seriously, and this was an assertion entirely out of the beaten path of claims for Watt.

"You can bet I did," was the emphatic reply. "I was going to apply the idea to my fire engine, making the connections to the rear wheels, but concluded I was altogether too far ahead of my time, and so I let it drop. Another reason was that the machine shops could not do the proper kind of work necessary for rotary engines. If they could, I would have had automobiles running over and killing people years ago."

I was fast learning that James made a grab for everything that belonged to him, but when it came to claiming to be the real originator of the automobile I concluded that it was about time to call him to account. Therefore, I said:

"Why, you can't lay claim to inventing the automobile, as well as rotary engines. Suppose you did, how did you arrange matters so as to regulate the speed of the machine?"

"The easiest thing in the world," replied Watt. "I designed the kind of interlocking gearing from the two different axles, so as to make the machine go fast or slow as I wanted it to. I did this by regulating the power applied to the shaft. That is about what they do today isn't it?" asked James, with a slight sneer on his ghostly features.

For some time I sat meditating upon the wonderful ability of Watt in the flesh, then, turning to ask a question, I found that I was alone once more.

Yasuzo Wadagaki, a Japanese engineer, read before the Northeast Coast Institution of Engineers and Ship Builders at Newcastle-upon-Tyne, recently, a paper on the "Adaptation of Steam Turbines for the Propulsion of Vessels of Moderate Speeds," in which he proposed two startling methods: (1) The putting of the propeller in the throat of a tube flaring in both directions so that the water at the throat would have a greater velocity relative to that of the ship and allow a faster running propeller to be used with efficiency, and (2) the use of a low-pressure turbine to compress the steam to a higher initial pressure and temperature before passing to the main engine.

Catechism of Electricity

Typical Forms of Direct-Current Generators

1058. *Are bipolar direct-current generators manufactured now?*

Yes; they are still being manufactured for small outputs. For outputs much above two kilowatts, multipolar generators have replaced them.

1059. *Illustrate and describe a bipolar generator as now manufactured.*

Fig. 290 shows a belt-driven bipolar machine which is made in capacities from ¾ to 1¾ kilowatts and wound to give 125 or 250 volts. The frame and magnet poles are cast in a single piece of gray iron. Fig. 291 shows the separate parts of the machine. The bearings are supported by arms *c*, *c*, etc., cast solid with the frame. The arms terminate in rings *m*, that are bored out at the same time and to the same diameter as the field-magnet poles *n* and *s* in order to provide seats for the circular bearing housings *b*. The armature *t* can be taken out by removing the four bolts which hold the rear housing. The circular bearing housings can be rotated to keep the oil wells under the bearings when the machine is mounted on a wall or ceiling.

The bearings are of the self-oiling ring type. Oil brought up from the wells by the rings is distributed by oil grooves to every part of the bearing. Covered openings are provided in the sides of the housings for inspecting the bearings and refilling the oil wells.

The field-magnet coils *h* and *l* are composed of cotton-covered wire, machine-wound on forms and then impregnated with insulating compound. They are protected by several layers of heavy tape and are held in place on the poles by clamping pieces.

The armature is of the drum type with slots to take winding, which is held in the slots by fiber wedges and by wire bands over the projecting end of the coils; no bands are used over the cores. The core laminations are punched from thin sheet steel and are assembled directly on the shaft and clamped between stiff

FIG. 290. WESTINGHOUSE BIPOLAR GENERATOR

end plates, one resting against a shoulder on the shaft and the other held by a nut on the shaft.

The commutator is made of hard-drawn copper bars separated by insulating strips of mica. The bars and insulation are assembled on bushings and clamped between V-shaped rings, from which it is insulated by mica; the clamping rings are set up after the commutator has been heated to a high temperature and while it is still hot, so as to hold every bar firmly in place. The complete commutator is pressed onto the shaft and pinned. The commutator leads are protected by tough canvas coverings and the ends are soldered into slotted projections on the bars.

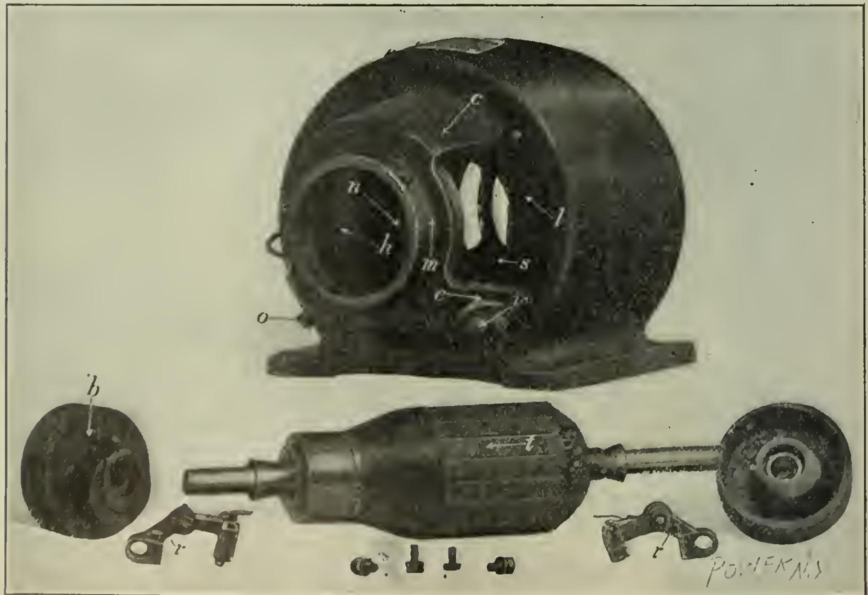


FIG. 291. PARTS OF THE BIPOLAR GENERATOR SHOWN IN FIG. 290

The rods on which the brush holders are clamped are supported by cast-iron rocker rings which are held rigidly against a machined surface on the front bearing bracket by set screws. The brush holders *r* are of the simple box type and the brushes are carbon blocks pressed radially against the commutator by flat spiral springs. The terminal wires are brought

FIG. 292. WESTINGHOUSE MULTIPOLAR GENERATOR

to binding posts *o* and *c* on the two lower arms supporting the front bearing.

1060. *Show a multipolar machine of the same type shown in Fig. 290.*

A four pole generator for outputs from 2 to 7½ kilowatts at 125 or 250 volts is shown in Figs. 292 and 293, the former illustration showing the machine assembled and the latter the separate parts. The magnet poles are cast with the frame and the field-magnet coils fastened to them as in the bipolar machine. The bearing brackets *a* and *c* are separate castings and are held to the frame by four equally spaced bolts. The armature *m* is built up in much the same way as before, but the stampings forming the core, being larger, are keyed to the shaft; ventilating ducts in the core and openings through the spider afford paths for cooling air currents. The armature coils are wound and shaped before being placed in the slots and the commutator, instead of being mounted on the shaft, is pressed on an extension of the armature spider and keyed to it. The rocker ring *s* is clamped over a machined seat on the inside of the front bearing bracket so that the brushes can be moved around the commutator.

The terminal wires *e* and *n* are brought out through an insulating bushing *o* in the side of the frame. As shown at *h*, a bedplate, equipped with belt tension adjusting screws *l* and *t*, is supplied with the generator.

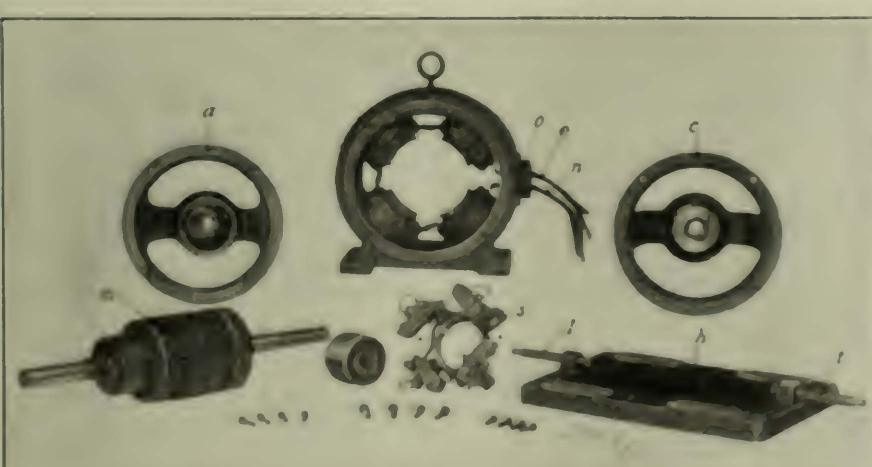


FIG. 293. PARTS OF THE MULTIPOLAR GENERATOR SHOWN IN FIG. 292

The Gas Engine in Blast Furnace Practice

By George A. Orrok

The modern American blast furnace is the most perfect gas producer. These furnaces are 100 feet high from the hearth to the stack line, 17 feet in internal diameter at the top, 24 feet in diameter at the base, with a hearth 10 feet high by 14 feet in diameter, the volume being about 25,000 cubic feet. Such a blast furnace, when running well, produces about 600 tons of pig iron each twenty-four hours and uses 1100 tons of 58 per cent. iron ore, 500 tons of coke, 200 tons of limestone and over 2000 tons of air. The gases discharged from the furnace amount to more than 3000 tons per day, or about 4,000,000 cubic feet per hour. About 30 per cent. of this gas is used in the hot stoves to heat the blast, 7½ per cent. is burned under the boilers to make the steam needed around the plant and about 2½ per cent. is used in the washers and scrubbers, leaving 60 per cent., or 2,400,000 cubic feet per hour, available for power purposes. The gas-driven blowing engines use about 15 per cent. more, leaving 1,800,000 cubic feet per hour available for the electric-generating plant. Assuming the gas to contain 80 B.t.u. per cubic foot and that 10,000 B.t.u. are required per horsepower-hour, 14,400 horsepower may be secured from the electric plant.

A 3000-Horsepower Gas Engine Pumping Station to be Installed for Fire Service in Philadelphia

By J. R. Bibbins

During March an important contract was closed by the city of Philadelphia for the equipment of a new high-pressure fire-service station, practically a duplicate of the Delaware avenue fire station, which has given satisfactory service for several years. The new plant will be located at Seventh and Lehigh avenues, in the Kensington mill district. It will take water from the old Fair Hill reservoir, as it is located some distance from the river.

The work is in charge of the Millard Construction Company, which is the general contractor, while detail-engineering work is being carried out by the Sanfield Engineering Company. The first contract covers ten 300-horsepower Westinghouse vertical single-acting gas engines, direct-connected to Deane triplex pumps, and a 150-horsepower unit for auxiliary purposes. The engines will take gas from the city mains, as in the case of the Delaware avenue station.

The decision again to employ pumps driven by gas engines for this high-pressure fire service is distinctly interesting in view of the discussion which took place previous to and after the installation of the Delaware avenue station, and which was mostly in favor of electrically driven pumps such as those in New York City.

A study of the first year's operation (1904) of the Philadelphia station indicates the kind of results that are obtainable from an installation of this kind. As this was the first year's operation of the plant, it was to be expected that the maximum interference from troubles, operative and otherwise, would be encountered. The year's record shows not a single case of failure to start, either in the actual fire service, or in the numerous experimental runs which were made to test out the equipment. During the year there were 37 alarms and nine actual services of any considerable duration, the services varying from a few minutes to 24 hours. The large pumping units ran [illegible] hours, and the small units [illegible] hours, during the year, with a total pumping service of [illegible] gallons. The average cost per thousand gallons pumped, including all the experimental runs, which were by far the major portion of the service, was 12.8 cents; but for a large fire of five or six hours' duration, the cost of pumping is barely over 3 cents per thousand gallons. The total cost of repairs on the gas engines, aggregating [illegible] horsepower, since their installation up to December, 1905, was $3.05.

On the average, one unit could be put upon the system at any [illegible] delivery pressure in from 45 to 60 seconds from the time of giving the signal from fire headquarters, and the entire station could be got under way in from 7 to 10 minutes. In ordinary operation, however, only one or two units are started on the first signal, as these are sufficient to start operations, and further units can be put on as the service may require.

A highly important feature of the Philadelphia situation is the attitude of the insurance authorities. Prior to the establishment of the Delaware avenue station the insurance underwriters had imposed an additional charge of 25 cents per $100. On the completion of the test of the high-pressure pipe line in May, 1902, a reduction of 15 cents per $100 was made, and on the final test of the gas-power station on April 18, 1905, the balance of the extra "pink slip" charge was removed and the system was declared approved. Formerly of a most decided conservatism toward gas engines, the authorities then expressed their complete confidence in the new system by suggesting extensions to the initial equipment

Commutator Brushers and Sparking

By H. B. Hadfield

Several letters have recently appeared in Power and The Engineer regarding sparking of commutators. While a widely diversified experience is shown along that line by the different writers, I am firm in the conviction that fully 95 per cent. of the trouble is caused by brushes and brushholders, while the remaining 5 per cent. would be ample to cover all the old timers and improperly designed machines which have no excuse for present existence.

I have had my troubles with "sparky" commutators, and while my present practice includes nothing of a wonderful nature, it is productive of excellent results, which is what we are all after.

I have handled machinery with brushes which have been boiled in engine oil, paraffin, beeswax, turpentine, tallow and what not, and while this "dope" seemed to give some improvement, it surely did not strike at the root of the evil; for while it would lubricate the brush it also increased the contact resistance with the brushholder and commutator and gave rise to trouble worse than that which it was intended to cure.

After the brushes are set at the correct point on the commutator, spaced evenly all around, and the load is not excessive, the commutator is true, the brushes fitted carefully to the holders and commutator, and still they spark, that is a condition productive of gray hairs and insomnia. But a careful analysis (or should it be diagnosis?) will usually trail the trouble to the door of the brushholder or the brush.

Some time ago I fell heir to several sparkers, and my experience with them has been productive of evidence against the brush and holder. A 55-horsepower type S-10 Westinghouse compound-wound 225-volt dynamo was carrying a load of 125 amperes. The brushes worked red hot most of the time, and frequently ran so hot as to melt the brushholders. This was so common that it had ceased to call forth even a moderate amount of profanity from the attendant. Today this machine carries 230 amperes and is as cool as could be desired. We are using the same brushholders that were furnished with the machine, and the same grade of carbon. The contact between carbon and

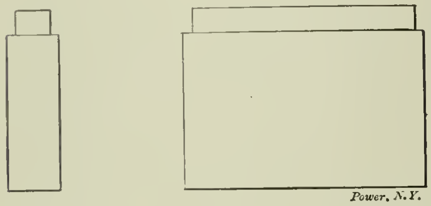


FIG. 1

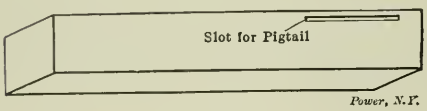


FIG. 2

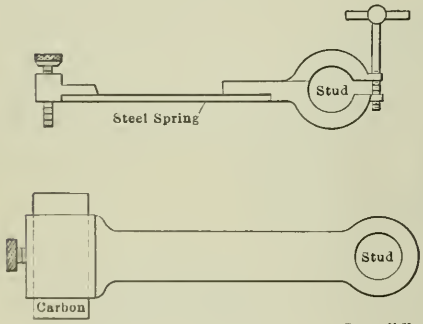


FIG. 3

holder has been improved. We found that the "pigtails" were secured to the brush by small brass bolts put through the copper webbing pigtail and a ¼-inch hole in each carbon brush. This made insufficient contact. The bolt made no contact with the brush inside the hole because it had to "clear." The point where the pigtail was squeezed against the carbon soon became overheated, carrying away the copper coating, adding to the resistance, starting the endless chain of more heat, more resistance, until it consumed either the brush or the holder.

Capping the Brushes

We made up a set of brushes like Fig. 1, which were copper-plated to insure good soldered contact. We then made caps of 1/32-inch sheet brass as represented in Fig. 2. A laminated copper pigtail was made up about ½ inch wide by ⅛-inch thick and passed through the slot at the top of the brass cap. The cap and pigtail were then soldered securely to the brush and the other end of the pigtail was fastened to a solid part of the brushholder. We have had no sparking nor overheating since. The brushes have lasted a year and are good yet; we have nearly doubled the load, and everybody is happy. This scheme of capping brushes has been carried out on about 25 motors ranging from 1 to 50 horsepower and is being applied wherever trouble comes up.

In capping brushes, no attempt should be made to solder caps to carbon without copper-plating, as only an indifferent contact will result, and while it may be inconvenient to buy brushes cut out at the top as needed it will pay to send them away for plating after cutting, if necessary.

That it is not always sufficient merely to carry out the instructions of the manufacturer can be clearly shown, although if these instructions were more generally followed much anxiety and expense would be saved. But there are cases where the man who designs a machine seldom or never sees it in regular operation, and certainly never has to "sweat blood" to keep a factory or a department of one running with a tricky motor.

We had a 40-horsepower motor running a positive blower two hours per day in a foundry. At the end of the run it was usually hot enough to fry eggs, and while running was so noisy as to be irritating. The brushholder was of the style shown in Fig. 3, where the brush is clamped to the holder for good contact, and the stud runs through a large hole in the other end of the holder, allowing the holder either to dance around like a dervish or require clamping the spring so tightly that it became practically jammed on the bars and squeeled like a pig.

In this case we made new brushholders of a different type and fitted them with capped brushes, and the machine now runs very coolly and quietly and is as good a motor as any we have.

One of the large manufacturers put out a 10-horsepower four-pole motor which has a commutator 3½ inches long, and is fitted with brushes 1¼ inches wide. The holders are attached to two wooden blocks, a pair on each block, and the blocks are fastened to the usual brushholder ring. All four of these brushes run in the middle of the commutator, making a track 1¼ inches wide. Trouble with one brush means trouble with four in a very short time. We took the wood blocks off and cut a notch ⅝ inch deep where each block fits the brush yoke. The two top holders were blocked in ⅝ inch and the two lower ones blocked out. This puts a positive and a negative brush in each track, which is no small advantage.

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

How the Steaming of a Boiler Was Improved

I have charge of a plant in which there are two 150-horsepower boilers and one 100-horsepower. The 100-horsepower boiler is represented in the accompanying Figs. 1 and 2. Fig. 1 shows how the boiler was arranged when I took charge of the plant. The boiler did not steam good at all and did not seem to have very much draft, although there was a good-sized stack.

I fixed some of the brickwork that was loose, thinking that was the trouble, but it did not help very much. When the boiler was cut out the next time I decided to change some of the brickwork, as shown in Fig. 2. The back wall *A* was removed and an extra wall *B* was built behind the boiler and filled in with earth between the two walls *C* and *B*, cutting the space down from 48 inches to 18 inches. Since the change was made the boiler steams good, burns less coal, has a splendid draft and is better every way. It seems that the arrangement shown in Fig. 1 gave a space so wide that the flames and gases just whirled around in the large arch before passing out through the flues.

D. M. Geare.

Covington, Va.

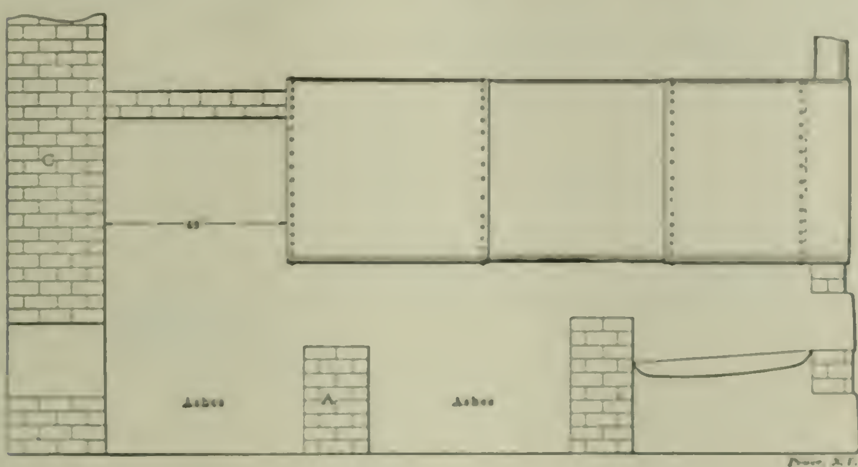


FIG. 1. BEFORE THE CHANGE

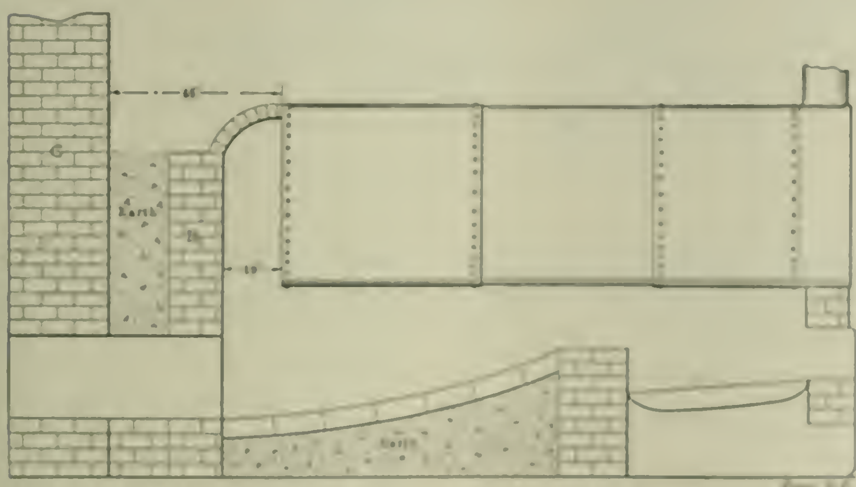


FIG. 2. AFTER THE CHANGE

Safety Cams

On page 730 of the April 20 number appeared a letter regarding safety cams, in which the writer states that the eccentric is set about 135 degrees ahead of the crank. This position gives the eccentric an angle of advance of about 45 degrees, which is excessive. He states that in this position the indicator diagram will show a square corner at the closure of the exhaust, or in other words no compression and late release. This is entirely wrong.

It would be impossible to get release and compression late on a Corliss engine with the eccentric set 135 degrees ahead of the crank. As a matter of fact, either one or both of these events must be very early. It would be possible to get both release and compression early, or it would be possible to get proper release or compression, while the other event in each case would be very much too early. The only way to get both events late, as Mr. Tryon states, would be to have the eccentric not set far enough ahead of the crank.

Suppose with the eccentric at 135 degrees advance we adjust the exhaust-valve reach rod, so as to get proper exhaust. The compression would be too high, and we would have to shift the eccentric back, then adjust the exhaust-valve reach rod to bring the exhaust right again, after which the compression will be seen to be reduced. If not enough, the eccentric and rod will have to be changed more in this same manner until both exhaust and compression are satisfactory.

Changing the eccentric in this way will have made the admission late, and to bring the admission right, the steam-valve reach rod must be shortened and the dashpot rod lengthened. The steam-valve reach rod is shortened to make the admission earlier, and the dashpot rod is lengthened to reduce the lap of the valve and allow the hook to catch on when in its lowest position.

These changes bring us to the trip collar, on which are mounted the safety cams and cam for tripping the hook by the action of the governor.

To set these trip collars it must be remembered that the block must always unhook and allow the valve to be closed by the action of the dashpot. The valve must never be allowed to be opened and closed by the hook. To set these trip collars, I unhook the hook and the eccentric placed with the safety stop in position for starting the engine; I then start the engine and have it run as slowly as possible until I get the trip collars set. At this speed the governor will remain on the safety stop and in this position the steam valves should close at the latest possible point of the piston stroke. To get this result the reach rod connecting the trip collar with the governor must be lengthened or shortened as the case requires, until the hook is tripped at the very latest point possible of its stroke upward.

When the trip collar is set in this position the safety cam should very nearly touch the end of the hook when the hook is in its lowest point, and if the governor is let down off the safety stop the engine should stop, because the safety cams should hold the hook off so that it cannot open the valve and admit the steam. If the safety cam does not hold off the valve hook when the governor is down and the valve gear is correctly adjusted otherwise, the safety cam should be set up on the trip collar until it is close enough to hold the hook off, and secured in this position.

Harry W. Benton.

Cleveland, O.

Faulty Engine Adjustment

On page 686 of the April 13 number, E. O. Brown presents two engine cards typical for badly adjusted old-style Fitchburg engines.

Two faults in adjustment may be detected: The change in lead of the head end at different loads points to a wrong position of the governor on the shaft. The excessive variation in cutoff of the head end compared to the crank end proves that the eccentric rod is too short, on account of which the rocker pin does not travel an equal distance on either side of the plumb line through the rocker-arm fulcrum.

The governor should be adjusted by trying to get the smallest movement in the valves, when swinging the governor weights in and out; the engine being put alternately on each dead center. Taking out the springs will convenience this operation greatly. If the governor is in the correct position a countersunk hole will likely be found on the shaft under the tap of the set screw in the hub of the governor wheel, which is generally drilled in by the manufacturers before shipment of the engine.

Before starting to change the length of the eccentric rod, mark the position of the crank end valve at the dead center, as its lead is correct and should not be changed. Then shorten the eccentric rod by turning the hook until the rocker pin swings an equal distance on either side past the plumb line through the center of the rocker-arm fulcrum. Put the engine at the farthest dead center and clamp the crank-end valve stem on its reach rod with the valve in the marked position. With this valve now in the correct position, the head-end valve should be adjusted by shifting its clamp until the indicator card shows the same lead at both ends of the cylinder at all loads.

Rulof Klein.

New York City.

Motor Controller Troubles

A short time ago the starting lever of a direct-current stationary-motor controller was broken, as shown in Fig. 1; it was impossible to get a new lever at once, so the old one was repaired with a patch. The repair took one hour, including the time spent in removing the lever and replacing it.

The break was due to one of the segments being loose and raised a little higher than the others. When the operator moved the starting lever the copper brush on the lever could not pass over the high segments, so force was used, with the result that the lever was broken and some of the segments were bent.

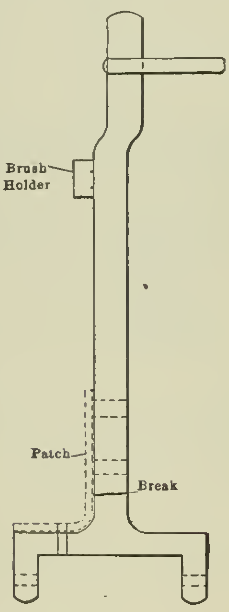


FIG. 1

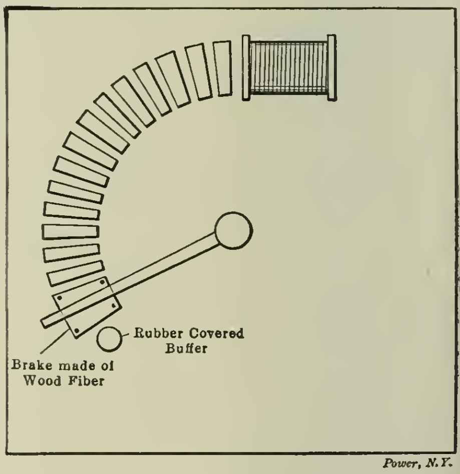


FIG. 2

Most motor controllers used in shop and factory work have rubber-covered buffers next to the brake (Fig. 2), in order to stop the starting lever when it is released by the magnet when the switch is thrown out. In time these buffers will wear out or break and, if not renewed in time, when the starting lever is released by the magnet it will strike against the pins which held the buffers on. These starting levers are made of cast iron, are very light and break easily.

Some makers of motor controllers use slate for the brake, which I think is bad practice, because when the copper brush on the starting lever becomes a little rough it will scratch the slate and dust gets under the copper brush, causing sparking at the segments when the lever is moved to the starting position. I had a controller of this type. I made a brake of wood fiber and had no more trouble.

A controller on one of our cranes used to spark badly. I found that the segments were all burned black. They were cleaned with sandpaper, but in a short time they were burned black again, when it was found that the carbon brush on the starting lever did not make good contact with the segments at the toe. After the brush was ground to a good fit with sandpaper there was no more trouble.

H. A. Jahnke.

Milwaukee, Wis.

Synchronizing Trouble

I think C. L. Greer's synchronizing trouble was caused by the pulsating unidirectional electromotive force which exists between any commutator brush and any collector ring of the converter. Since the three-phase alternating-current electromotive force is 400 volts, the direct-current voltage will be about 650 volts. The instantaneous values of the pulsating electromotive force vary from 0 to 650 volts, giving an effective voltage of about 460 volts.

If the voltmeter plug is placed in *A*, the positive brush is connected to the positive busbar through the middle voltmeter lead. In synchronizing with the voltmeter plug in *A* and one of the synchronizing plug switches closed, the effective electromotive force impressed upon the lamps varies from 0, when the machines are in phase, to about 460 volts when in opposition. Therefore, the lamps receive about 460 volts instead of 400 volts. The plug *A* burned because the voltages were not equal, or because they were not exactly in phase when the switch was closed.

H. C. Coates.

Granite City, Ill.

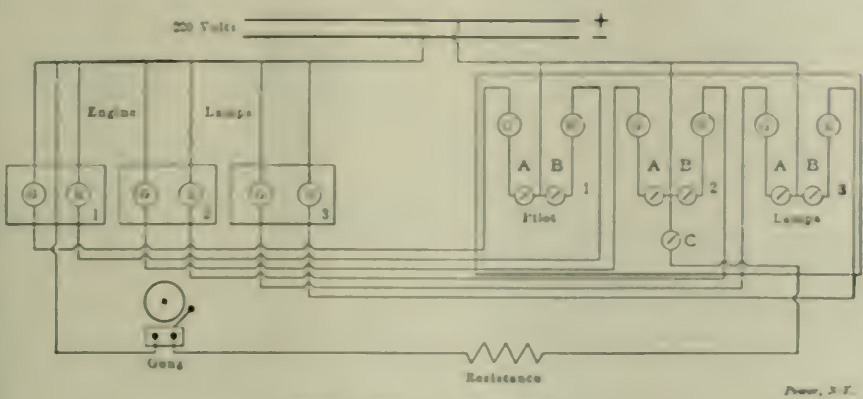
A Gas Engine Signal System

In dealing with the minor difficulties incident to gas-engine operation, the signal system represented by the accompanying diagram is a great convenience. It is preferable to have the signal control on the panel of the generator driven by the engine for which it is intended. This will avoid any confusion of machine numbers. In cases where the wiring on the panel does not permit of any additional wiring, a separate signal board may be used, as shown in the figure. A set of signals must be arranged between the gas engine and switchboard operators. A red and green lamp are placed over each engine at some convenient spot where they can be seen by the engineer from any part of his engine. These are indicated in the diagram by R and G and corresponding pilot lights R' and G' are placed on the signal panel for the guidance of the switchboard operator. By means of the small push-button switches A and B the lights are controlled. The lamps R and R', and G and G' are in series, respectively, across a 220-volt supply circuit, or one of some other convenient voltage. A large gong is placed near the center of the power house and rung by the switch C to call the attention of the engineers to their signal lights. The simpler the code of signals, the more effective it will be. The following code of signals for paralleling generators is very easily understood: Red lights to slow down, green to increase the speed, and red and green to balance the mixture in the cylinders. This code is also applicable for readjusting the load during parallel operation. For example, suppose that the load carried by three 2000-kilowatt alternators becomes unequally divided so that No. 1 generator carries 2000 kilowatts, No. 2 generator, 2000 kilowatts and No. 3 generator 1000 kilowatts. With these conditions there will be a decided hunting action between the units. To readjust the load it is necessary to look at the frequency meter to see if the speed is correct. If so, the gong is sounded, the red lamp is lighted over engine No. 1, both lamps are dark over No. 2 and the green lamp is lighted over No. 3. When the load has been divided equally among the three generators the lamps are extinguished, of course.

The governor switch is used in most cases, where mixtures are adjusted by hand, only to synchronize the machines. After the generators have been synchronized and the load becomes unbalanced, the engineer advances or retards the spark and adjusts the supply of gas alone until the proper conditions are restored.

William D. Little.

Wilkinsburg, Penn.



SIGNAL-SYSTEM CONNECTIONS

Trouble in a Pumping Plant

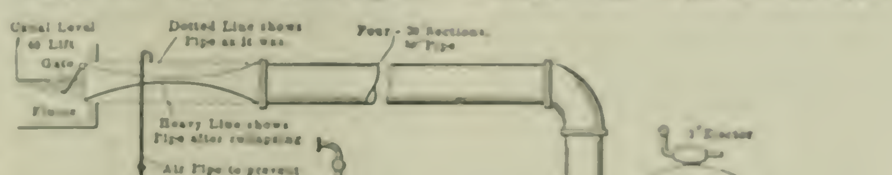
The article in a recent issue about "Pethlyn P. D." was very interesting, and I am sorry that I did not know the "P. D." some four years ago when I was engaged as chief engineer in an irrigation pumping plant, where on several occasions a very peculiar thing took place.

The 20-inch centrifugal pump, running at 240 revolutions per minute, pulled by nine wraps of 1¼-inch rope, was guaranteed to throw 25,000 gallons of water per minute, and after several tests was found to throw some 30,000 gallons. One morning I found a bearing hot on one side, which was something unusual. I noticed that the engine acted as if the load was light. I climbed up to the flume and found that only about one-half the usual amount of water was being delivered by the pump. I thought I had solved the mystery and that the suction was stopped up. As the suction pipe was not equipped with a foot valve, the water was raised by a 2-inch ejector. I got a long pole and ran it down along the suction pipe in the water, thinking perhaps that one of the floor planks in the intake had got loose and obstructed the flow in the pipe, but nothing was found wrong. I was in somewhat of a bad fix, 500 miles from home, 19 miles from a railroad, and 90 miles from a machine shop and if I had known of "P. D." I would gladly have given half of the hardest part of my past life. The water was badly needed, as some 3000 acres was planted with rice, and water had to be had. I shut down the engine and started the ejector, and I could feel the water in both suction pipes, and starting and running the engine and pump up to speed, the hot box was something of the past.

This same thing happened several times, and I never found the cause, and will give "P. D." a chance to solve the problem. The accompanying illustration shows details of the installation.

On one occasion, having plenty of water in the canal, we had stopped the engine to change the suction pipe in the fuel-oil tank, and to pack the boiler-feed pump. While we were working on the pump, the engine started, stopped and again started. The fireman had shut down the plant and was sure he had closed the main engine throttle. Looking at the receiver gage, it showed a pressure of 180 pounds. One can imagine my thoughts as the receiver was made of cast iron, and we never had more than 90 pounds in it.

During the installation, I had a be-



TROUBLE IN A PUMPING PLANT

pass put in between the receiver and trap, so that in case the trap should fail, it could be removed and repaired, and the bypass used for draining the condensation in the receiver, and not have water passing into the low-pressure cylinder. I opened the bypass, which was the only time it was used. We afterward found a globe valve partly open, on a pipe leading from the steam main to the receiver. We maintained a receiver pressure of 12 pounds by cracking the valve, and found the engine worked without any undue noise with this pressure for the low-pressure cylinder and 180 pounds for high-pressure cylinder.

When running night and day, we usually stopped at 6 a.m. and 6 p.m. to fill the grease cup on the crank pin. One morning the night engineer stopped as usual and, while filling the grease cup, heard the water from the flume rushing back to the river through the pump. He then knew that he had forgotten to drop the flap door on the end of the discharge pipe. He loosened the rope, dropped the door, and the result was that the velocity of the water and the sudden vacuum created in the discharge pipe caused one 20-foot length to collapse. This caused a shutdown for one week until a new section could be made. When this was put in I tapped a 1-inch pipe on top of the discharge pipe, with a globe valve at the bottom within reach. This valve was opened when shutting down the plant, and permitted air to go into the discharge pipe as the water went back through the pump after the flap door was closed.

C. WILHELMSEN.

Kentwood, La.

Explosion of a Fire Hoe

Engineers are all more or less familiar with boiler and flywheel explosions, but the explosion of a fire hoe is probably a new "wrinkle."

The photograph shows the handle of a

FIRE HOE AFTER EXPLOSION

fire hoe which exploded while the fireman was cleaning fires. The handle was made of ¾ inch steam pipe. Slack was used as fuel, and the coal pile was so near the boilers that in pulling out the ashes the handle had been jammed full of slack. Repeated heatings had baked the slack so that it tightly plugged the end of the handle.

On the occasion of the explosion the fires were very hot and very dirty, so that the handle got hot enough to ignite the gas formed on the inside of it by the coal.

RAY L. RAYBURN.

Decatur, Ill.

A Peculiar Pump Trouble

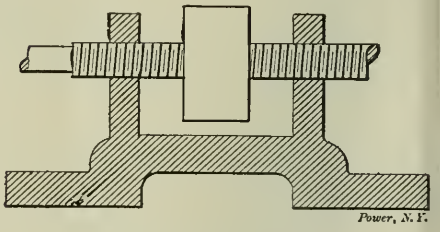
In the course of a somewhat varied and lengthy experience, the writer has come across some curious pump troubles and their remedies, but the following is the only one of its kind that he ever saw or heard of:

The incident happened in a pumping plant, consisting of a 14x24x14x18-inch compound condensing pump, and a 7½x7x12-inch independent air pump and condenser. The main pump was operated at 15 revolutions per minute and the air pump would form a vacuum of 26½ or 27 inches, with the steam valve one-third of a turn open. The boiler pressure was 65 pounds.

Upon starting the pump one day it was noticed that the air pump did not pull down the vacuum as usual, so the steam valve was at once examined to see if it was open its customary one-third turn, and was found to be so. The steam was at full pressure. The water valve to the condenser was never changed, so we looked for leaks, but could discover none, so the steam valve was opened a little more.

This condition continued for some time and we were compelled gradually to open the steam valve until it was wide open, and we were just about able to hold the 26½ inches of vacuum, but with the valve wide open there was no increase in the speed of the pump. The writer had suggested several times that the pump be examined internally, but was gently sat upon, until the vacuum began to disappear. Then it was decided that something must be done and the pump was shut down and opened up. The water end was thoroughly examined as a starter, everything being found as it should be. Next the steam cylinders were examined, but everything was found all right. The valve covers were then taken off, which in the writer's opinion should have been done first, and the valves appeared to be all right; the pump was then traveled to test them and they worked correctly. Then the valves were cocked up on one side to allow the ports and bridges to be seen. While the edges of the ports showed some little erosion, there was nothing to account for the extra amount of steam to operate the pump or the falling away of the vacuum.

Again the writer ventured a suggestion, this time to the effect that the trouble must be in the valves or ports, and advised that the valves be taken out altogether to enable a thorough examination of ports and valves. He was told to go ahead and do as he liked, and was immediately left alone. Upon removing both valves, which were of the ordinary D type, with two lugs on the top, between which was a rectangular block about ¾ inch



A PECULIAR PUMP TROUBLE

square, with a hole in the center, through which the valve stem passed and moved the valve, instead of locknuts, everything looked all right. It began to look like a case of "stumped," when upon turning the valve over again, the block upon the top moved over to the other lug, and the trouble was found.

In the top of the valve on one side, where the block rested as it moved back and forth, it had worn a hole through the valve, and when the valve was turned over, with the block held on top of it, it was hardly perceptible, yet upon taking the block out it seemed as though a blind man ought to have seen it, although five of us were unable to discover it.

A new valve was immediately procured and when the pump started again it went on the job with one-third turn on the steam valve as usual.

W. N. WING.

Brooklyn, N. Y.

What Would Happen if the Belt Came Off

In answer to H. B. Adcock, in the April 20 number, I will say that in case one of the exciter belts breaks he will have to look out for fireworks at that exciter's commutator.

The generator, running without a field, would draw excessive current from the busbars and if fused would probably blow the fuses. It would act as a sort of transformer, taking current from the busbars and pumping it into the exciter, probably burning the commutator badly.

If the other alternator could supply the current, the speed would increase, as the heavy lagging current would react upon the fields to demagnetize them and drop the load, although the current would be a great deal above normal full-load current.

CHARLES O. RANKIN.

Craftonville, Cal.

In reply to H. B. Adcock's question in the April 20 issue, I will say that the alternator whose exciter belt is thrown can be considered practically a transformer with its secondary circuit completed by a moderately high impedance. I venture to say that with some characteristics of design the alternator would continue to run somewhat as an induction motor, while upon the other hand it may draw such an excessive current from the other machine as to make it necessary to take it off the line at once. I am of the opinion, however, that no serious results would occur.

L. Earle Brown.

Ensley, Ala.

Replying to H. B. Adcock's inquiry in the April 20 number, as to what will happen if the belt driving an exciter should break, there would be no current flowing through the field circuit, but the generator would run as an unexcited synchronous motor, taking a very heavy lagging current from the busbars.

If both machines were operating at near their rated capacity when the belt broke, it would put quite a load on the one machine and I believe there would be some fireworks in a short time. It would be a good investment to install fuses between the generators and busbars, especially in this case, where the exciters do not operate in parallel and no auto-switches are provided.

Louis B. Carl.

Marshfield, Wis.

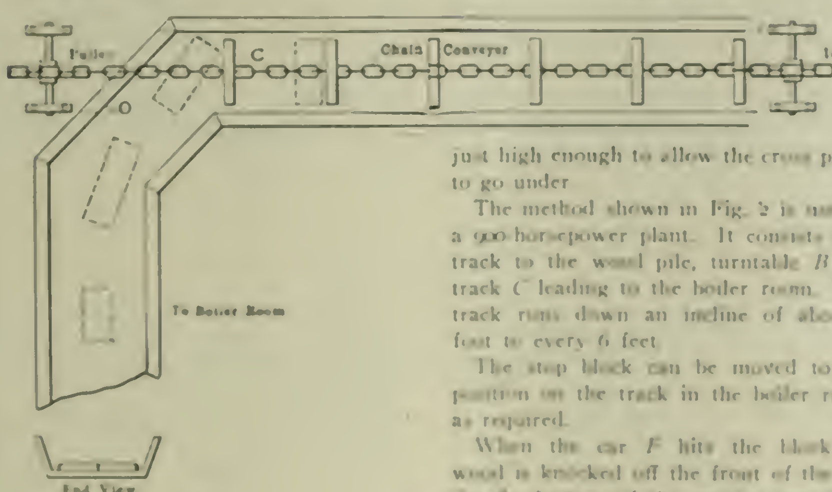


FIG. 1

I think the alternator would continue to run and carry the load. This would be because of its field being magnetized by an induced current from the other alternator, and if there were no fuses or breakers in the exciter circuit the exciter would probably continue running as a motor. Of course, the voltage and power factor of the system would be very much below normal.

Harry J. Bremer.

Schenectady, N. Y.

Handling Wood Economically

On page 121 of the January 12 number, I. B. Sutton wishes to know of a way to handle wood economically. The accompanying illustrations show two ways of handling wood which work successfully.

The system shown in Fig. 1 is located in a 3000-horsepower plant, and consists of a chute C which leads to the boiler room, having several openings which are opened and closed by a rope leading to any convenient place.

The conveyer is a common endless-chain conveyer with the cross pieces about 15 inches apart. The turning board is just high enough to allow the cross pieces to go under.

The method shown in Fig. 2 is used in a 900-horsepower plant. It consists of a track to the wood pile, turntable *B* and track *C* leading to the boiler room. This track runs down an incline of about 1 foot to every 6 feet.

The stop block can be moved to any position on the track in the boiler room, as required.

When the car *F* hits the block the wood is knocked off the front of the car. On the bottom of the car are two strips of iron to keep the wood from sticking. The car is built of heavy timber to withstand the jolt of stopping.

When wood is required in the boiler room, one of the firemen rings a bell to let the wood handler know. He in turn rings a bell and lets the car go and applies enough pressure on the brake of the engine to keep the cable tight and stop the engine when the car stops. When the car hits and unloads it is hauled up and loaded for the next call.

In Mr. Sutton's case, I should think power could be taken from the main engine, if the cable was returned to the boiler room, or the hoisting engine done away with by using two cars and make a double track part of the way at least.

Albin Sears.

Elberton, Wash.

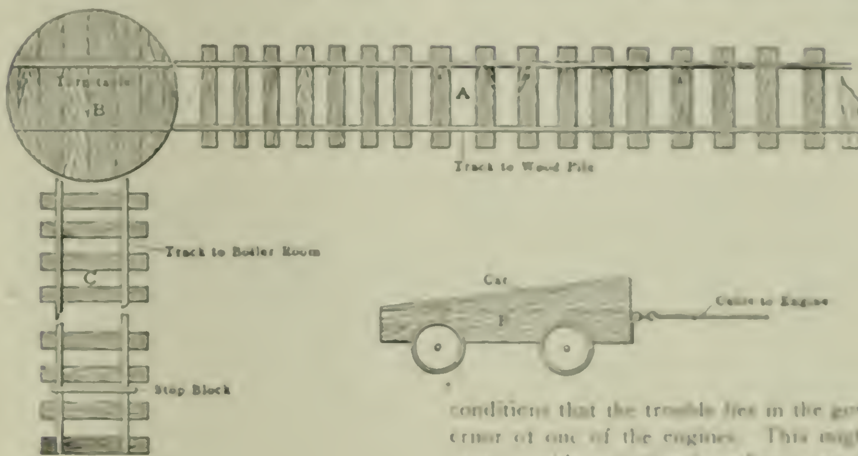


FIG. 2

Reversing Polarity

Referring to the letter in the April 20 number, by H. F. West, in regard to trouble in operating two direct-current machines in parallel, the fact that one machine is larger than the other should not interfere with their proper operation.

I take it that these machines are separately driven. It is possible under such conditions that the trouble lies in the governor of one of the engines. This might cause a wide variation in voltage, especially if one machine had a rising characteristic and the other not.

The compounding of his machine may not be correct for satisfactory parallel operation and if he can determine which machine has a tendency to produce the highest voltage at the busbars he could improve the conditions by inserting a coil of wire into the leads from this machine so as to give a greater drop in the leads between machine and busbar and, therefore, bring the voltage down. This coil need be only a large coil of the same wire as the leads and connected into the lead on the positive side.

T. A. Lees.

Quincy, Mass.

In answering H. F. West in regard to one of his direct-current machines reversing the other one at times, I will give my experience.

Taking it for granted that his machines are connected with an equalizer, I find that it is possible to run compound machines of greatly varying sizes together if they are wound for the same voltage, but it is sometimes necessary to put an extra shunt in the shunt field circuit on the machine which tries to take the load in grabbing heavy loads. Sometimes one machine will be found to be considerably quicker than the other and by increasing the size of the shunt he can obviate this, and I would advise him to try it. He can easily make the shunt out of german-silver wire and insulate it with tape; put the shunt on the machine which reverses the other one.

J. G. Dennington.

South Oil City, Penn.

Hydraulic Information

In a recent issue, under the head of "Hydraulic Information Wanted," William E. Pipe gives a certain stream flow, and states that by going back 500 feet from the proposed location of the plant a fall of 140 feet can be obtained. He inquires as to the size and grade of pipe, class and size of wheel most applicable to the case in hand, and the number of 16-candlepower lamps that could be carried.

His letter of inquiry does not contain sufficient information to enable one to make a very definite or reliable reply, and on the basis of incomplete and general information a reply must necessarily be considered equally incomplete and general. It may be of interest, however, to consider the matter in the light of the data furnished.

By a stream of water delivering 360 inches under a 12-inch pressure, doubtless a discharge of 360 miner's inches under a head of 1 foot is meant. Such being the case, a continuous discharge of this amount would mean approximately 12.45 cubic feet per second.

The selection of the proper size of pipe or penstock is in itself quite a problem, increasing in importance with the plants in which the cost of the pipe line is a large percentage of the total cost. The chief factors on which the proper solution of this problem depends are quantity of flow through the pipe, static head, probable total cost of development per horsepower, and the cost per pound of the penstock erected. Based on the above, expressions of considerable value have been worked out for the most economical diameter to install in any particular case. Since the friction in a pipe line for a fixed quantity flowing decreases with an increase in the size of pipe, it follows that the annual saving in the value of power occasioned by a reduction in the frictional resistance must be considered in connection with the increased yearly interest and depreciation on the first cost of the larger pipe. For example, if the reduced friction head in a 26-inch pipe line is such as to increase the available power 0.2 horsepower over that obtainable with a 24-inch penstock and power is worth $75 per horsepower per year, the annual saving would amount to $15. If the increased cost of the larger pipe erected is $200, with interest and depreciation figured at 8 per cent. per annum, the change would not be warranted. Briefly stated, then, that size of penstock would seem most economical for which the yearly interest and depreciation on the first cost of the pipe plus the value of the power lost in the pipe line per year are minimum. The accompanying table shows what diameter of pipe seems most economical.

The table was first prepared to include pipes of smaller diameter, as well as a 36-inch pipe, but as the proper size aupeared to be within the limits of a 22- to 30-inch pipe, only that section of the table is included. The value of power per year, the cost of the pipe line per pound, and the interest and depreciation figures are only approximate and cannot be expected to fit exactly the case in hand.

1 Pipe Diam. Inches.	2 Velocity per Feet Second.	3 Friction, Feet.	4 Power Lost. Horse-power.	5 Yearly Loss.	6 Cost of Pipe.	7 Yearly Interest and Depreciation.	8 Sum of Columns 5 and 7.
22	4 72	2.50	3.54	$177.00	$1100.00	$110.00	$287.00
24	3.97	1.70	2.41	120.50	1600.00	160.00	280.50
26	3 38	1 20	1.70	85.00	1775.00	177.50	262.50
28	3 02	0 90	1 27	63.50	1900.00	190.00	253.50
30	2 54	0 60	0 85	42 50	2240 00	224 00	266.50

Power at $50 per horsepower year. Interest and depreciation at 10 per cent. Pipe at $0.10 per pound.

From a consideration of the data contained in this table the 28-inch pipe appears to be the proper one. The friction losses are taken from tables for sheet-steel riveted pipe, as this grade of pipe is considered the proper one to use.

Based on the flow given and the effective head of practically 139 feet the power to be delivered by a turbine of 80 per cent. efficiency would be equal to

$$\frac{12.45 \times 139 \times 0.80 \times 62.5}{550} = 157.30$$

horsepower. Under the conditions of head and flow a high-pressure turbine would seem the most advisable. Figured on catalog conditions for this type of wheel the proper relation of power and diameter would call for a 20- to 25-inch wheel. The standard 22-inch wheel of one of the reliable companies is rated at 176 horsepower at 495 revolutions per minute, and a discharge of 13.9 cubic feet per second, and would appear to be the nearest fitted for the case in hand.

Assuming the combined generator and wire efficiency to be 80 per cent., the power delivered for lighting would be equivalent to

$$157.5 \times 0.08 \times 746 = 93{,}877$$

watts. The average power required to carry one 16-candlepower lamp is

$$16 \times 3.3 = 52.8$$

watts. The number of lamps that could be carried, therefore, would be

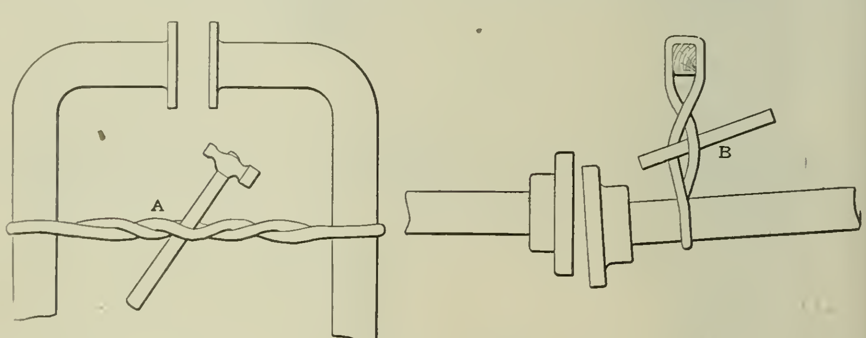
$$93{,}877 \div 52.8 = 1778.$$

B. R. McBride.

Madison, Wis.

The Spanish Windlass

The origin of the term "Spanish Windlass" is somewhat obscure, and as far as I have been able to ascertain it is not Spanish, and it is not a windlass, but of its utility as an improvised tackle there is not the slightest doubt. Among sea-going engineers it is a great favorite, as most of the machinery, etc, under their control is put together with a view to economizing space and is consequently not amenable to shop methods.



THE SPANISH WINDLASS

The accompanying line cuts show how it is applied at *A* for bringing two pipes together for jointing and at *B* for raising one end of a length of shafting to bring it into line for coupling. It will be seen that it does the duty of turn-buckle, screw, pulley blocks, or crowbar. The travel, or rather the length of pull exerted in proportion to the power applied to the "tommy" is enormous, being limited only by the strength of the rope itself. I have used it hundreds of times, and for as many different purposes, and I always regard it as one of the simplest and most useful emergency tackles. Many a time when working in cramped or otherwise inconvenient places such as the bilges of a ship, where it was not possible to use pinch-bar or pulleys, I have easily got over a difficulty by using a Spanish windlass on it, and frequently when I have been sent out into the country to overhaul engines, etc., I have been able to save considerable time by its use, particularly in some out-of-the-way places where the only available tools were a coal hammer and a monkey wrench with a loose jaw.

S. J. Bean.

London, England.

Three Engine Room Kinks

A main stop-gate valve on a boiler leaked so badly that it could not be entered for cleaning as steam leaked through from the other boilers. This was remedied by tapping a hole between the

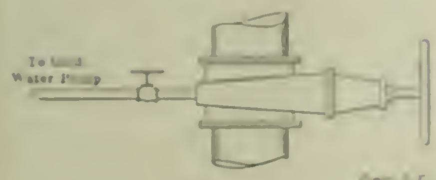


FIG. 1

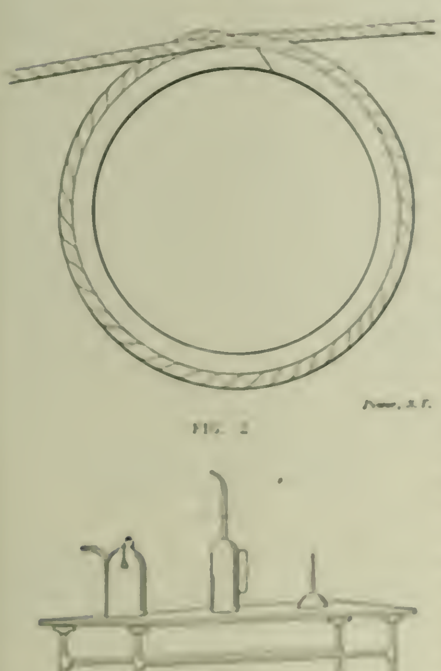


FIG. 2

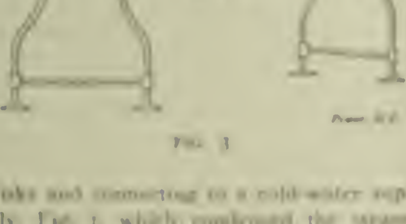


FIG. 3

disks and connecting to a cold-water supply, Fig. 1, which condensed the steam, and allowed the boiler to be entered.

A good way to enter small piston rings in a cylinder is to tie a string around them which compresses them and allows an easy entering to the cylinder. See Fig. 2.

A table for oil cans, etc., which I made for my engine room, is shown in Fig. 3. When painted or bronzed it makes a showy affair.

Milton Hiller.

Cincinnati, O.

Cleaning Fires

It is interesting to note the different way firemen go about cleaning fires. One man will make it a job to be dreaded, while another will do it so easily that it is apparently very little trouble.

To a large extent, it is a matter of good judgment. The man who uses judgment will begin about an hour before cleaning time to get his water level, fire and steam pressure in proper condition. He will then clean the fires with very little loss of pressure, and a minimum of discomfort and work. The man who uses no judgment and makes no preparations in advance will have several bushels of half-burned coal raked out with the clinkers, which makes it so hot as to be almost impossible to stand in front of it, fills the room with smoke and soot, and by the time he is done his own temperature and temper, also, are about as high as that of the boiler, and he will have to fight his fires for an hour to get the steam pressure up again.

The amount of coal wasted by carelessness in cleaning fires is very large in most cases. If the boilers are being forced, or a cheap grade of coal is used, it is impossible to clean the fires without raking out a pile of red-hot clinkers. The usual practice in this case is to have an assistant stand by and play a hose on them to quench the heat. This is a bad thing to do, however, as it makes it impossible to keep the boiler fronts in good condition, besides raising a stifling gas which must be breathed by the man doing the cleaning.

A better method is, before beginning to clean, to rake out several shovelfuls of ashes from the pit, and have the assistant throw a shovelful on the clinkers from time to time. This effectually kills the heat and causes no discomfort to the one cleaning the fire.

About an hour before time to clean the fires, the feed pumps should be speeded up, and the water level raised as high as is safe to avoid priming. The poker should be run over the grates frequently to sift all fine ashes through, being careful not to raise it up, or to get the clinkers up into the burning coal. This allows a free draft, burns all unconsumed coal that might be among the clinkers and leaves them dead and comparatively cool.

About five or ten minutes before beginning to clean, throw in a fire on the opposite side of the grates from the side to be cleaned, and slow down or stop the feed pumps. Then shove the live coals back against the bridgewall with the hoe, draw all clinkers out, draw the live coals forward and rake the clinkers from the back end of the grates out over the fire. Then level the fire over the cleaned grates and cover moderately thick with fresh coal, using lump coal broken medium fine, if available.

If there is not enough live coal remaining to start the fresh coal well, use the hoe to draw some over from the other side of the grates, and then throw in a light fire on this side also. As soon as the fire is up to an even thickness on the side cleaned, the other side can be allowed to burn down, and be cleaned in the same manner. If properly managed, fires can be cleaned in this way with little or no loss of steam pressure, with a decided saving in fuel over most methods, and with a minimum amount of labor and discomfort on the part of the fireman.

One of the hardest possible methods, and one very commonly used, is that of letting ashes and clinkers collect so thick on the grates up to the time to clean that a heavy fire is necessary to hold the steam, then using the slice bar to pry the fire over to each side while raking out the clinkers.

It is necessary to use both the slice bar and hoe in cleaning this way, and there is sure to be a large amount of partly burned coal raked out with the clinkers.

S. Kiron.

New York City.

Hot Bearings

In an article on "Hot Bearings; Some Causes and Remedies," page 678, April 6 issue, H. S. Brown mentions his experience with locomotive rod brasses, and suggests cutting away the brass at the sides so that only an end or crown bearing remains. In his Fig. 4 only about two-fifths of the projected area of the bearing remains. A modification of this which is sometimes used when it is desired to sacrifice as little as possible of the projected area is to relieve the brass slightly with a file for about ½ inch at the edges. This prevents binding at this point and provides a small oil pocket while the brass is coming down to a bearing on the crown.

Another method of preventing this pinching action consists essentially in placing a very thin liner between the two halves of the brass and then boring larger, the excess diameter being equal to the thickness of the liner. When there is no pinching this method gives theoretically only a line bearing in the crown of the brass and should be used only when the service is such that the part may be broken in by careful running. Either of these methods, however, may often be used to advantage in places where a half bearing held in pedestals is used, and where strains due to changes in temperature may cause the bearing to close slightly at the edges.

The suggestion that it is a mistake to reduce the amount of metal by coring out at the back brings up the subject of bearings of other than rod brasses and the use of light brass liners for the bearing surfaces, and suggests the desirability, where the service is severe enough to warrant it, of using all brass boxes, or at least enough readily to conduct away the heat generated by friction to a radiating surface sufficient to get rid of it. This will be appreciated when it is remembered that the conductivity of copper alloys will range between 2 and 2½ that of cast iron.

As to open grain in the material and the desirability of having a dense surface, forging in dies close to the finished size while excellent for small parts is not always possible with heavy unwieldy parts, such as shafts. A good method in this case is to roll the journal with a roller somewhat similar to that mentioned for rolling babbitt, the roller being held in the toolpost of the lathe, after the finishing cut has been taken, and forced against the journal by the cross feed. This gives the journal a very dense and smooth outer surface, effectively closing all open grain.

An excellent method of cooling plain high-speed (not ring-oiling) babbitted bearings, which I have sometimes used with considerable success, and which has not received the publicity that I believe it deserves, is to feed beeswax, in strings of 3/32 inch or ⅛ inch diameter into the oil hole. The running journal, especially if warm, readily takes the wax. The preparation of the beeswax strings is a simple matter, the only apparatus required being a short piece of ¾-inch or 1-inch pipe, a pipe cap and a rod of the same diameter as the pipe and of equal length. The cap is screwed onto the end of the pipe, a hole a trifle smaller than the desired diameter of the beeswax string is drilled in the pipe close to the cap, the pipe is nearly filled with the wax and the rod forced in in a vise. The wax is forced out at the drilled hole in the form of a continuous string. Any hard grease may be put into this convenient form for feeding through an oil hole in the same way.

Mr. Brown's article brings to mind certain troubles with old wrought-iron journals and pins. In one case a bearing on which the load was always in the same direction, and not alternating as in a connecting rod, ran hot whenever it was allowed to heat up beyond a certain moderate temperature. It was perfectly free, there was no binding and examination showed that both the journal and bearing surfaces were smooth; there was no visible cutting due to grit or foreign matter, and changes of oil had little effect. The trouble was finally located in a seam which was almost invisible when the bearing was cool, but evidently opened up and acted as an oil wiper when warmed up. When once located the trouble was overcome by scraping down the sharp edge of the seam with the corner of a file properly ground.

A. S. Williamson.

Urbana, Ill.

A Whistle Repair

The stem of a whistle was broken as shown in Fig. 1 and was repaired by drilling a hole nearly the size of the stem.

The hole *C* is drilled about ½ inch from the top of the hole drilled through the center of the stem. I ground the two ends of the whistle stem smooth and placed them together. After closing the hole *C* and the bottom of hole *D*, I filled the hole in the stem with the best grade of babbitt through the hole *D*. The

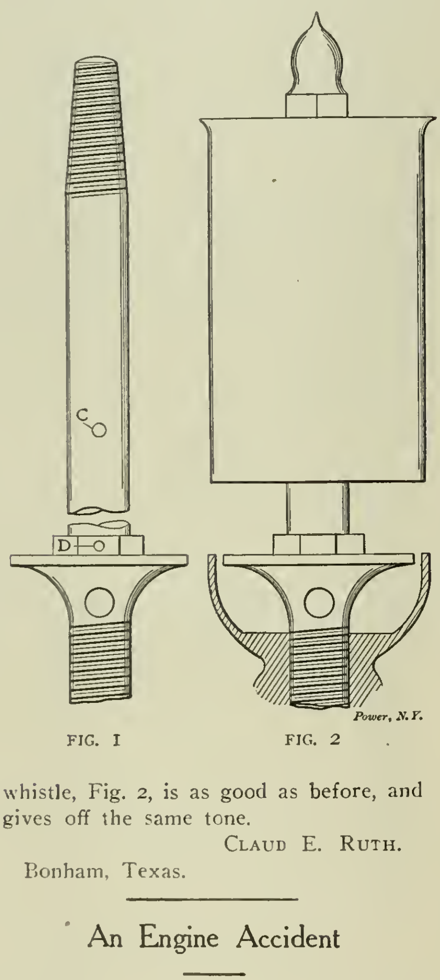


FIG. 1 FIG. 2

whistle, Fig. 2, is as good as before, and gives off the same tone.

Claud E. Ruth.

Bonham, Texas.

An Engine Accident

Referring to the letter in the issue of March 23, entitled "An Engine Accident," it appears that Mr. Sheehan, the writer, has been imposed upon. It seems incredible that an engine builder would attempt to shift the responsibility upon the operator for breaking a rod which had already cracked. It would not be any more unreasonable for a boiler manufacturer to claim that a defective tube would not have burst if the pressure had been reduced. It is doubtful that a reputable builder produced the engine in question.

It is true that the engine was unbalanced at the time the diagrams shown were taken, for the left-hand high-pressure diagram indicates 161.2 horsepower, while the right-hand low-pressure diagram indicates 147.4 horsepower. It does not appear, however, that the high- and low-pressure were taken under the same conditions; for upon reducing the former to the same pressure scale as the latter, the combination will show that the high-pressure exhausts at a lower pressure than the low-pressure cylinder receives and the diagrams will lap. Possibly the springs were inaccurate.

The unequal distribution of work should not have broken the rod, for a 3-inch rod transmitting the whole work of the engine (308.6 horsepower) would in the high-pressure cylinder, at 80 revolutions per minute, be subjected to a total load of 18,183 pounds; which is the product of the area of the high-pressure piston (198.5 square inches net) and the mean effective pressure necessary to develop 308.6 horsepower in the high-pressure cylinder alone (91.6 pounds).

The rod would then have been subjected to a unit stress of 18,183 divided by 7.07 (its cross-sectional area), or 2557 pounds per square inch; which, if the rod were not good for more than 50,000 pounds, ultimate, would represent a factor of safety of practically 20.

Assuming that Mr. Sheehan's statements are facts, this failure is clearly the fault of the builders, for it is clear from the above deduction that a 3-inch rod, even of wrought iron would, if sound, have carried the total load of the engine. That the rod showed an old break would indicate that excessive tension was not the cause of the trouble, but that bending, or some local weakness developed it.

Alfred Williamson.

New York City

Vibration and Tension

If an elevator rope, with the car three or four stories from the top, is pulled to one side and then released, it will vibrate slow enough to permit one to count the vibrations.

When two ropes of the same size are suspending the same car, if the tension in one is greater than in the other, the first will vibrate the faster; but I am not certain just what relation exists between the rate of vibration and the tension. If they are directly proportional, it certainly would afford an easy and accurate method of determining the relative tension in two or more ropes.

It seems quite evident that, if the ropes are of the same length, and weight, the rate of vibration depends only on the tension.

Who knows about this subject?

H. H. Hastings.

St. Louis, Mo.

Some Useful Lessons of Limewater

The Chemistry of Sulphur and the Importance of Becoming Familiar with Its Varied Properties, Compounds and Affiliations

BY CHARLES S. PALMER

In starting out on the systematic study of sulphur and its compounds, theoretically one might reasonably ask for a table of the principal compounds, in their oxidized and reduced relations, just as we considered the tables of the compounds of carbon. All that will come in due season, but first let us ask for some tangible and practical illustrations of the compounds of sulphur, at least to show their great importance. One will not have to search long for such an illustration. We find it right at hand, in sulphuric acid, and in many substances which are directly dependent on sulphuric acid for their production and cheap abundance.

Of course, every worker in iron knows how commonly oil of vitriol, that is sulphuric acid, is used to eat off the scale formed on iron forgings; and likewise everyone thinks of the common production of effervescent sparkling waters which are aërated, that is, "airified," by carbonic-acid gas, which is itself set free from soda carbonates by means of this same oil of vitriol. But there are other illustrations of the importance of sulphuric acid, illustrations which are just as important and common but not quite so obvious, unless attention is called directly to them.

Thus, soda and its compounds until recently have been entirely dependent on sulphuric acid for their production; and when one mentions soda he is unconsciously suggesting the importance of such common things as glass and soap both of which are made from soda or its compounds. Moreover, many of the other acids are made by the use of sulphuric acid. Nitric acid is made by the action of sulphuric acid on certain nitrates, and hydrochloric acid is made by the action of sulphuric acid on common salt. Vast quantities of sulphuric acid are used in the purification of crude petroleum, and in manufacturing therefrom the various kinds and grades of burning, cleaning, illuminating and friction oils. Further, large quantities of the waste "sludge acid" from the purification of crude petroleum and also large quantities of fresh sulphuric acid are used in the treatment of crude phosphate rock in order to change into a soluble form the insoluble phosphoric acid so that it can be made soluble for use as fertilizer. These lessons are not primarily written for students of farming, but it is interesting to know that the three chief ingredients of fertilizers are phosphoric acid, potash and nitrogen in some form; and thus we see that one of the three, phosphoric acid as fertilizer, is dependent on sulphuric acid.

Importance of Sulphuric Acid

Indeed, the manufacture of sulphuric acid is so important that nothing else in the whole field of chemistry can be compared to it, except the manufacture of its opposite and contrasted mate, soda and its compounds, always excepting of course, the chemistry of fire and combustion.

There are immense quantities of sulphuric acid locked up in union with lime in the form of calcium sulphate, or gypsum; and yet, strange to say, we have not discovered any cheap and easy method for obtaining sulphuric acid from gypsum. Instead of this we are practically dependent for the manufacture of sulphuric acid on the burning of native sulphur or brimstone, or from the burning of sulphur contained in iron pyrites and copper pyrites. Formerly most of the sulphur used in the preparation of sulphuric acid was obtained from Sicily; but a few years ago it was discovered, accidentally, in boring for oil and water in Louisiana, that vast deposits of sulphur are to be found only a few hundred feet from the surface. Later on we will consider these sulphur deposits, but at present we will keep our attention fixed on the manufacture, the properties and the uses of the king of chemicals, sulphuric acid.

In the burning of pyrites, and particularly in the smelting of copper ores associated with pyrites, vast quantities of sulphur are burned off, and formerly the sulphur dioxide (two-oxide, SO_2) was wasted. In the far West, where the freight rates prohibit the manufacture and cheap shipping of such a common commodity as sulphuric acid, the sulphur fumes from the roasting of pyrites are wasted by the hundreds of tons every day. At the great smelters at Anaconda, Montana, where the low-grade copper ores are mixed with much iron pyrites, sulphur is thrown off into the air by immense chimney stacks in such quantities that it is safely estimated that enough of this material is wasted every day to make some two thousand or more tons of sulphuric acid; and yet this enormous waste goes on, in monotonous regularity, because it would not pay to save the sulphur for making sulphuric acid for which there would be no market. But in some of the works on or near the eastern coast pyrites are roasted in such a manner that the sulphur fume is saved for making sulphuric acid to be used in manufacturing fertilizer, or for any of the other common uses of sulphuric acid.

When the heaps of crude sulphur compounds of iron are allowed to stand exposed to the weather, there is formed much of common sulphate of iron, or "green vitriol," and when this green vitriol is collected and heated in closed stills, it gives off its water and sulphuric acid in the form of a very concentrated and caustic sulphuric acid, called "fuming" or "Nordhausen" sulphuric acid, from the name of a little German town where it was made over a hundred years ago. Afterward a method was discovered for making sulphuric acid from the sulphur fumes, or sulphur dioxide, by using the oxygen of the air in connection with nitric fumes. These nitric fumes are a mixture of several of the oxides of nitrogen, and in the presence of these nitric fumes, with the oxygen of the air, the sulphur dioxide goes over to the sulphur trioxide (SO_3, sulphur three-oxide), or sulphuric form. Later I will show just how the nitric fumes, "NO_2," help the oxygen of the air to make sulphuric acid out of water and the sulphur dioxide (sulphur two-oxide, SO_2).

When sulphur burns in the air, most of it goes to the SO_2, or sulphur two-oxide stage, only 1 or 2 per cent. of the whole going on to the sulphuric or SO_3 stage (sulphur three-oxide stage). In the presence of the nitric fumes, and with just the right amount of water or steam present, all of the sulphur goes over from the sulphurous or SO_2 stage to the sulphuric or SO_3 stage. The SO_3 or sulphuric stage is practically sulphuric acid, for sulphur three-oxide is the anhydride of sulphuric acid.

In this way sulphuric acid has been made so cheap for many years that in recent times the price of the crude acid is not far from a cent a pound. That means that the acid must be used near its place of manufacture, for such a cheap product will not stand the tax of distant and expensive carrying. Therefore, we will usually find a sulphuric-acid plant placed near the factory where it is to be used, in purifying crude petroleum, in making fertilizer, in making soda by the old Leblanc process, or in any of the other more important ways.

In this way it has come about, naturally, that chemical manufacture has built itself up and around the making of sulphuric acid. That is why we rightly call sulphuric acid the king of chemicals. Not to mention fertilizer and refined petroleum, or the other acids which are made from sulphuric acid, also note that the chemical opposite, soda and its compounds (the carbonate, the bicarbonate and caustic soda or sodium hydroxide), are the chemical opposites of and are made by the use of sulphuric acid. Noting all this, one is rightly glad to yield the leadership to sulphuric acid. Of course, in modern times the immense production of "sulphuric pulp," in making common paper from the softer woods, has come to be an industry which is almost incredibly great in its figures, and here we find that the sulphurous oxide, SO_2, or sulphur dioxide or two-oxide, is the active agent in softening the wood fiber; but great as this is, it is secondary to the larger use of sulphuric acid directly and indirectly.

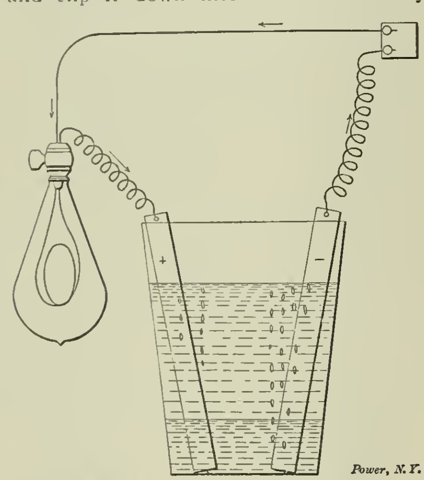
What Sulphuric Acid Is

But it is time to study sulphuric acid for itself. Note, first, that it is a heavy, oily liquid—"oil of vitriol," because it was first made by distilling green vitriol, or sulphate of iron. This sulphuric acid is a very harsh, corrosive liquid. One cannot touch it with anything which contains any water or the ingredients of water, without seeing the sulphuric acid take hold of it like a thirsty wild beast. Drop a little on common white pine or other soft white wood and you will note the inky spots where the acid takes the ingredients of water out of the wood.

Moreover, when the concentrated sulphuric acid takes hold of water, there is some sort of chemical union between the strong acid and the water; for much heat is developed. To show this, pour about an inch of water into a test tube, and then on this, carefully, about as much more of the strong acid. You can scarcely hold the tube, at the lower part, in the unprotected hand, such is the heat developed. Remember the rule which has been given several times as to mixing sulphuric acid and water, to the effect that the acid should always be poured into the water, never the water into the acid. If you stop and think of this, you will see the reason why this is so. Water boils at 212 degrees Fahrenheit (100 degrees Celsius or Centrigrade) and sulphuric acid boils at a much higher temperature, nearly up to the melting of common solder. Consequently, if the water is poured on the acid, so much heat is let loose by the first drops of water that the acid is warmed up at once, and the next drops are liable to be driven off into steam, as the acid gets at it; at any rate an explosive shooting-out of the water and acid occurs.

But if the acid is poured into the water, it mixes evenly with the water and, although the temperature rises quite high, the results act as though the water were a part of the acid, which is not far from the truth. This difference between strong or concentrated acid and dilute acid is so marked that the acid is often used in taking water out of things. Common alcohol can be turned into ether by distilling the two together, and the resulting ether is still popularly called "sulphuric ether;" not that ether contains any sulphuric acid, but simply that it is made from alcohol by the dehydrating or "water-subtracting" action of the strong acid. This difference between the concentrated and the dilute acid is so marked that it is now said, and quite truly, that sulphuric acid is not really an acid until it is diluted with water.

What is meant by this is shown best by an experiment. Take a strip of zinc, say half an inch wide and three inches long, and slip it down into a clean and dry



EXPERIMENT WITH DILUTE SULPHURIC ACID

test tube. Then pour over it about an inch of strong sulphuric acid. If you have never done this before you will be surprised to see but little action of the metal and acid on each other. But now, cautiously, break the rule just given (as to never pouring water on strong sulphuric acid) and you will note that, as you carefully pour on enough water to dilute the acid to, say, one part in four or five of water, the action between the metal and the acid will begin vigorously. You want to study this experiment and do some thinking with it. It used to be said that the first action of the acid on the metal is to make sulphate of zinc, and that then the action stops until some water is added to dissolve off this zinc sulphate so that more acid can get at the zinc. But that is hardly the way to look at it, for much more than this is happening.

Dilute Sulphuric Acid an Electrical Conductor

You will remember that it has been stated that acids are salts of hydrogen. Now the action of zinc on dilute sulphuric acid is to displace the hydrogen from the acid. But if the zinc cannot do this from the strong and concentrated acid, evidently the hydrogen is not ready to be set free from the concentrated acid as it is ready to be set free from the dilute acid. This is precisely what happens. The action of the water on the strong acid is to unlock, in some strange way, the hydrogen so that it is ready to be thrown off by the zinc. This difference between the locked and unlocked states of the hydrogen in the sulphuric acid is also shown by the fact that strong sulphuric acid is not a good conductor of electricity, while dilute sulphuric acid is an excellent conductor. This is shown by the following experiment:

I will suppose that you have a common electric light in your boiler room, with direct current. Arrange your tumbler electric battery cell, as shown in the illustration, but with both poles made of copper. Connect one pole to the leading wire from the current supply, and the other wire to a common lamp, using the lamp as a resistance. No more current can go through the tumbler electrolytic cell than can go through the lamp, so you are safe there. Having all ready, as shown in the illustration, pour about an inch of strong acid into the tumbler with the copper poles. You will note that but little current will flow and the proof is that the electric lamp will give out hardly any light. But replace the strong sulphuric acid by several inches of dilute acid and at once the electric lamp will light up, because the dilute acid is a good conductor of electricity. If you watch to see at which of the two copper poles the hydrogen comes off, you can tell which is the anode or in-going pole and which the cathode or out-going pole. Remember that hydrogen will come off from the cathode in the electrolytic cell, because the hydrogen, being the metallic element, goes with the positive current.

Some gas will come off from both poles, but the hydrogen is twice as great in volume as the oxygen; and so it is easy to decide which is the cathode or out-going pole of the current. In this way one can tell the direction of the direct current which is supplying his light. Of course one can use the small battery of the zinc-copper couple, described in a previous lesson; but that is rather a weak current with which to get satisfactory results. Still, one can do much good work even with weak currents.

Just why the concentrated sulphuric acid does not readily conduct electricity and why the dilute acid does conduct it are interesting questions. Broadly, it may be said that this difference between concentrated and dilute sulphuric acid is one of the main points in the modern theory of solution. It is evident that adding water to dilute the strong acid does something to the hydrogen so that it can be released from the sulphuric acid, either by the zinc, or by the electric current. This quality or condition of the dilute sulphuric acid, as contrasted with the concentrated acid, is called "dissociation," and that word means just what you have noted in the ready release of the hydrogen from the sulphuric acid by either the zinc or the electric current. The acid acts as though it were in some way separated or dissociated into its active parts. The two atoms of combining parts of hydrogen in sulphuric acid, H_2SO_4 make the parts on one side. To find what are the other parts of sulphuric acid, just write out the formulas of several of the sulphates or salts of sulphuric acid with several of the metals, and note what is common to all of the sulphates. You will find that the imaginary group, "sulphion," SO_4, is found both in sulphuric acid itself, and in each of its sulphates, thus: Sulphuric acid itself is $H_2—SO_4$; blue vitriol, or sulphate of copper, is $Cu—SO_4$; green vitriol, or sulphate of iron, is $Fe—SO_4$; white vitriol or zinc sulphate, is $Zn—SO_4$; gypsum, or calcium sulphate, is $Ca—SO_4$; glauber's salt, or sodium sulphate, is $Na_2—SO_4$; epsom salt, or magnesium sulphate, is $Mg—SO_4$, and so on.

Peculiar Action of Water

In all of these salts there is more or less of "water of crystallization;" but I have neglected that part of the formulas, to keep the attention fixed on the simple form of the salts in question, and you will note that in every case there is the imaginary group, SO_4, sulphion, which runs through all of the sulphates or salts of sulphuric acid. Evidently this sulphion group is the other part of sulphuric acid which remains when it is separated or dissociated into its active chemical or electrical parts by simple dilution with water. I shall have much more to say about this peculiar action of water from time to time; but it should be noted here that while the old chemistry used to say that when an acid and a base act upon each other a salt is formed, and water is the side product, modern chemistry says that when an acid and a base act upon each other water is formed and the respective salt is the side product. This is only one way of saying over again, what has already been noted, namely, that we live under the conditions of a water chemistry. It is water that acts upon common chemicals, waking them up to life and quick response to mutual exchange. We shall find that dilute solutions of acids, bases and salts make the common field of active chemical reaction and of quick electrical conductivity.

But we are studying the chemistry of sulphur in particular; and before closing this chapter, let us look for a moment at the accompanying plain oxidation table of sulphur. Note that on the left-hand, or reduced end, comes hydrogen sulphide, then sulphur itself, then sulphur dioxide, SO_2 (sulphur two-oxide, or sulphurous anhydride, because it is the anhydride of sulphurous acid); and, lastly, sulphur trioxide, SO_3 (sulphur three-oxide), the anhydride of sulphuric acid and sulphuric acid itself, H_2SO_4.

Here it is well for us to note that salts are usually named from the acid which makes them, giving the salt the ending "ate" if the name of the acid ends in "ic," and giving the salt the ending "ite" if the name of the acid ends in "ous." Thus sulphuric acid forms *sulphates*; from nitric acid comes a *nitrate*; from phosphoric acid comes a *phosphate*; from oxalic acid comes an *oxalate*, from acetic acid comes an *acetate*; from silicic acid comes a silicate, and so on. Similarly from the "ous" acids, come the salts ending in "ite." Thus sulphur*ous* acid makes the sulph*ites*; nitr*ous* acid, the nitr*ites*; phosphor*ous* acid, the phosph*ites*; and so on. It will be easily remembered that the "ous" acids and their salts, the "ites," are in a relatively lower state of oxidation than the "ic" acids, and their salts, the "ates." Sulphurous acid and the sulphites are in a lower state of oxidation than the sulphates and sulphuric acid.

If there were such a thing as "carbonous" acid, it would form the "carbonites," just as the more highly oxidized carbonic acid makes carbonates. As a matter of fact, real "carbonous" acid is well known, only it happens to be called formic acid, and makes the formates, as you will find by looking at the oxidation tables of carbon in a previous lesson. All this naming of acids and salts is a part of what is called chemical nomenclature, the long-name-ology of chemistry, and it will repay one to master the simple rules here given in naming common salts, for it is part of the system in general use. The only common exception to the naming of salts from acids is found in the names of such a thing as common salt, NaCl, which is made from common hydrochloric acid or muriatic acid. Common salt, NaCl, sodium chloride and hydrochloric acid, HCl or hydrogen chloride, are so-called because they are made up of two things, and two-thing compounds (or binary compounds) are given names which end in "ide," as the chlorides, the oxides, the sulphides, the nitrides, and so on. Thus, hydrobromic acid, HBr, hydrogen bromide, makes the bromides, as potassium bromide, KBr (kalium is the chemical Latin for potassium, the alkali metal). This careful use of names is only giving one many delicate mental forceps for picking up and handling neatly many valuable chemical facts. One handles potatoes with a potato digger, but one picks up diamonds with fine pincers; so you are assembling your kit of chemical tools for much good work which will be to your later and practical advantage. But just put in a few minutes with this table of sulphur compounds; it will be needed in treating this wonderful subject of sulphur, which is only a part of chemistry, the finest subject in the world.

TABLE OF SULPHUR COMPOUNDS

Reduced End			Oxidized End
H_2S Hydrogen Sulphide. The sulphides	S, or S_2 Elemental Sulphur. Lower Amorphous Crystalline	SO_2 Dioxide Sulphurous Anhydride	SO_3 Trioxide Sulphuric Anhydride
		H_2SO_3 Sulphurous acid	H_2SO_4 Sulphuric acid
		Sulphites	Sulphates

Fallacious Reasoning

By C. M. Ripley

Will one kind of coal with 13,000 B.t.u. per pound evaporate 30 per cent. more water than another kind of coal containing 10,000 B.t.u. per pound? At first glance many of us might be inclined to say yes to this question. But it is a fallacy to reason that as it takes heat to evaporate water and the B.t.u. is a measure of heat, therefore the more B.t.u. per pound of coal the more water will be evaporated proportionally.

Where the Fallacy Is

The weak point in the argument is that while the B.t.u. is an exact measure of the heat in the coal, it is not an exact measure, by any means, of the heat that can be put into the water. Obviously, the difference between total heat and useful heat is boiler efficiency. And right here comes in a question that is not often asked: "Does the efficiency of any certain boiler change as the type of fuel is changed?"

The answer to this question is that the efficiency of a boiler does change and can be 20 per cent. different in the same day, with the same wind prevailing and the same conditions existing in the draft, dampers, door openings, depth and care of fire, etc.

Why Boiler Efficiencies Change

The heating value which goes up the stack consists partly of unconsumed gases. Bituminous coal has a much larger percentage of volatile matter than any other solid fuel in common use. This volatile matter, called the "volatile hydrocarbons," is from 20 to 40 per cent. of the weight of the coal. As soon as coal is fired, the volatile matter begins to separate itself from the coal and start toward the stack. Since anthracite has on the average from one-sixth to one-tenth as much volatile matter as bituminous coal, it at once becomes apparent that the chance of unconsumed gases going up the stack from bituminous coal is six to ten times greater than if anthracite were used.

It is for this reason that it is difficult to get more than 80 or 85 per cent. boiler efficiency with bituminous coal, although anthracite carefully fired can easily give from 70 to 80 per cent. boiler efficiency.

The fixed carbon in both cases has little tendency to do anything besides stay on the grate bars until perfectly consumed. We can see therefore one of the great advantages in burning coke, since coke has no volatile matter and runs about 92 per cent. fixed carbon. The following analyses of different fuels will show the variations in the combinations between fixed carbon and the volatile hydrocarbon of four different fuels, and also their B.t.u. per pound:

CHEMICAL ANALYSES OF DIFFERENT FUELS.

	Bituminous.	Anthracite.	Buckwheat.	Coke.
Fixed car	60%	80.87%	76.92%	92.38%
Vol. H.C.	32%	3.98%	1.05%	
Ash.....	8 to 10%	11.23%	16.62%	7.21%
Heat units, B.t.u..	11,000 to 14,500	12,000	11,000	13,500

It would not necessarily be true for a fuel salesman to say: "I am selling a low-grade fuel which costs only a little more than half as much as buckwheat, and but little more than a third as much as a larger size anthracite. You get in my fuel 20 per cent. more B.t.u. for a dollar than in the kind of fuel you are now burning. Therefore you can expect a reduction of 20 per cent. in your fuel bill."

The shrewd engineer, before accepting this statement as true, will inquire: "What are the percentages of fixed carbon, volatile matter and ash in this fuel?" This is a very pointed question, and when we realize that the losses up the stack increase rapidly as the volatile matter in the fuel increases over 20 per cent., we can see readily that the heat units in a fuel are not a true measure of the usefulness of that fuel.

The error of this method of judging fuel can be corrected approximately by estimating what the efficiency of the boiler would probably be. The foregoing figures regarding boiler efficiency show a possible error, which can be stated as follows: Bituminous coal with 32 per cent. volatile matter, as compared with anthracite containing 4 per cent. volatile matter, gives approximately 20 per cent. lower boiler efficiency.

The advocates of elaborate tests of the B.t.u. in samples of coal should bear in mind that the item of boiler efficiency is to be reckoned with. In the same general types of coal the B.t.u. value is a fair judge of the evaporating value of the coal. But in comparing fuels of an entirely different nature, the discussion of the heat unit per pound is valuable only when taken in conjunction with boiler efficiency and proportion of volatile matter, ash, etc.

In a recent interview on this subject, Percival Robert Moses, consulting engineer, said:

"I have appreciated this fact for some years, and in the capacity of advisory engineer have recommended the use of those fuels which are low in the percentage of volatile hydrocarbons. The extent to which high boiler efficiency shows up on the cost record is amazing. We have frequently, working in conjunction with the chief engineer of a power plant, replaced a fuel costing $4.10 per ton with a different fuel costing $2.08 per ton. The surprising part is that with a theoretical difference of 2000 B.t.u. per pound in favor of the more expensive fuel, the month's consumption of the lower-grade fuel would show the same number of tons as when the expensive fuel was used. Since cheap steam is the foundation of power-plant economy, the savings effected have sometimes been remarkable."

Two Interesting Boiler Accidents

While inspecting and applying hydrostatic pressure to several small vertical boilers connected to hoisting engines operating on Devonshire street, Boston, Mass., the inspector's attention was called to a leak at one of the rivets in the lap seam of one of the boilers which had not been examined. Apparently the rivet had been calked several times without stopping the leak.

The working pressure carried was irregular, varying from that which would operate the engine under light loads to 90 pounds, at which point the safety valve prevented farther rise of pressure. Hydrostatic pressure was applied and at 93 pounds pressure, with a light snap, a crack about 2 feet long appeared in the overlapping sheet along the edge of the row of rivet heads. See Fig. 1.

This form of crack is exactly what would be expected if two sheets of metal were joined with a lap-riveted seam and then subjected to repeated bendings back and forth, until one of the sheets cracked. In the nature of the case it would not fail anywhere else.

A course in a boiler with a lap seam cannot be round and the pressure of steam tends to make it round. When the pressure is lowered or removed, the course tends to return to its original shape, and it is this bending, or breathing as it is sometimes called, that makes the lap seam an unsafe joint in boiler construction.

In the boiler room of the American Wringer Company, Woonsocket, R. I., on Sunday, September 27, 1908, at about 6 p.m., while steam was being raised in a boiler which had been out of service for some days for cleaning and minor repairs, the attention of the engineer was called to escaping steam near the rear end. Examination showed that it was coming from the longitudinal seam in the end course.

Pressure on the boiler, which had reached 85 pounds, was reduced as rapidly as possible and an examination made. This point was of butt double-strap treble-riveted construction and failed by cracking through the outer row of rivet holes, and it is believed to be the only failure of this nature that ever occurred in a butt and strap seam.

Inspection showed that the cause of the failure was not difficult to locate and could with certainty have been predicted from the beginning had the conditions been known. The boiler was not round and at the joint the curvature of the sheet departed 5/16 of an inch from the circle to which it should have conformed.

The boiler was of the horizontal tubular type, 17 feet 4 inches long. The inside diameter of the outside course was $72\frac{5}{16}$ inches; thickness of shell plates, 0.45 inch; thickness of heads, 0.5 inch. There were 132 three-inch tubes, 16 feet long, and six $1\frac{1}{2}$-inch through stays of iron upset to $1\frac{3}{4}$ inches where threaded, passing through channel-iron bars on the heads with nuts inside and out. Stamps found on the rear course in which the crack developed gave the name of the manufacturer and stated that the firebox had a tensile strength of 60,000 pounds. The type of longitudinal joint was butt and double strap, the inside strap being wider than the outside strap. The riveting was triple, the pitch of rivets on the rear and middle courses being $3\frac{3}{8}$ and $6\frac{3}{4}$ inches; on the front course it was $3\frac{1}{4}$ and $6\frac{1}{2}$ inches. The size of the rivet holes was 15/16 inch. The efficiency of the joint was 85.5 per cent. on the front course and 86.1 per cent. on the other courses. The safe working pressure, using a factor of safety of 4.5 and a tensile strength of 60,000 pounds would have been 141.8 pounds. Using 55,100 pounds, the actual tensile strength, the safe working pressure would have been 130 pounds.

The result of physical tests and chemical analysis made on test specimens cut from the shell plate in the immediate vicinity of the cracked section and in a girth-wise direction showed a tensile strength of 55,100 pounds, the elastic limit being 35,300 pounds per square inch. The elongation in 8 inches was 23 per cent. The appearance of the fracture of the test piece after breaking was silky. The chemical analysis was as follows: Manganese 0.65 per cent.; sulphur 0.045 per cent.; phosphorus 0.033 per cent.

A strip bent cold closed down upon itself without fracture on the outside of the bent portion, but developed two cracks on the inside. A strip heated cherry red and quenched in water was bent down upon itself and developed no fractures inside or out. A templet sawed to a radius of $35\frac{19}{32}$ inches, placed on the rear course of the boiler, developed the fact that the boiler departed 5/16 of an inch from a circle at the joint. A templet was sawed to fit the actual curve of the boiler. The templets nailed together giving a graphical representation of the difference between what the curvature of the boiler should have been and what the curvature was. An examination of the rivet holes in the rear course of the boiler developed the fact that the holes had been punched nearly full size, the slight amount of metal, taken out by reaming not being sufficient to leave the full size holes fair, this being shown by the rivets which were taken out of the boiler not being of uniform diameter. The burs at the edges of the rivet holes had not been entirely removed. The distance from the center of the rivet holes to the edge of the plate was not 1½ times the diameter of the rivet hole.

Internal inspection disclosed the fact that the shell plate on the lower half of the joint was cracked on the outside row of rivet holes, which were pitched 6⅛ inches apart as stated elsewhere, this crack starting at a point 1⅛ inches to the right of the second rivet hole from the rear girth seam and extending through seven consecutive rivet holes to a point 1½ inches from the seventh hole, or a total distance of 43⅝ inches. Internal inspection also disclosed the fact that the shell plate on the upper half of the joint, on the outside row of 6⅛ inches pitch, was also cracked. These cracks, however, were not continuous, and were confined to the region of the rivet holes, extending about 1 inch each side of three consecutive rivet holes, then skipping a hole. The next rivet hole was cracked on one side for about 1 inch, the rear end of the crack starting at a point between the third and fourth rivet holes, counting from the rivet holes in the rear-head flange, after skipping one hole, counting from the rivet holes in the rear girth seam, ending at a point between the second and third rivet holes, counting from the rear girth seam.

The crack on the lower half of the joint extended on the outside of the plate a distance of 29½ inches through five consecutive rivet holes, starting at a point 1⅛ inches to the left of the fourth rivet hole in the outside row, continuing from the rear girth seam and extending to a point 1¼ inches to the right of the first rivet hole in the outside row counting from the rivet holes in the rear-head flange. The third rivet hole, however, counting from the rear girth seam had two cracks extending from it a distance of 1¼ inches to the right of the hole and a crack 1 inch to the left of the hole. Adding the length of these two cracks to the continuous crack of 29½ inches would make 31¾ inches, the length of the entire cracked portion as seen from the outside of the boiler. Comparing this length of 31¾ inches with the length of the continuous crack of 43⅝ inches, as seen from the inside of the boiler, it will readily be seen that the crack started from the inside of the boiler and worked its way through to the outside. The crack as seen from either the inside or outside of the boiler resembles in no way the ordinary lap-joint crack. Ordinary lap-joint cracks extend in a more or less straight line through the solid plate along the edge of the rivet heads.

This boiler was sixteen years old and keeping in mind that it was exposed to excessive vibration for five years, that a cold-bending test resulted in two cracks on the inside of the bent portion, that the chemical analysis showed an excess of manganese, sulphur and phosphorus, and that the rear course of the boiler departed from a true circle 3-16 of an inch at the joint, and that the rivet holes had been punched almost full size, it would seem that the wonder is not that the boiler developed these cracks, but that it did not develop them before and that a disastrous explosion did not occur. Fig. 2 shows quite clearly the condition of the plate.

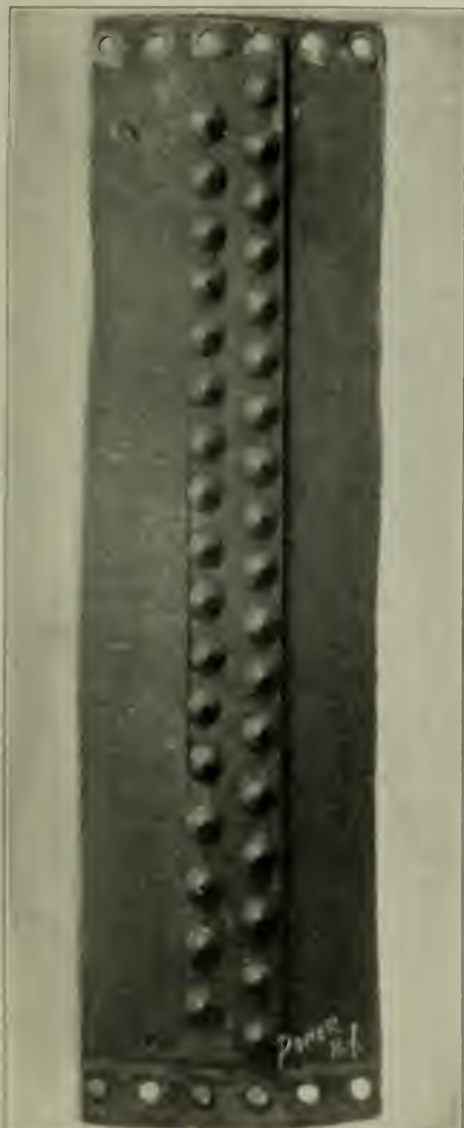


FIG. 1

FIG. 2

In transmitting a list of Nova Scotia firms handling steam pumps and machinery, which is on file at the Bureau of Manufactures, Consul-General David F. Wilber reports from Halifax as follows:

The sale of steam pumps in this district is largely by catalog, the same being in the hands of various machinists and general dealers in such lines. It is my opinion that if a competent agent were secured in that city and supplied with pumps for display in his salesrooms the chances for increased sales would be better than trying to sell by catalogs, as is done at present.

Consul-General Wilber further, in forwarding a list of firms at Halifax which might be interested in the sale of windmills and pumps, states that from his observations in Nova Scotia there is no single article which should be in demand among the farmers through that Canadian province so much as pumps and windmills.

POWER AND THE ENGINEER

DEVOTED TO THE GENERATION AND TRANSMISSION OF POWER

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Contents PAGE

Uniform Boiler Laws

Mr. Thomas Durban, of the Erie City Iron Works, in an address presented to the National Association of Manufacturers, at its meeting in New York recently, complained of the hardships to which the manufacturer of steam boilers is subjected by reason of the varying requirements of the boiler-inspection departments of different States, and even of different cities. "Various States in the Union," he says, "have enacted laws governing the matter of steam boilers, stating the quality of material to be used, the thickness of the material, and the manner in which it shall be put together, and in no two States are these laws similar, so that a general contractor or a general manufacturer who finds it necessary to locate branch factories in various States is confronted by the fact that he must have boilers built to conform with the various laws of the States, and a boiler that would fully comply with the requirements in New York State could not be used in Massachusetts, and one that could be used in Massachusetts could not be used in Pennsylvania, etc.

"The detriment of this can be readily realized when you take the case of a general contractor building buildings. A man may have a hoisting engine working on a job in New York. If he bids on a job in Boston, he is not allowed to use this engine in Boston; or he may have a contract in the City of Harrisburg, Penn., and cannot use the same equipment to complete a contract in the City of Philadelphia. In order to keep down the cost of production most manufacturers bring their goods through in duplicate and in quantities; in fact, the ability to do this distinguishes the manufacturer from the builder. This not only appertains to stationary boilers and portable boilers used in the construction of roads or buildings, but also portable boilers used by farmers in general farm work or in threshing. A manufacturer of threshing machines is compelled to build a different boiler for Massachusetts than he builds for Washington, and a different one for the State of Washington than the one built for Montana. So that the tendency is to localize business and to work against the manufacturer who is attempting to develop a large trade. This is not only detrimental to the manufacturer, but is equally detrimental to the user or the consumer, from the fact that he must pay an advanced price for his goods, and it greatly delays shipment."

The situation pointed out by Mr. Durban suggests the necessity of organization and uniformity of practice and requirements by the boiler inspectors. At present comparatively few States and cities have boiler-inspection departments, but the agitation is ripe and each season many bills for the creation of such departments are introduced. With their multiplication, and without substantial agreement among them, the situation of the boiler manufacturer might become very uncomfortable.

But the reputable boiler manufacturer does not want to build boilers that are not safe, and no board of inspectors wants to make rules that are unreasonable or unnecessarily severe. A boiler that is safe in one class of service in one State is as safe in the same class of service in another State. The laws of statics are not of political origin, and the capacity of material to resist rupture knows no geographical bounds. Such differences of opinion and of practice as exist between the various boards should be easily reconcilable and manufacturers would be unlikely to oppose whatever restrictions and regulations such boards might impose, provided they were imposed uniformly and all manufacturers and users were treated alike.

How Much Does It Cost to Clean Boilers?

How much better off would you be if you had absolutely pure feed water for your boilers, so pure that it would leave absolutely nothing behind it when it boiled away?

Our thought deals not so much with the decrease of efficiency by reason of the presence of scale, grease, etc., as with the cost of removing these deposits, and of making good the damage which they have caused, the loss of the use of the boiler during the cleaning and repairing process and the increased investment and standing charges created by the necessity for extra boilers.

The loss from scale while running is an indeterminate and widely variable factor. If one has plenty of boiler-heating surface, if the ratio of grate to heating surface is low and the rate of combustion moderate, the fouling of some of the surface to a considerable degree, or of all of it to a moderate degree, will have little effect upon the number of pounds of steam made per pound of coal. If, on the other hand, the heating surface is worked to its capacity and the number of pounds of coal burned per square foot of heating surface is large any deposition of scale upon that surface will have a much more serious effect upon the boiler efficiency. When, in addition, the influence of the density or porosity of the scale is taken into account the engineer is inclined to shrug his shoulders when he sees the frequently published statements of the percentage effect of various thicknesses of scale upon the coal consumption.

Some interesting figures could be made upon the other costs which have been mentioned, were the data available. How often must a boiler be cleaned? It depends, of course, upon the amount and character of foreign matter in solution or suspended in the feed water, but we need actual information for the general case, with such particulars as are available of the character of the feed and of the means which are resorted to to prevent scale. How much does it cost to clean a boiler of a given type and capacity? How long is it out of service? How often are tubes required to be renewed? How many fire sheets are burned or bulged by the presence of scale or grease? Practical information of this kind based upon records of experience would be especially desirable for our correspondence columns and we should be glad to have our contributors turn their attention in that direction.

Place the Blame for Boiler Accidents

In a sawmill out West the boiler exploded, killing six men and seriously injuring five others. It is stated that the sentiment of the coroner's jury in the case was expressed by the remark of one of them, who said: "They are dead, anyway, so what is the use of making a fuss?"

It is possible that the responsibility for a preventable calamity which either destroys or mars the life of eleven men, and adds to the burden carried by those directly connected to them by the various ties of human life, may not be placed at the door of the mill owners. But it should be placed, in a way that cannot be misunderstood, where it belongs. It may rest on the engineer, on the inspector or perhaps on the man who made the boiler. But blame there is, for every occurrence of this kind. These things happen because of the ignorance or cupidity, or perhaps both, of some man or some set of men, who bring about a condition which inevitably results in loss of life and the destruction of property.

That this state of affairs is not necessary is amply proved by the comparative immunity from disastrous boiler explosions enjoyed by Massachusetts and by the city of New York, where intelligent construction and inspection are compulsory. It is a fundamental principle in modern civilization that the individual has no rights which society is bound to respect and the privilege of manufacturing, installing and operating potentially dangerous apparatus has been allowed altogether too long. It may not be possible entirely to stop boiler explosions, but until that day comes when the use of high pressure steam for the transmission of power shall be unfashionable the manufacture and use of steam boilers should be regulated by society and not by individuals or groups of individuals with no interest beyond the profit arising from traffic and use.

State Boiler Inspection

In 1908 there were 470 explosions of stationary and portable boilers in the United States, a total almost identical with the record for 1907, and the number of persons killed by explosions was 281, as compared with 300 in 1907, 235 in 1906, 383 in 1905 and 220 in 1904. These figures were recently published by the Hartford Steam Boiler Inspection and Insurance Company. The company's records for the forty years from 1868 to 1907 show a total of 9550 boiler explosions, and the casualties resulting number 10,555 persons killed and 15,051 injured. This means a total of 25,606 persons maimed or killed in forty years, an average of 640 per annum, although in late years the annual number has been considerably in excess of this average, not to mention an enormous property loss.

These figures show plainly the menace to life and property of the high-pressure steam boiler, as it is now built and inspected, and indicates the urgent need of State legislation. With boilers properly built and carefully inspected, and the use of a reasonable amount of care in operation, there is little necessity for a single explosion, and no occasion whatever for the wholesale number now appearing in the annual reports. The lap-seam boiler has been the cause of many of these explosions, careless inspection has added its quota and inferior construction in boilers of the better class has augmented the total.

Bearing in mind that it is possible to operate a boiler with immunity, provided it is properly designed and constructed and is subject to a systematic and careful inspection, it is surprising that the subject of boiler explosions has not been given more general attention. Only five States have considered this annual destruction of life and property of enough importance to enact legislation providing for State inspection of boilers and regulation of their manufacture. Other States have given their municipalities the privilege of passing and enforcing ordinances, but legislation along this line is not uniform even in cities of the same State, and in most of the smaller towns it has been entirely neglected.

If this same number of people were killed and injured in one State there would undoubtedly be legislation, and if limited to one city such disaster would be deemed appalling. Its effect would be far reaching, and every State in the country would undoubtedly inspect the manufacture and operation of its boilers. When the matter is seriously considered, is there really any difference? The 300 lives are lost annually, and twice this number injured, and does it matter whether the unfortunates all live in one city or in one State, or are distributed throughout the country? In time of war, when 300 men are killed so many soldiers are lost to the country, and the loss is just as great and of as much importance whether the entire number come from New York State or are equally divided among the forty-six States of the Union. In a similar way should the annual loss of 300 lives from boiler explosions be regarded. Each State should assume its share of the responsibility and contribute to the general welfare of the country by preventing a needless waste of life and property within its borders.

Keeping Power Plant Records

One of the important factors in the cost of power-plant operation after fuel and labor expenses are figured, is the cost of maintenance. In order to know just what a plant is doing it is essential to keep an accurate record of the repair work. This is not difficult if the proper entries on the log sheet or in the engineer's notebook are made as soon as possible after the different jobs are finished. It often happens that the operating engineer is not informed what the different repairs cost. He is certainly entitled to know, if he is required to figure out the cost of power at regular intervals, but even if the actual costs are withheld through thoughtlessness or other cause, it is decidedly worth while to keep a record of the important repair items.

In one plant the cost of power production at the direct-current busbars per kilowatt-hour was 1.88 cents, for a recent month, as compared with 1.59 cents the previous month. The manager of the company naturally looked into the cause with the chief engineer. Incidentally, the cost had been figured in the company's offices by clerks out of touch with the operating condition. The chief engineer knew that he had used about one-tenth of a pound of coal per kilowatt-hour more in the second month, and also that the cost of coal per ton at the plant was 15 cents less than in the month when the total expense was lower. The labor cost was about 0.1 cent higher per kilowatt-hour in the second month, on account of a considerable reduction in the station load. The difference, as proved by the notes of the chief engineer, was largely due to an improvement at the station which had been charged up to operation by the bookkeeping department.

This improvement was the tearing out of all the wiring bearing on the lighting service and the replacement of the old system of incandescents by a higher-powered installation having much greater operating convenience. That the engineer was able to look over his notes of daily happenings made it easy for him to put his finger on the exact causes of cost variation, and clear himself.

Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

The New Class E American Stoker

The latest design of underfeed stoker is the "New American Stoker, Class E," of the American Stoker Company, 11 Broadway, New York City. It is so designed that no working part is in contact with fire, thereby eliminating the danger of burnt parts.

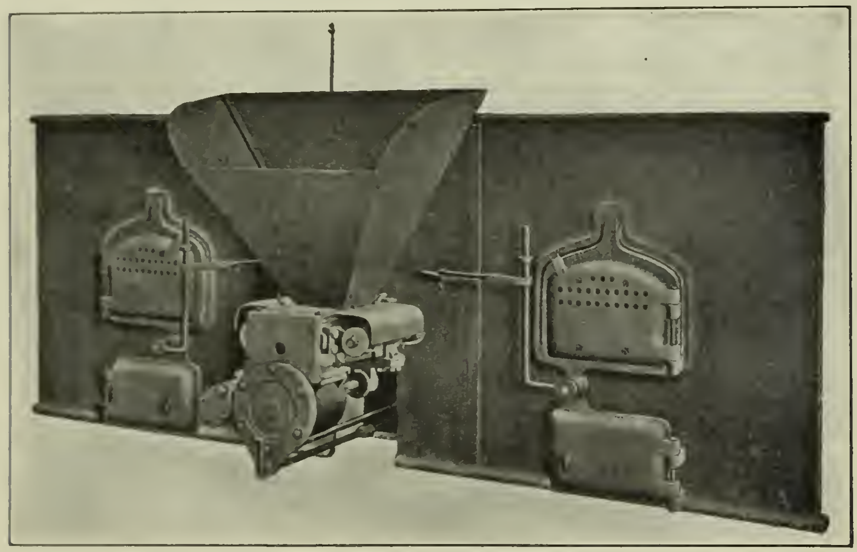


FIG. 1. FRONT VIEW OF "AMERICAN CLASS E" STOKER

This stoker is built on an oscillating-bottom principle, the feeding trough being in constant motion, gradually feeding coal to the fire above. While the coal is never allowed to settle in this trough, it cannot be driven in chunks or masses into the fire, even in the case of overloading.

The furnace doors, grate bars, etc., are air cooled, while the air for combustion is heated before its introduction to the combustion chamber. Every other grate bar is hollow, a current of air constantly passing through to the coal trough, at which point it is mixed with the gases which have been liberated from the coal, while between alternate bars there are spaces through which air is forced from the ashpit below.

The operation of the stoker is as follows: The fuel may be conveyed to the hopper either by coal-conveying machinery or by hand labor, and from the hopper it is carried under the fire by means of the reciprocating sliding bottom. As the coal rises from the trough, it is distributed to the sides of the furnace by the moving bars, shown in Fig. 2, which keep it constantly on the move toward the dumping trays along each side wall, where the clinkers and ashes are deposited. By means of levers on the outside these dumping trays can be actuated to discharge the ash and clinker automatically. The sliding bottom is actuated by a steam motor, shown in Fig. 1, the number of strokes of which may be varied from 1 in three minutes to 15 in one minute, and as each stoker is said to carry into the furnace about six pounds of coal, it will be seen that the rate of feed has a wide range of adjustment.

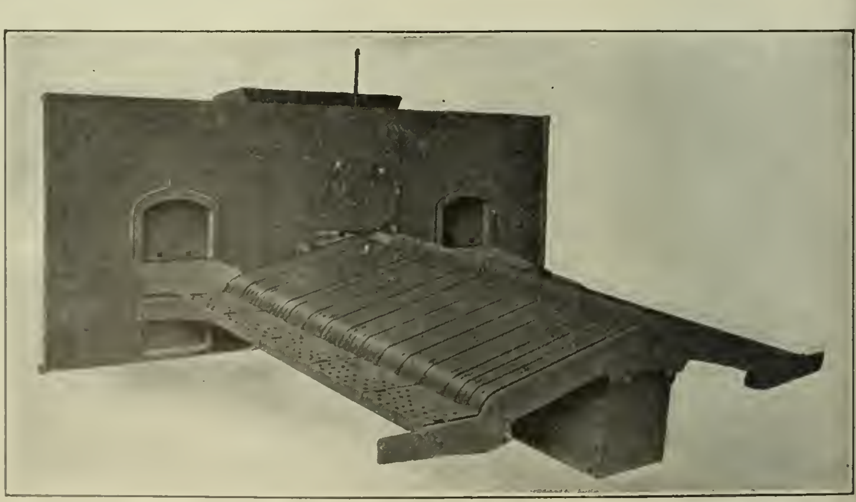


FIG. 2. SHOWING GRATE SETTING IN "AMERICAN CLASS E" STOKER

The movement of the piston of the cylinder *C*, Fig. 3, is transmitted directly through the piston rod to the crosshead *D*, which is bolted to the sliding bottom *E*. As the block *B* has the same movement as *D* and *E*, the coal is fed by it from the bottom of the hopper *A* onto the sliding bottom *E*, which not only carries it to the back end of the furnace but forces it to rise the full length of the trough. As the coal rises in the trough or coking retort, it is flooded onto the grate bars *F*, which are alternately moving and fixed bars, the moving bars working transversely to the retort, the extent of the movement being from ½ to 1 inch, depending upon the size of the furnace.

On the bottom of each moving bar are cast two lugs which engage with a bulb of the longitudinal rocking bars *H*, Fig. 4. These rocking bars in turn receive their movement through the agency of two spirals and nuts, which mechanism is entirely outside the furnace. The nuts are bolted to the crosshead *D* and reciprocate with the bottom *E*, the reciprocation of the nuts causing the spirals to rock to and fro.

The movement of the grate, in addition to carrying the burning fuel to the sides of the furnace, also conveys the clinker down and deposits it on the plates *K*, which are fastened to the hinge bars *L*. These hinge bars are actuated by levers conveniently placed outside of the furnace for dumping the accumulation of ash and clinker on the plates *K* when necessary.

One of the important features of the

stoker is the distribution of the air which enters the stoker through the aperture N, Fig. 3, which is covered by the wind gate O. This wind gate is adjustable by a crank P at the outer end of the furnace. The air upon entering the wind box Q passes upward along each side of the troughs or retorts and is discharged partly through the holes R into the retorts. The surplus air passes through the bar F

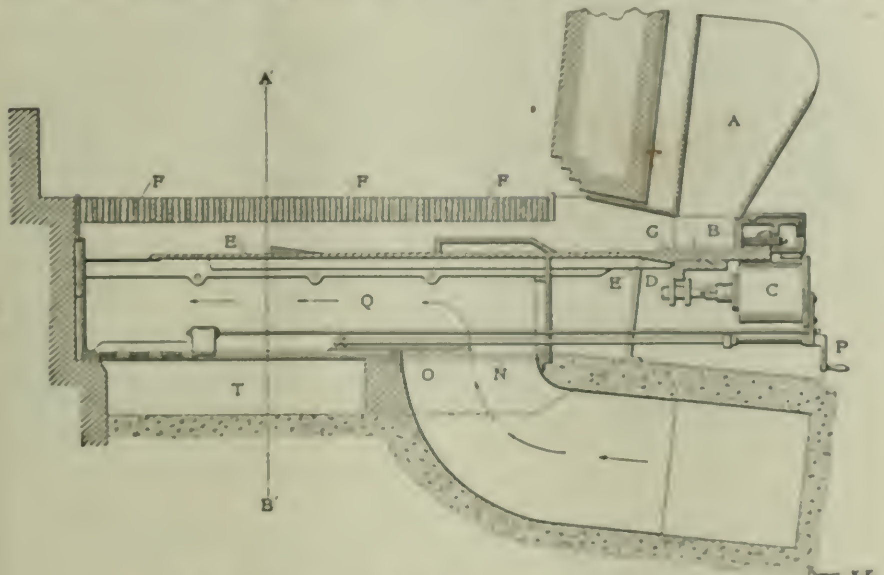


FIG. 3. SECTIONAL VIEW OF "AMERICAN CLASS E" STOKER

which is made hollow, but as the bar has no opening in its top surface, no air can find its way into the fire above it until it has passed through the aperture S at the bottom end of the bar, from which aperture it is discharged into the ash-pit. The air then rises and passes through the small spaces between the bars into the coked fuel.

The air passing through the bars keeps them cool and prevents their being burned

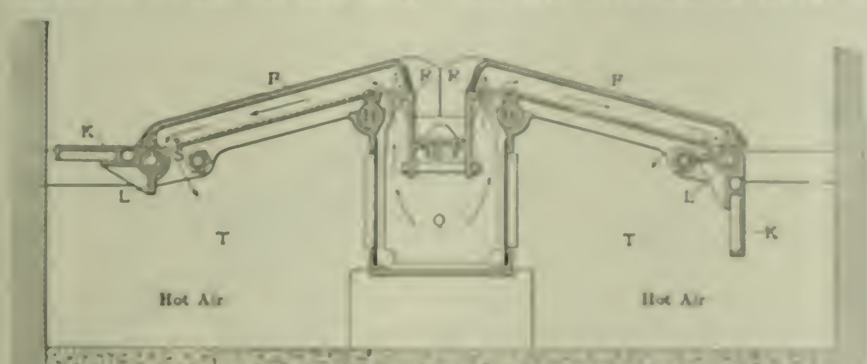


FIG. 4. SHOWING MECHANICAL OPERATING FEATURES

out. The heat taken from the bar in this way is said to raise the temperature of the air in the ashpit from 150 to 400 degrees Fahrenheit. The pressure of the air in the wind box Q is said to vary from ½ inch to 1¼ inches, and at T from 0 to ¼ inch.

When the dumping plates K are let down, air will find its way upward among the boiler tubes, but as the action of dumping and raising them takes but a moment, the loss from air passing upward into the boiler tubes is so slight that it is not necessary to close the wind gate O at such time.

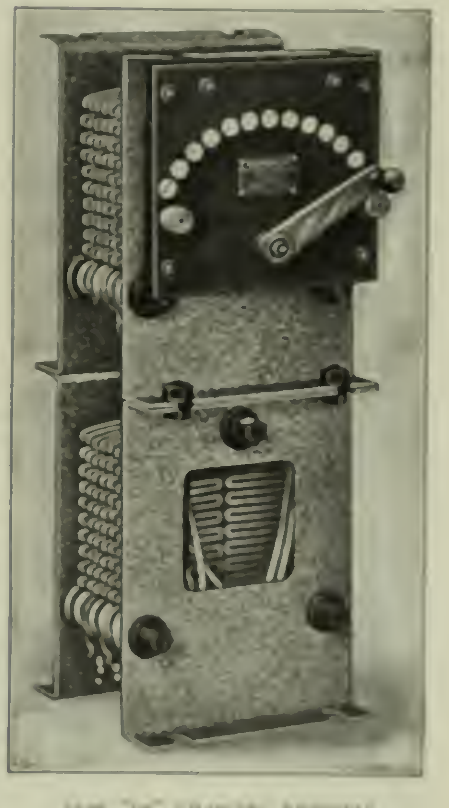
A test sheet was exhibited at the office of the company, showing that on coal of 10,400 B.t.u., showing over 10 per cent. of ash, an evaporation of 9 pounds of water from and at 212 degrees Fahrenheit was obtained. This coal was stated to be practically useless as hand-fired fuel, being a mine refuse. Another performance sheet was shown in which a coal of 10,816 B.t.u., with over 9 per cent. of ash, was made to produce an evaporation of 9.29 pounds of steam from and at 212 degrees Fahrenheit. Attention was called especially to the poor quality of coals used in these tests, which were the average for the plant at which stokers were installed. When it is considered that the average performance with good coal in the ordinary practice on flat grates is about 8 pounds of water to one pound of coal, the attractiveness of these results is readily apparent. Especially is this true when it is taken into consideration that the company claims to be able to evaporate as much water from the poorest slack coal as can ordinarily be obtained from coal costing 50 per cent. more per ton than slack coal.

The company has also perfected a marine stoker along very much the same lines, which it is to place on the market simultaneously with the "Class E."

Several governments, including the United States, England and Japan, are using the "American" stoker.

Rheostats for Charging Small Storage Batteries from Lighting Circuits

For use where a small storage battery is maintained, as in gas-engine power plants where only direct current at lighting voltage is available, the storage-battery rheostat herewith illustrated has been brought out by the Westinghouse Electric and Manufacturing Company, East Pittsburg, Penn. Some form of adjustable resistance must be employed, since the voltage at the beginning of the charge is less than that required when the batteries are fully charged, and the maximum voltage of the battery is lower than the voltage of the available charging current. The voltage applied to the battery should be increased gradually from the minimum value required at the beginning to about 2.7 volts per cell at the end of the charge.



TYPE "OB" CHARGING RHEOSTAT

The illustration shows a "Type OB" charging rheostat for 30 to 55 cells which is capable of carrying 50 amperes at any position of the regulating arm: this type of rheostat is also supplied, in the same current capacity, to charge 10 to 14 cells from a 110- to 120-volt circuit.

To select a charging rheostat for a given service, the circuit voltage, the minimum allowable battery voltage and the charging current in amperes must be known, and these should be specified when ordering such a rheostat or inquiring about one. The minimum battery voltage is the product of the number of cells in series and the volts per cell, usually 2 volts; in other words, twice the number of cells that are connected in series. Although these rheostats are rated as for 110 to 120 volts it is possible to use them on circuits of higher voltages, provided the difference between the minimum battery voltage and that of the supply circuit does not exceed that which would exist with the rated number of cells and rated circuit voltage.

These rheostats are finished in black marine on the face plate, the resistance conductors are coated with aluminum paint, and the supporting frames are galvanized. The resistance is of the grid type and is rigid, compact and substantial in construction. There are thirteen steps of resistance abjustment.

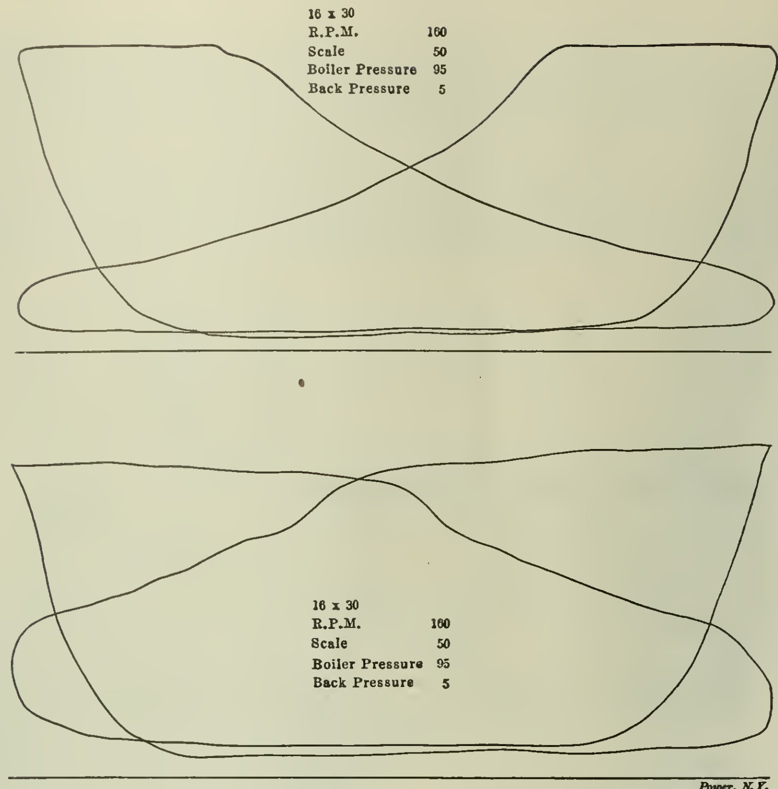


FIG. 2. DIAGRAMS FROM 16X30 HEWES & PHILLIPS ENGINE FITTED WITH FRANKLIN VALVE GEAR

The Franklin Valve Gear

The increasing demand for higher speeds in Corliss engines has led to the development by the Hewes & Phillips Engine Company, of Newark, N. J., of a new type of releasing gear which handles the valves quietly and effectively at speeds as high as two hundred revolutions per minute. Its construction will be apparent from the accompanying engravings.

The loose arm *A*, Fig. 1, is oscillated from the wristplate by the usual right-and-left connection and carries at its top a long bearing *B* for the liberating latch *C*. The length and stability of this bearing is well shown in the left-hand view of Fig. 1, and is one of the details which contributes most to the positive and smooth working of the device. The latch *C* is a bronze bar, practically straight, hollowed out for lightness and suspended in such a position that gravity enables it to function properly even at speeds as high as two hundred revolutions per minute without the aid of the light spring *E* with

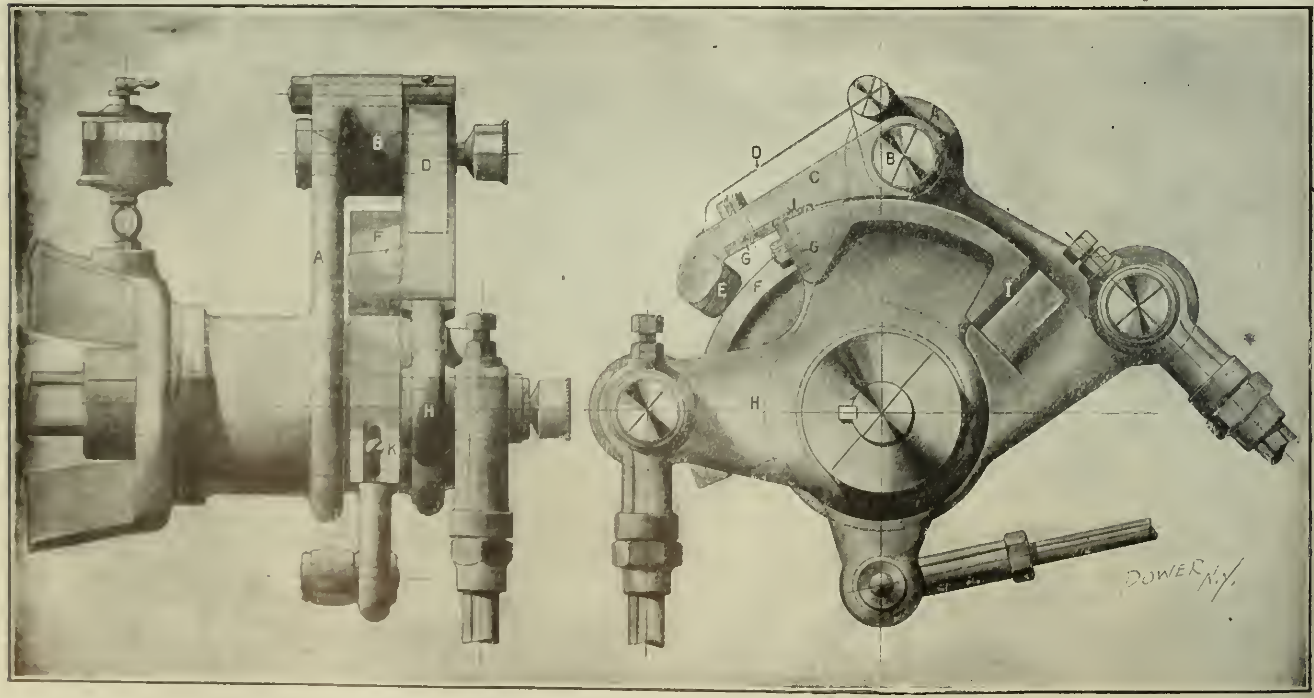


FIG. 1. DETAILS OF THE FRANKLIN VALVE GEAR

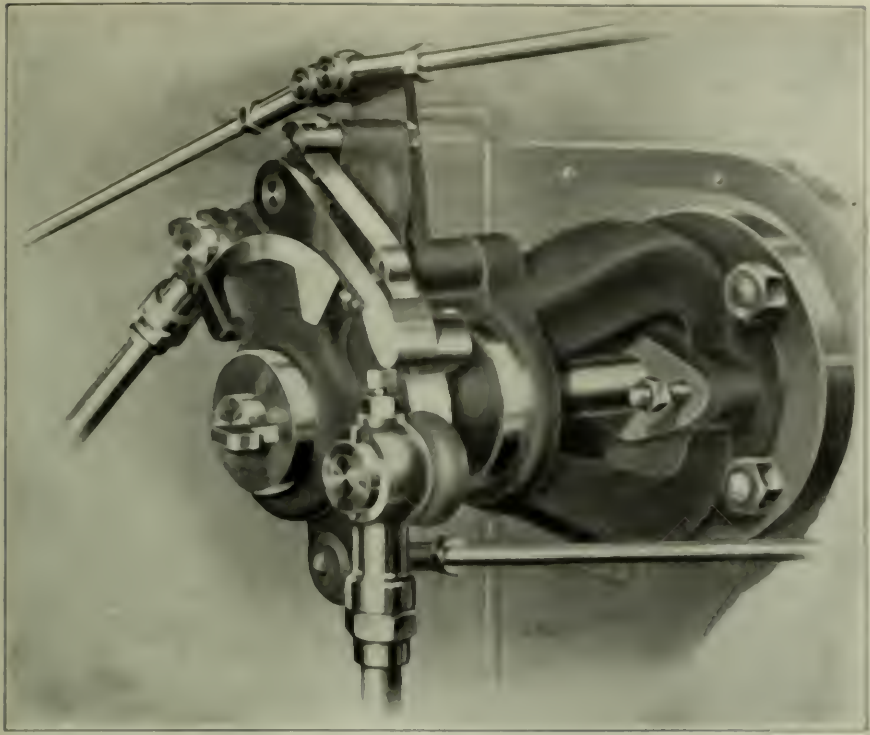


FIG. 3. THE FRANKLIN VALVE GEAR

which it is furnished for additional security.

The latch carries at its extremity the antifriction fiber block *E* which rests upon the face of the cutoff cam *F*, the position of which is determined by the governor. When this block rests on the low portion of the cam, as shown in Fig. 1, the latch blocks *G G* can come into engagement as shown and the member *H*, keyed to the valve stem, will be carried backward with the arm *A* opening the valve. When the fiber block *E* rides up on the high part of the cam, the blocks *G G* are drawn out of engagement and the valve is closed by the dashpot. If for any reason the valve should not close it will be pushed to by the fiber-faced block *I* upon the lever arm positively moved by the wristplate.

The sharpness with which the valve closes and the excellent manner in which the steam line holds up even with a late cutoff are shown by the accompanying diagrams taken from a 16x36 Hewes & Phillips engine fitted with this gear, running at 120 revolutions per minute and located at the plant of the *Newark Evening News*. The latch blocks *G G* are of hardened steel and square, presenting eight working edges each which may be used successively by reversing the position of the block. When the latch blocks engage, the contact of the latch arm takes place upon a fiber block *J* alongside the upper block *G*, avoiding even the clicking sound which usually accompanies the operation of a releasing gear. The construction of the latch enables an oil well of considerable capacity to be formed within it, provision being made by means of ducts to convey the oil stored in lamp-wicks, or other fibrous material, to the faces of the liberating latches, eliminating possibility of wear from lack of lubrication. The safety block *K* on the governor cam is so attached, as will be plain from the drawing, that no shearing off and destruction of the gear could occur from a loosening up of its attaching screw. The governor cam presents a considerable mass to receive the blow of the fiber block on the toe of the latch, and the thrust upon the governor is extremely slight, as may be experienced by handling the lever controlling the cutoff upon the shop apparatus upon which each gear is tested before being sent out. The success of the design has been attained, in fact, by using mass where it was needed and was either stationary or in motion at a very moderate velocity, in reducing the freely moving parts to the lightest possible weight and providing them with bearings which permit of the limited movement required while maintaining steadiness and freedom from vibration.

"Bestyet" Power Pump

The Lucas Pump Company, Dayton, O., recently redesigned its "Bestyet" power pump, the principal new feature being double gears in place of the single gear formerly used. The illustration shows a side view of the pump as now built. The main casting supports the two large gears, which have long hubs and run loose on shafts held in place by set screws. The crank pin connects the two gears and runs in a sliding bronze block in the link or crosshead. An oil pocket on top of the link distributes oil to the block and crank pin. The driving pinion is also double, to correspond with the gears. An outboard guide bearing is used on the piston rod, and an overhanging cylinder is provided, with an air chamber on the discharge side. The valves are easily accessible, by removing the valve-seat covers,

"BESTYET" POWER PUMP

without disturbing the suction or discharge connections.

These pumps, which are designed for pressures up to 110 pounds, and capacities of 1200, 2200 and 4200 gallons per hour, are fitted with rubber valves resting on brass seats, with brass stems and springs, the latter being wound in a peculiar manner for the purpose of maintaining an equal tension at all lifts. The pistons are of standard construction and fitted with square packing. Brass piston rods and cylinder linings are furnished when specified.

Casey-Hedges Boiler

The Casey-Hedges water-tube boiler, manufactured by the Casey-Hedges Company, Chattanooga, Tenn., is herewith illustrated. The chief features of this boiler are its simplicity of construction and the fact that the superheater may be installed without disturbing the setting.

The boiler consists of one or more steam and water drums, having two wrought-steel headers or water legs, one at each end, each header consisting of a handhole plate and a tube plate. The water legs are thoroughly braced with large, hollow staybolts. The construction of the legs is such as to form the strongest part of the boiler. The front water leg is 12 inches wide at the bottom, doing away with all restricted areas at this point, thus permitting free circulation of steam and water. The rear leg is 10 inches wide at the top, the lower portion being increased to meet the inclination of the lower bank of tubes at right angles, and forming a large settling chamber at this point.

Fig. 1 is a rear view of a Casey-Hedges tube boiler with the superheater connected through the header. It will be noticed that the superheater is in the direct path of the hottest gas and is so located that accumulated soot can be easily cleaned from it by steam jets blown through the hollow staybolts in the rear header.

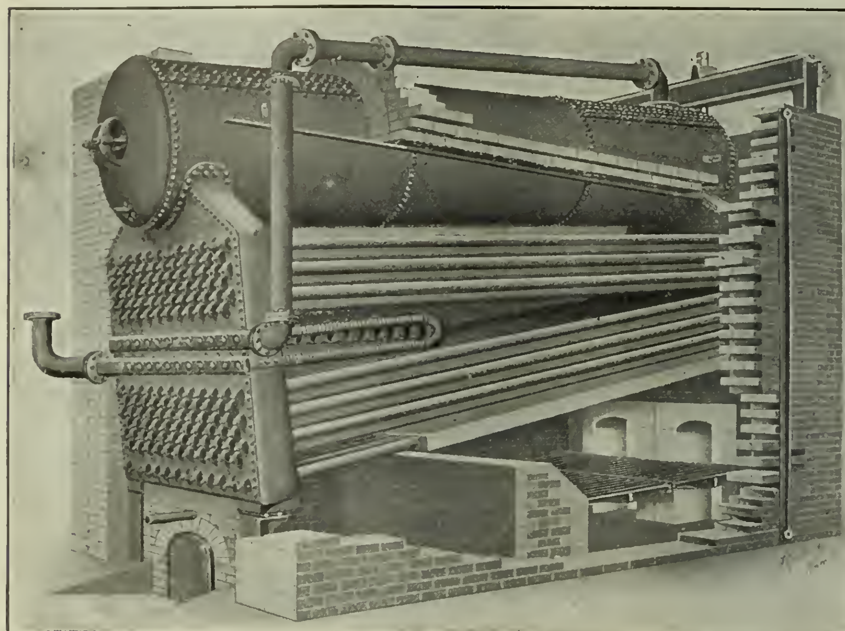


FIG. 1. REAR VIEW OF CASEY-HEDGES BOILER WITH SUPERHEATER ATTACHED

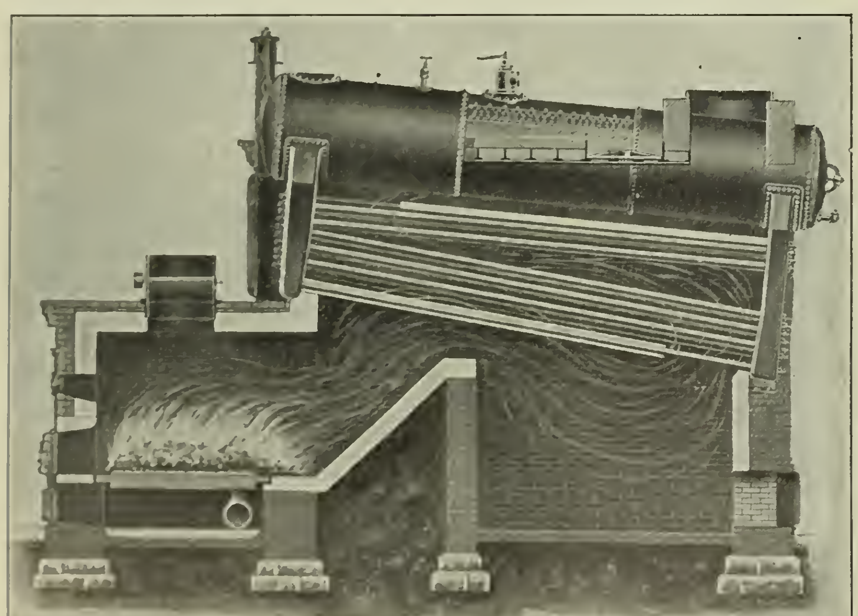


FIG. 2. CASEY-HEDGES BOILER WITH DUTCH OVEN ATTACHED

The tubes are divided into two banks, an upper and a lower, the upper bank and the drum being inclined 1 inch to the foot and the lower bank being inclined 2 inches to the foot. The lower tubes being the hottest, the inclination here is the greatest. This construction permits of a large area at the rear of the tubes, allowing for complete expansion of the gases at this point, the area decreasing as it reaches the front end, as the gases cool. The upper baffle consists of a special V-tile, the design of which is such that the passage for the gases may be decreased or increased to suit the fuel and draft conditions.

The circulation is an important feature with any boiler. In this type the double inclination of the tubes is a feature that allows for a rapid circulation of steam and water through the lower bank of tubes. The steam outlet is at the front end of the boiler and is provided with a dry pipe and a deflector or baffle plate which should insure dry steam, the steam outlet being about three-fourths the diameter of the drum away from the water level.

The downward circulation is through the rear leg which swells out to form a precipitating chamber for all solids that have not been deposited in the mud drum, the blowoff being tapped in the extreme bottom of the rear leg, which can be drained completely through the blowoff.

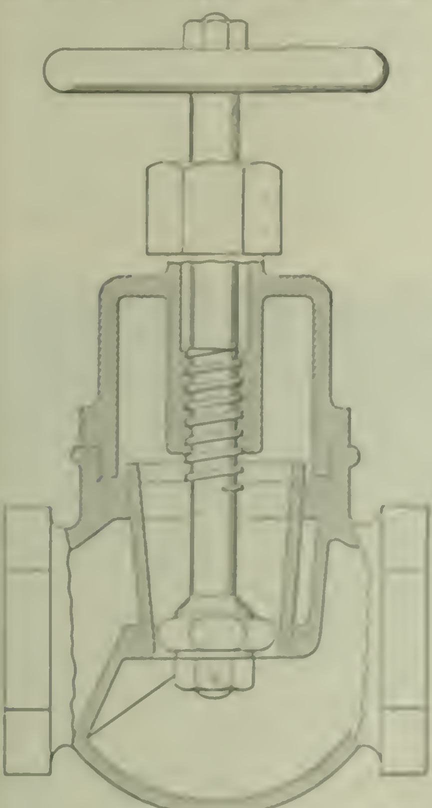
The boiler is constructed entirely of open-hearth steel, there being no cast-iron parts about the boiler proper. Each of the headers or water legs is stayed with hollow staybolts arranged so that a steam blower can be inserted through them and all soot that has collected on the tubes and tiling can be blown down into the combustion chamber. All cleaning may be done while the boiler is in operation, without admitting cold air to the fittings, which is an important feature. In order to clean the interior of the boiler there is provided, opposite the end of each tube water leg, a wrought-steel handhole plate that tightens under internal pressure, thus throwing no strain on the manhole bolts or arch. The handhole covers are easily removed and with a hose or tube scraper inserted the scale may be washed into the rear water leg, where it can be removed by taking off a few of the handhole plates in the bottom row. It is said that as many as five tubes can be cleaned with one handhole opening in the front end. A mud drum or sediment chamber, 8 inches in diameter, is provided with each boiler, located in the top drum. The feed water empties into the mud drum and all scale and impurities are deposited in it.

The blowoff extends from the rear of the sediment collector out through the rear of the drum, through which the sediment can be blown out at intervals. Owing to the construction of this boiler no cleaning aisles between batteries are necessary, and any number of boilers can be placed in a continuous row, which admits of a saving in brickwork.

In Fig. 2 is shown one of these water-tube boilers arranged with a dutch oven, which permits of burning out sawdust, bagasse, spent tan bark, etc.

Storle High Pressure Valve

The accompanying view illustrates the Storle high-pressure valve, manufactured by the O. O. Storle Valve Company,



STORLE HIGH-PRESSURE VALVE

Kewaunee, Wis. Its salient feature is that it can be opened and closed easily under pressure. The valve cone is swiveled on the stem, and when the valve is opened or closed it leaves or enters the seat without turning in it. This practically obviates leaks as a result of wear.

An additional safeguard against leaks is provided in the long cone used instead of a disk, which would sink deeper into the seat should it wear small and thereby continue tight. An accumulation of dirt or scale on the cone or the seat face is obviously improbable.

"Autoforce" Air Pump

A system for automatically ventilating engine and boiler rooms, workshops, or other places where the air may become

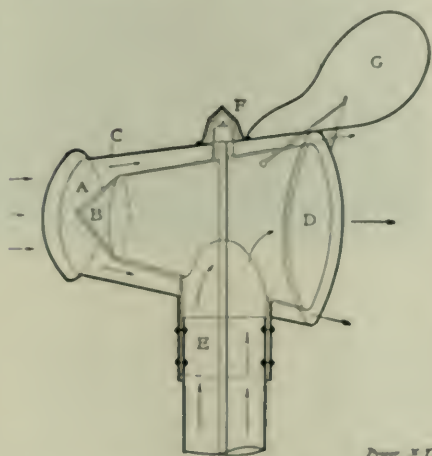


FIG. 1. SECTIONAL VIEW OF "AUTOFORCE" AIR-PUMP VENTILATOR

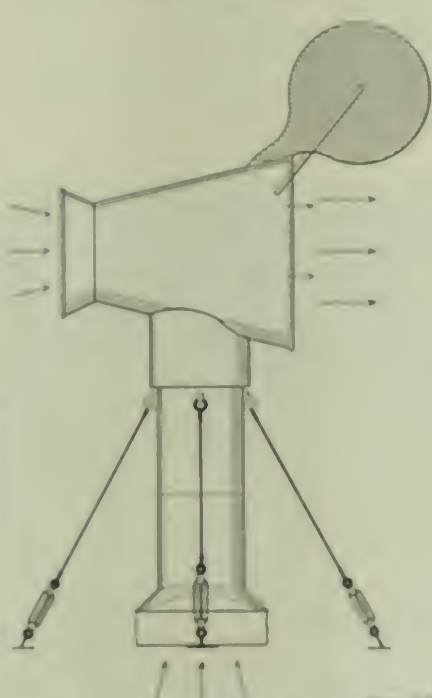


FIG. 2. EXTERIOR VIEW OF "AUTOFORCE" AIR-PUMP HOOD

foul is found in the "Autoforce" ventilating system, made by the Natural Automatic Ventilator Company, 53 Devonshire street, Boston, Mass.

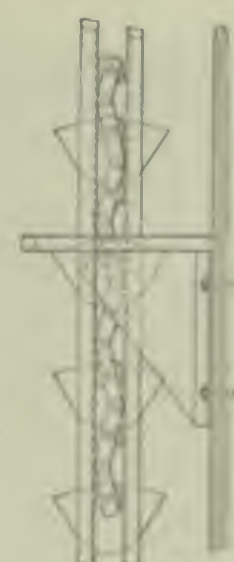
The so-called air pump is connected to common piping of suitable size, or properly installed air ducts, air shafts or chimney flues, and forms a natural system of ventilation, it is said. No machinery is required to operate it, and it requires no attention. Owing to its construction the "Autoforce" ventilator is said to create a constant unbroken suction flow of air upward each hour of the day, and also to prevent the possibility of its flowing downward. The operation is as follows:

The air enters at *A*, Fig. 1, and is spread by the point of the inner cone *B* into a conical form in the passage *C*. Upon reaching the outlet at *D*, the outward rush of air from between the inner and outer cones causes a partial vacuum in the interior of the inner cone, and as this partial vacuum must be occupied, it produces a continuous rush of air up the pipe *E*, as the pull of the air at *D* practically never ceases. The ventilating hood is pivoted at *F*, thus enabling the tail G to swing it, keeping the smaller end toward the wind, regardless of the direction from which it blows.

Fig. 2 is an exterior view of the hood as it would appear on the roof of a building.

Conveyer Safety Device

The accompanying sketch illustrates a conveyer safety device designed by Spencer & Co., Ltd., of Melksham, England, for the Greenwich generating station of the London County Council Tramways. At the south end of the boiler house,



CONVEYER SAFETY DEVICE

where the conveyer chains descend vertically, this arrangement was provided to prevent the chains and buckets from falling in event of breakage. Two continuous vertical runners are fixed the whole height of the building, and should the chain break it can fall only a few inches, as it would quickly jam in the runners.

Convention of Illinois State Association, N. A. S. E.

This was the fifth annual convention, held at Elgin, Ill., May 14 and 15, and was declared to be one of the most successful and enjoyable meetings ever held by the State organization. The time was well chosen, the place could not be improved upon and the result was satisfaction all round. Illinois, always famous for the relative number of ladies in attendance, did not disappoint in this regard, and all told, with delegates, members, friends and visitors, fully one hundred and twenty-five persons were gathered in Strauss hall when E. S. Purdy, president of Illinois No. 49, called the meeting to order. After prayer by Rev. W. H. Fuller, Mayor W. W. Fehrman spoke a few words of welcome in behalf of the city, followed by an eloquent address delivered by F. C. Joslyn, corporation counsel, of Elgin.

SUPPLYMEN AT ILLINOIS STATE CONVENTION, N. A. S. E., ELGIN, ILL., MAY 14-15, 1909

W. W. Brooker, of Joliet, president of the State association, responded to the address of Mr. Joslyn, following which R. I. White, superintendent of the Elgin schools, talked on "Education," in which it was shown how important a factor was knowledge in the development of this country. In responding, John W. Lane, editor of *National Engineer*, pointed out that while general knowledge was necessary to the country, the specific technical knowledge of power-plant operation was necessary to the engineer of today, especially so as the engineering-school graduate was beginning to compete with the operating engineer on his own stamping ground, and hard study was needed in order to meet this new competition.

Winding up the opening exercises was the address on "The Relation of the Engineering Experiment Station to the N. A. S. E." by K. G. Smith, assistant professor of mechanical engineering, University of Illinois, Urbana. This was listened to with much interest, as it touched upon points that have not been quite clear to engineers. It was shown that this institution could be of great benefit to men operating plants if they would take the pains to coöperate with it. Mutual confidence and helpfulness between the experiment station and the N. A. S. E. should exist, as both had education for their primary object, and while it was the function of the university to develop discoveries and new methods, it was up to the engineer to put them into practice. Furthermore, the operating engineer was in a position to gather data that the college could not possibly get, and working

DELEGATES AND VISITORS, ILLINOIS STATE CONVENTION, N. A. S. E., ELGIN, ILL., MAY 14-15, 1909 together should result in great benefit to all concerned. Professor Smith concluded by extending a cordial invitation to the State body to meet at the university, and promised that every facility necessary to a successful meeting would be placed at its disposal.

The afternoon session was consumed in discussing means for obtaining a State license law and for furthering the educational work of the association. Each of the fourteen delegates reporting was heard from on all topics discussed. In addition, many members who were not delegates participated in the meeting and offered a number of valuable suggestions.

In concluding the session, President Brooker spoke regretfully of the recent death of J. E. Boyle, No. 11, of Joliet, an active member of the association.

Election of officers resulted in the choosing of J. L. Randles, No. 6, of Peoria, as president; W. L. Parker, No. 49, of Elgin, vice-president; and W. E. Hill, No. 17, Moline (reelected), secretary and treasurer. Installation of officers was by F. W. Raven, national secretary, of Chicago. The meeting was then adjourned subject to the call of the president.

Meanwhile the ladies returned from the automobile ride with which they had enjoyed the afternoon, and all gathered at Unity hall, where a chicken-pie supper was served by the ladies of the local committee.

In the evening the entertainment was somewhat novel. Assembled in Strauss hall, the visitors were treated to piano, violin and vocal selections by local talent, which was well received. Stereopticon pictures were shown and music was available for those who cared to dance. By way of refreshments, peanuts, popcorn, apples and lemonade were served and everybody was instructed to talk to his neighbor and enjoy himself. The success of the arrangement proved it to be one of the leading features of the entertainment program.

D. K. Swartwout, president of the Ohio Blower Company, of Cleveland, presented a paper, which made a profound impression, at the joint meeting of the American Society of Machinery Manufacturers' Association with the National Supply and Machinery Dealers' Association at Pittsburg recently, dealing with the benefits of organization in the sales department. Mr. Swartwout was elected a vice-president of the association.

The May meeting of the Electric Power Association was held on the evening of May 27, at 8 o'clock, in the lecture room of the R. R. Y. M. C. A. building, corner Forty-fifth street and Madison avenue, New York City. C. W. E. Clarke, steam engineer for the New York Central, delivered a talk on "Efficiency Testing of Steam Apparatus."

Brooklyn Engineers' Club's New Home

The Brooklyn Engineers' Club recently purchased a building for a clubhouse at 117 Remsen street, Brooklyn, N. Y., into which it has removed, after having been located for nearly 13 years in the Montague street library building. The club's new home, which was one of the finest residences on what is known as "The Heights," has a brownstone exterior, and its interior design, decorations and appointments are very fine.

There is a reception room, 20x30 feet on the ground floor, with a small stage at one end—just the place for lectures, etc. The dining room is on this floor, also. On the second floor are the library, the secretary's office and smoking and retiring rooms. On the third floor are five bedrooms and a bathroom.

In a sense the Brooklyn Engineers' Club is an outgrowth of the Montague street library, for before that library became free to the public and a yearly subscription was collected from the readers, the trustees set aside certain shelves and alcoves for the use of people interested in engineering problems. Books on scientific subjects were gathered on the shelves in these alcoves and thus the Brooklyn engineers were thrown together in their search for information. That social intercourse led to the forming of a club, "the object of which is to promote social and professional intercourse among its members, to advance engineering knowledge and practice, and to maintain a high professional standard within all branches of engineering."

When the club was incorporated on December 29, 1896, the membership was fifty. The next year it had grown to 131, in 1902 it was 204, in 1904, 246, and at the present time it is 350.

The officers for the present year are: President, James C. Meem; vice-president, Winifred H. Roberts; secretary, Joseph Strachan; treasurer, William T. Donnelly; librarian, Frank J. Coelon. Board of directors: James C. Meem, Joseph Strachan, James W. Nelson, Winifred H. Roberts, William T. Donnelly, Charles M. Spofford, George C. Whipple. Standing committees: Library, James B. Van Vleck, Frederick C. Noble, George A. Orrok; membership, John M. Steinmetz, John W. Goodridge, Willard P. Hough; entertainment, C. A. Sonnet, Frank W. Coun, Harry P. Morse. Special committee: excursions, Frank C. Schmitz, Harry B. Snell, Francis W. Perry.

The annual convention of the Canadian Electrical Association will be held at Quebec on Wednesday, Thursday and Friday, June 16, 17 and 18. The headquarters will be at the Chateau Frontenac. T. S. Young, Confederation Life building, Toronto, is the secretary.

Engineers' Blue Club Banquet

The third annual banquet and reunion of the Engineers' Blue Club, of Boston, Mass., was held on Saturday evening, May 22, at the Century building. There was a reception from 6 to 7 o'clock in Sewall hall, the banquet, at 7 o'clock, being held in Howe hall, followed by an entertainment in Potter hall, the three halls being in the same building. Fully five hundred members and guests were seated at the table. When the coffee stage was reached, Albion H. Parker, president, closed his crisp speech of welcome by introducing Albert C. Ashton, of the Ashton Valve Company, as toastmaster, and the duties of this important office were disposed of in a most creditable manner. Those who made addresses were: Thomas Hawley, of the Hawley School of Engineering; Andrew J. Savage, United States Local Inspector of Vessels; Prof. Edward Miller, of the Massachusetts Institute of Technology; Dr. Louis C. Loewenstein, of the General Electric Company; Hon. William P. White, mayor of Lawrence, Mass.; Walter Lamont, manager of the Wood Worsted Mills, Lawrence; W. G. Smith, general manager, Fall River Ship and Engineering Building Company; Joseph H. McNeil, Massachusetts deputy chief boiler inspector; William J. Ranton, of Rochester, N. Y., grand worthy chief Universal Craftsman, Council of Engineers; Herbert E. Stone, New York, of the Dearborn Drug and Chemical Works. At close of the banquet an enjoyable vaudeville performance was given, during which John W. Armour, of Power, entertained. The committee in charge of this successful event comprised R. K. Neptune, H. H. Ashton and Harry H. Atkinson.

Wisconsin N. A. S. E. Convention

The ninth annual convention of the Wisconsin State Association of the N. A. S. E. will be held at La Crosse, June 18 to 20. An elaborate program has been prepared.

Personal

Lieut.-Commander Hutch I. Cone, U. S. N., has been appointed chief of the Bureau of Steam Engineering, which position had been filled by Rear-Admiral Rae.

Obituary

Francis S. Pool, vice-president of the D. T. Williams Valve Company, of Cincinnati, died Saturday, May 8, in his fifty-eighth year.

Business Items

The Wipaco Packing Company has removed to new offices in the Engineering building, 114 and 116 Liberty street, New York City.

Woodward Wight & Co., of New Orleans, La., will represent the Homestead Valve Manufacturing Company, of Pittsburg, in the Louisiana territory, carrying a full line of Homestead valves.

The Minneapolis Steel and Machinery Company secured an order for a 125-horsepower Muenzel producer gas engine and gas-producer plant from the Sisseton Mill and Light Company, Sisseton, South Dakota. This engine will run both the flour mill and electric-light plant and will be in service 24 hours a day.

The Leon-Ferenbach Silk Company, Wilkes-Barre, Penn., has purchased a Hewes & Phillips heavy girder-frame Corliss engine, with heavy flywheel and shaft arranged for two engines, which will go in its new mill at Wilkes-Barre. Members of this company have been using several of the Hewes & Phillips engines. The Sanitary Can Company, Bridgeton, N. J., is installing a 12x30-inch, 100-horsepower Hewes & Phillips Corliss engine for the operation of its plant.

Norman C. Brize has been elected president of the Standard Steam Specialty Company in place of E. H. Roberts, who died recently. Mr. Brize has had an extensive steam-engineering experience, both with this company and the Babcock & Wilcox Co., with which he was formerly connected. Percy A. Pinder has also been elected secretary and treasurer of the company. Mr. Pinder has been connected with the Standard Steam Specialty Company since its incorporation and was instrumental with Mr. Roberts in bringing the "Utility" specialties made by this company to their present successful position in the power-plant field. The main offices of the company will be continued at 542 West Broadway, New York, and branch offices will be established in some of the other large cities.

The Charles A. Schieren Company, of New York, has received a letter from the Barrett Manufacturing Company, of Elizabeth, N. J., to the following effect: "In regard to the 48-inch three-ply 'Duxbak' waterproof leather belt which you put on for us May 2, 1907, we take pleasure in stating that the belt has been in service ever since, running 24 hours a day, 6 days a week, and has caused us no trouble whatever during that time. After the belt had been running for about six weeks it became a little slack, as all belts do, and we had it taken up on a Sunday and the following Monday morning it was doing its duties the same as usual. Since the time it was first put on our pulleys it has run true, and has required no dressing or other attention, and we could not ask better service of any belt under any conditions."

Among the direct-current generators recently sold by the Crocker-Wheeler Company, of Ampere, N. J., is one of 300 kilowatts capacity, 250 volts, purchased by Perry Fay Manufacturing Company, Elyria, Ohio. Another machine of this type, having a capacity of 200 kilowatts, 125 volts, was bought by the Cleveland Provision Company, Cleveland, O. There were many sales of smaller generators ranging in size from 35 to 100 kilowatts. A large order was placed with the Spanish American Iron Company, Felton, Nipe Bay, Cuba, for 230-volt direct-current motors aggregating 235 horsepower. Another sale of direct-current motors, which totaled 135 horsepower, was made to the Morgan Engineering Company, Alliance, Ohio. The International Silver Company, Meriden, Conn., has ordered six Crocker-Wheeler Form I machines, having a combined capacity of 131 horsepower. In addition to the above a large number of smaller orders for direct-current motors have been booked.

Henry Docker Jackson, consulting engineer, 88 Broad street, Boston, Mass., visited the works of the Westinghouse Electric and Manufacturing Company, at Pittsburg, recently, to make an acceptance test on a special 250-horsepower motor which is to be used to operate a ventilating fan in a coal mine in West Virginia. This is one of the largest electrically operated ventilating fans in the country. The motor is a specially designed one, the general scheme being suggested by Mr. Jackson, the design and details being worked out by the Westinghouse company, the idea being to get the starting characteristics of the best type of induction motor combined with the operating and line-regulating characteristics of the synchronous motor. The tests were eminently successful, both the starting characteristics and the regulating characteristics being remarkably good. The motor and fan are being installed in connection with other work at the mine, the consulting engineers on which are Timothy W. Sprague and Henry Docker Jackson.

The Ontario Hydro-Electric Power Commission, which is charged with the construction of the provincial government system for transmitting power from Niagara Falls to leading cities and towns of Western Ontario, has decided to install the protective system over the entire transmission line. In addition to giving protection against accidents it promises to reduce the chances of the dislocation of the time through electrical disturbances to a minimum. The system is operated by an arrangement of automatic cutouts working as soon as a break occurs in the transmission conduit. If a short-circuit occurs the wire is grounded, or should the wires break at any place, that section immediately becomes "dead," so that the broken wire can be handled by, or come into contact with, any one without danger. The estimated cost of the protective system is $106,000. The commission awarded contracts for the copper wire required for it to the Dominion Wire Manufacturing Company, Montreal, and for the porcelain insulators, intended as a safeguard against lightning, to the Ohio Brass Manufacturing Company, of Mansfield, Ohio.

A good example of the results obtained by a sales department and factory organization working in harmony is afforded by a recent contract handled by the Buffalo Forge Company, Buffalo, N. Y. In connection with cold-storage warehouses operated by the Pacific Fruit Express Company at Roseville and at Colton, Cal., eight large fans were required by the Pacific Engineering Company, San Francisco. Each fan was to deliver 44,500 cubic feet of cold air against a pressure of three ounces per square inch, and to be of the full housing type with bearings supported on concrete piers, with the blast wheels overhung on the shaft, and with stuffing boxes on the fan housings, to prevent leakage of air. Although special in several particulars the Buffalo Forge Company undertook to furnish these fans, each having 7-foot wheels running at 380 revolutions, making shipment of four in 10 days and the balance in 15 days afterward. As the entire shipment weighed 32,000 pounds, the advantage in freight on account of shipping in one car would be considerable, and when the order was received by wire at the factory on April 19 it was decided to make a special effort to complete the eight fans in the time promised for the first four. Shop drawings were not started until the receipt of the order, but preliminary notice was sent to the factory and by the time prints were received by the various departments on April 20 much of the material had been got ready. Friday, April 30, the tenth day after the order was received, shipping was begun, and by that night the eight fans, with shafts, pulley and outboard bearings were loaded on a 42-foot gondola.

New Equipment

Schram & Sons, Oshkosh, Wis., are putting in a new engine room.

The Rumford Falls (Me.) Power Company is building a new power house.

The Shore Electric Company, Red Bank, N. J., will build a new power plant.

The Brunswick (Me.) Electric Light and Power Company is building a new plant.

The West Hampton (L. I.) Ice Company is erecting a new building for its 15-ton ice plant.

The Grimes Milling Company, Salisbury, N. C., contemplates installing a new Corliss engine.

The City Councils, Harrisburg, Penn., have appointed a committee to learn if the city may legally erect a municipal ice plant.

The Milwaukee (Wis.) Linseed Oil Company is making improvements in power plant, including installation of new boiler.

The Merchants Association, Newburg, N. Y., is considering the formation of a company for the purpose of erecting a co-operative electric-light plant.

The Superior Ice Manufacturing Company, Columbus, Ohio, has been incorporated with $75,000 by William S. Nigh, E. W. Edwards, Chas, E. Klunk.

The Isthmian Canal Commission, Washington, D. C., will receive bids up to 10:30 a.m., June 14, for centrifugal pump and engine, gasolene motors, transformers, electric hoist, etc., as per Circular No. 512.

The Alpine Power Company, Alpine, Texas, has been organized with $35,000 capital by H. W. Townsend, J. H. Derrick, R. B. Slight, etc. Besides furnishing power the company will manufacture ice.

Sealed proposals will be received by the Board of Trustees of the Massillon State Hospital, Massillon, Ohio, for the installation of a new high pressure steam main and to make certain alterations in the boiler house.

New Catalogs

Foster Engineering Company, Newark, N. J. Folder. Pilot and emergency valves, pressure regulator, etc. Illustrated.

Murphy Iron Works, Detroit, Mich. Booklet. The Murphy Furnace in the Paper Mill. Illustrated, 48 pages, 4½x6 inches.

The Foos Gas Engine Company, Springfield, Ohio. Catalog No. 21. Horizontal engines. Illustrated, 56 pages, 7x9 inches.

The Kennedy Valve Manufacturing Company Elmira, N. Y. Catalog. Valves, hydrants, etc. Illustrated, 132 pages, 5x9 inches.

Gesellschaft fur Hochdruck-Rohrleitungen, M. B. H. Berlin, 0.27. Catalog. Pipe fittings. Illustrated, 114 pages, 7½x10½ inches.

American Ship Windlass Company, Providence, R. I. Catalog. Taylor gravity underfeed stoker. Illustrated, 30 pages, 6x9 inches.

American Blower Company, Detroit, Mich. Booklet. Handbook of Information on Blowers and Exhausters. Illustrated, 24 pages, 3½x6 inches.

Green Engineering Company, Commercial National Bank building, Chicago, Ill. Catalog G. Green chain grate stokers. Illustrated, 46 pages, 7x10 inches.

Harbison-Walker Refractories Company, Pittsburg, Penn. Catalog. Refractories, including silica, magnesia, chrome, fire clay, brick, etc. Illustrated, 158 pages, 4x6½ inches.

The Morigrieve Engineering Company, 44 Market street, Perth Amboy, N. J. Bulletin

A 42-Inch Low Pressure Elevator Pump

Run on the Exhaust of Electric-Light Engines; Vacuum Produced by an Evaporative Condenser Condensing 1 lb. of Steam with 3-4 lb. of Water

In 1903, the L. S. Donaldson Company, a large retailer of Minneapolis, Minn., announced its intention to enlarge its already extensive building, together with its mechanical equipment. This magnificent building with its unique front of glass and iron attracts the attention of all visitors and justly deserves its popular name of the "Glass Block," as more than efficiency and adaptability to the purpose for which it was designed. Mr Donaldson's instructions when the design of the plant was under way were "The best that money can buy," and he has every reason to feel proud of the result. The engine-room floor is of white tile picked out with a figure not shown in the photographs. The walls are tiled to a hight of to electric generators. There is also a 2-ton Wolff refrigerating machine with a 12x36 Corliss cylinder attached, and an American blower capable of delivering 90,000 cubic feet of air per minute into the building for ventilating purposes.

But the unique feature of the installation is the method employed for running the pumping engine for the elevators,

FIG. 1. CONDENSER, WITH SPRAY OPERATING [illegible]

seventy-five per cent. of the façade is of plate glass. The structure therefore presents a striking appearance even in the daytime, but is still more impressive at night, when illuminated by 4000 incandescent lights on the exterior and [illegible] arc lights within.

The power plant, as may be judged from the illustrations presented herewith, is a model not only in appearance but in a feet and, together with the ceiling, are handsomely tinted above this line. All the columns and other trimmings, including a handsome switchboard, are of pink Tennessee marble. The engines are handsomely finished in a deep wine color.

The power plant consists of [illegible] and a [illegible] Corliss engines, all built by the Minneapolis Steel and Machinery Company and directly connected worked out by Joseph [illegible], designing engineer for the Minneapolis Steel and Machinery Company, along lines suggested by F. M. [illegible], chief engineer for the L. S. Donaldson Company. The pumping engine is of the horizontal flywheel Corliss type with a steam cylinder 42 inches in diameter directly connected to a water cylinder [illegible] inches in diameter, with a stroke com-

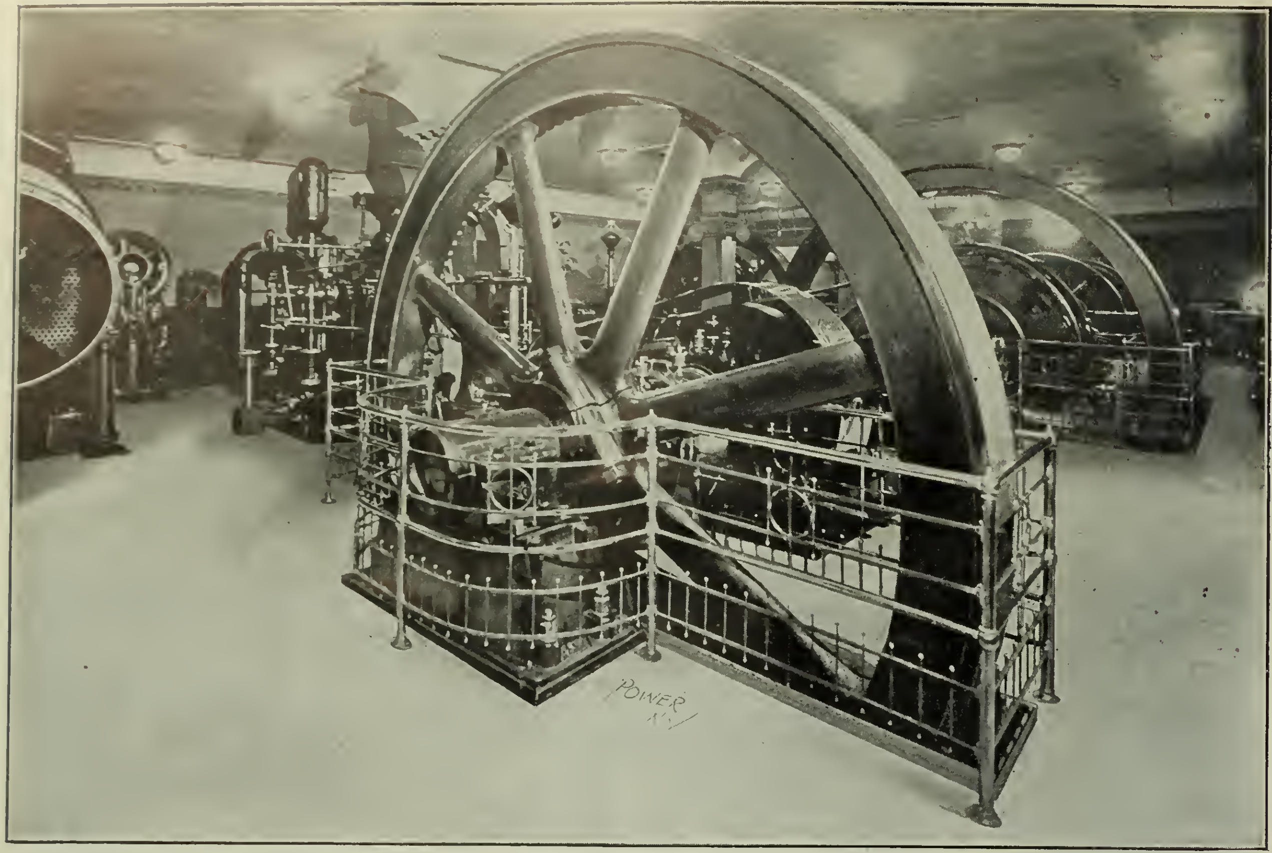


FIG. 2. PUMPING ENGINE, IN FOREGROUND, AND PARTS OF CONDENSER AND AIR PUMP

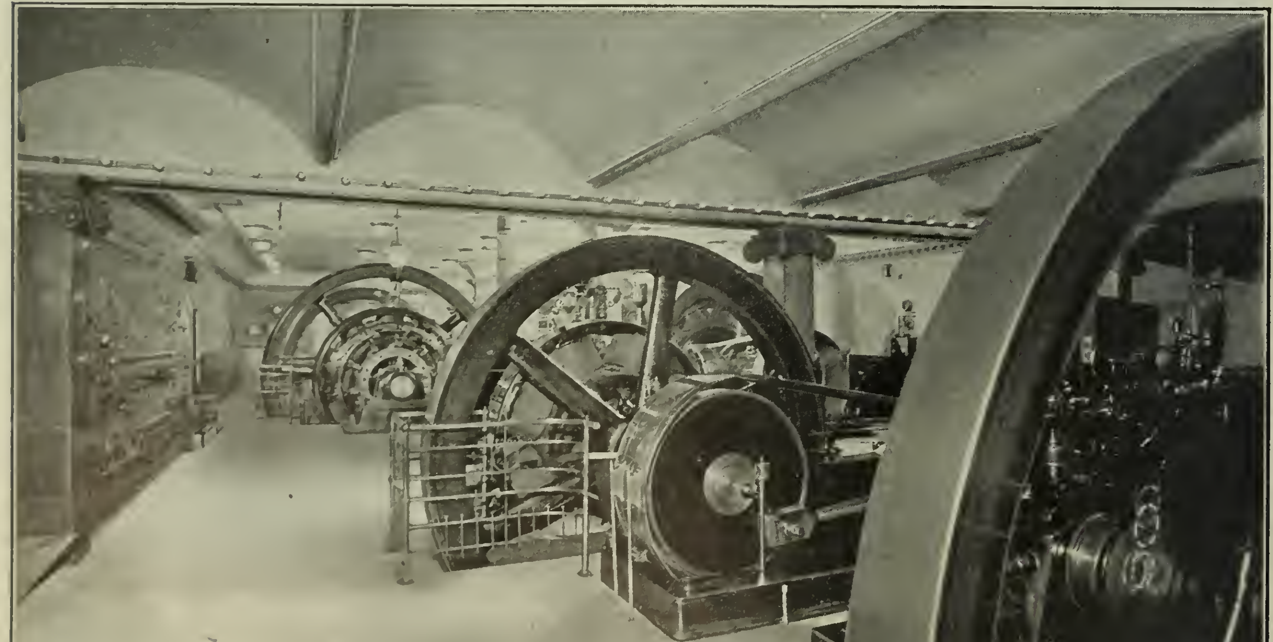
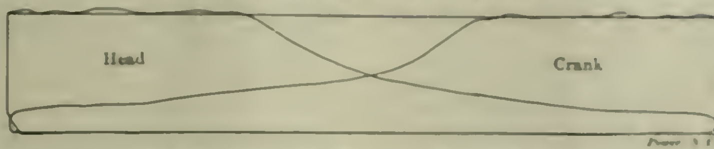


FIG. 3. VIEW IN ENGINE ROOM; SHOWING ALSO SECTION OF ICE MACHINE

mon to both of 42 inches. The pumping head of 120 pounds per square inch is automatically maintained by placing the regulation of the engine under the control of the water pressure. The system has never once failed during the six years in which it has been in use.

Nothing very remarkable so far, but this pumping engine is run upon the exhaust steam of the other units, working it from about atmospheric pressure into a vacuum of 24 inches, as shown by the accompanying indicator diagrams, in the center of the retail district of Minneapolis, where it would appear to be as impracticable to run a condensing plant as it would be to keep cows on the Sahara. It is made possible thus to run this engine condensing, in a locality where condensing water is out of the question, by the use of an evaporative condenser, shown at the left in Fig. 1. This condenser consists of a cast-iron case containing 1260 one-inch brass tubes, 66 inches in length, disposed horizontally as shown. The exhaust steam from the pumping engine is introduced into the shell and surrounds the tubes. One end of the shell is extended and into this extension is introduced a 1½-inch pipe provided with a rose head which sprays the cooling water, taken from a hotwell at a temperature of 125 degrees Fahrenheit, into the tubes. Connected to an extension at the other end of the shell is a 90-inch ventilating fan which draws its air supply through the tubes of the condenser, incidentally ventilating the engine room which, although located in the basement and, as the photographs show, not lofty in its ceiling, is thus made perfectly comfortable even in midsummer. The water sprayed into the tubes is evaporated, each pound disposed of in this way abstracting the heat necessary to condense a pound of the steam, and enough additional heat being carried away by the air to condense one-quarter of the steam which comes to the condenser, so that for each pound of water produced in the condenser and made available for boiler supply, only three-quarters of a pound has to be furnished to the condenser. The spray is handled by a 2x4-inch duplex pump. The air pump is a 10x12-inch single-acting Edwards, shown against the back wall in Fig. 1, while at the right in the same illustration is seen the steam cylinder of the pumping engine. The fan and air pump are driven by an electric motor using 55 amperes at 110 volts.



INDICATOR DIAGRAMS FROM THE PUMPING ENGINE

Fig. 2 shows the pumping engine in its entirety, with the condenser still visible at the left and with the other units of the plant in the background, and Fig. 3 is a view from the other end of the room. Attention is called to the lighting scheme, the illumination being sufficient to have allowed the photographs from which our illustrations were made to be taken without the aid of other light than that habitually used. The entire responsibility of enlarging and remodeling the power and light plant fell upon Mr. Overholt and although the pump in question was designed and built by the Minneapolis Steel and Machinery Company, the scheme for operating it with the exhaust of the other engines in connection with the evaporative condenser was evolved by Mr. Overholt and he has been granted a patent upon the arrangement.

FIG. 4 ANOTHER VIEW OF THE ENGINE ROOM

A Course in Plant Management

Since 1906 the Teachers' College of Columbia University, New York City, has been giving a series of evening technical courses on a variety of subjects. These courses are open without examination to men or women who desire to obtain higher technical knowledge in their trades and professions, but no academic credit is given. For the school year 1909-10 it is proposed to introduce a course in plant management, which will be under the direction of J. C. Jurgensen, formerly chief engineer at the St. Regis hotel. The course will consist of forty sessions, held on Monday and Wednesday evenings, from 7.15 to 9.15 o'clock and will begin on October 25. This particular course is intended for operating engineers, engineers' assistants, building superintendents and others. A good knowledge of arithmetic and elementary physics is required of all who enter, and the following aspects of plant management will be studied from a practical standpoint:

Introduction—Machinery selection, layout and installation of the plant; schedules for identification and operation; common units for measuring plant economy; instruments and measurements.

Engine Room Accounting—Records of operation; compilation of operating data; billing of records for daily comparison and reference; purchase of coal, supplies and labor; storeroom and toolroom management; computation of total operating costs per unit output; plant depreciation, interest, depreciation annuities; computation of actual cost per unit output; arrangement of expense and plant deficiency reports to owner.

Cost Analysis and Expense Control—Method of determining standard unit costs; distribution of expense to various systems operated; leaks in direct expenses; leaks in operation and machinery; relation between plant efficiency and actual cost per unit.

Industrial Betterment Methods—Training and handling of men; apprenticeship and bonus systems for power plants; accidents and liability insurance; fire-underwriters' regulations; fire protection and appliances; fire-fighting organization for individual buildings.

This in brief is a summary of the course which should prove of value to engineers and those wishing to join their ranks.

From all accounts Mr. Jurgensen is the very man to conduct this course. Formerly, while at the St. Regis hotel, it was his custom to sign apprentices after the European fashion, compelling embryo engineers to work two years and at the end of that period to sign a contract for four years more as machinery operators. At the end of the fifth year those who proved efficient were given certificates as operating engineers and recommended to police headquarters for licenses. The certificates were based upon two years' continued service as apprentice engineers, with good-conduct marks for sobriety, truthful and manly conduct, punctuality in attendance, industry and faithfulness in giving employers a full day's work, and a strict and willing obedience to orders. The rules established by Mr. Jurgensen were brought to the attention of members of the governing board of Columbia, and the offer to him to conduct the course in plant management followed.

Efficiency Test of Three-Wire Balancing Dynamos

By J. W. Himmelsbach

The following test was made on two direct-current generators forming a balancing set on a three-wire 250-volt system. The rating of each generator was 250 kilowatts at 125 volts and 500 revolutions per minute. These two generators and their driving-motor, a 550-kilowatt three-phase synchronous machine, were built with a common shaft supported by four bearings. The object of the test was to determine whether or not the generator met the guarantees made for them, particularly in regard to efficiency. The generators were shunt-wound and each had eight poles and eight brushholder studs with eight brushes on each stud; the commutators had 288 bars each. Before the test was commenced, all brushes were refitted and the commutators turned true. As the test was made in a large substation supplying a 250-volt three-wire system, the load for the set was obtained directly from station busbars. The connections were as shown in Fig. 1.

The armature currents were measured by Weston shunt ammeters connected in the main generator leads. These ammeters were mounted on the switchboard. The field currents were measured by shunt ammeters in series with the field circuits. The armature voltage was measured across the machine terminals; the field voltage was measured directly across the field-winding terminals and therefore did not include the drop in the leads nor across the field rheostat. All instruments used in the test were given an accurate check with standard instruments before the test was commenced. For measuring temperature rise, glass mercury thermometers reading up to 100 degrees Centigrade, were used. As temperature rise by thermometer was the method decided upon, no cold resistances were taken.

Full-load Run

This test was of 24 hours duration, with both machines running at approximately full ampere load and 117 volts across machine terminals. Every 15 minutes readings were taken of the armature and field currents and armature and field voltages. At each reading the temperatures were taken of the air at each end of the set and of field coils, one on each machine. At the end of the run, the temperatures of the armature winding, field winding and commutator on each machine were taken at short intervals until the maximum was ascertained.

Hot Resistances

The hot resistances of the armature and field windings were taken immediately after the 24-hour full-load run. Just before load was taken off, the field resistances were taken by the fall of potential method, with full-load field current. The armature resistances were measured with all brushes down, using a small storage battery giving approximately 450 amperes. The drop was taken across 36 commutator bars beginning immediately under a brush, light readings being taken between the commutator segments under each positive and negative brushholder. The readings obtained were considered as showing too great a variation, due to the low current density, and on that account were not accepted. Another set of readings on armature resistance was taken after the 125-per cent. load run, at a temperature approximating the temperature of the armature at the end of the full-load run. These readings were obtained by blocking the armature and then forcing the full-load

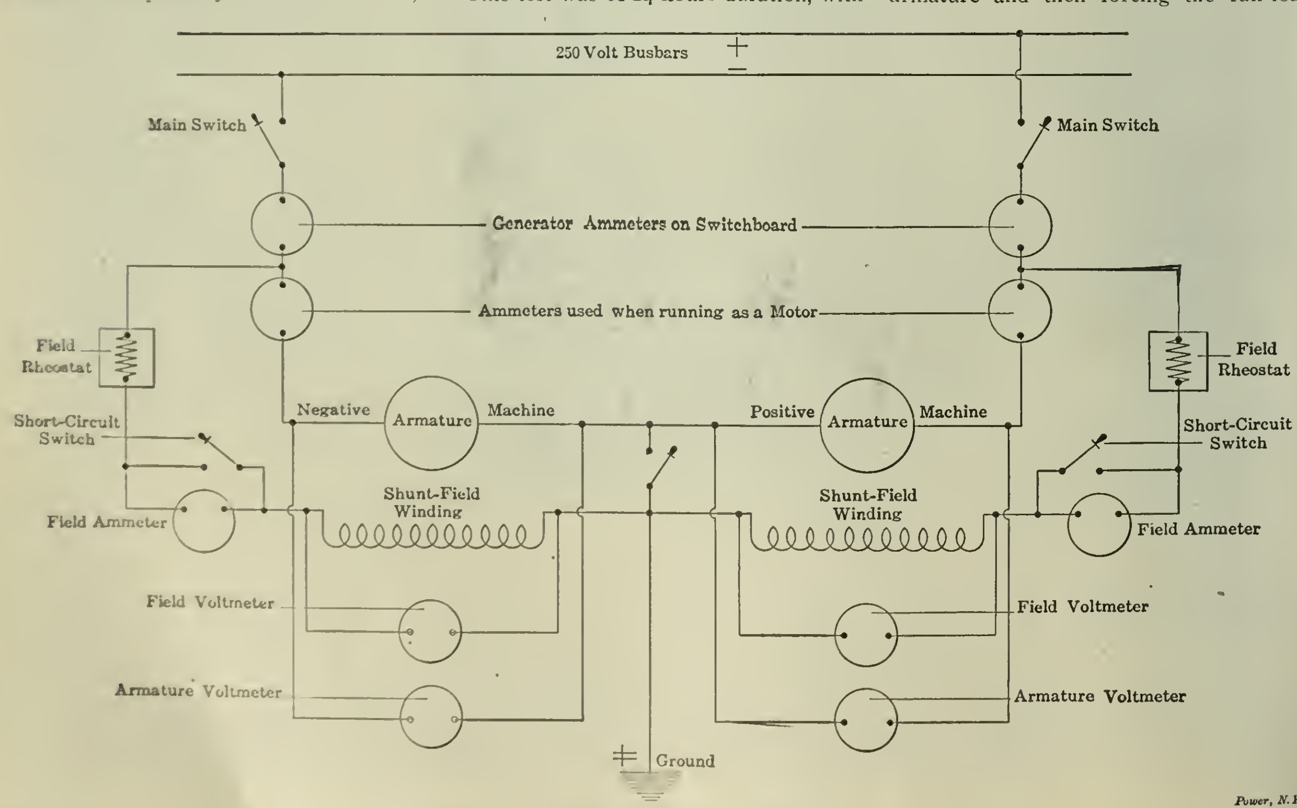


FIG. 1. DIAGRAM OF WIRING CONNECTIONS

current of 2000 amperes through the circuit. The drop was taken between adjacent brushholders as before, and the resulting resistance values checked fairly well.

Brush Contact Resistances

These measurements were taken at the end of the full-load run. Pilot brushes, consisting of two copper wires set in a wooden block fitted in the brushholders were employed, one brush being on a negative brushholder and the other on a positive brushholder. With full-load current on the machine the drop was measured between the negative pilot brush and negative machine terminal and between the positive pilot brush and positive machine terminal. From these readings the total resistances of brush contact, brushes and machine leads were obtained.

Overload Run

As soon as possible after the full-load run, a load of 2500 amperes (25 per cent. overload) was put on the set, which was run under these conditions for two hours. At the end of this time temperatures were taken of the armature windings, field windings and commutators. The air temperatures at each end of the set were also taken.

Windage, Friction and Iron Losses

These measurements were taken at the end of the run with 25 per cent. overload and were obtained by driving the set with one 125-volt generator running as a motor and measuring the input. The set of readings first taken included iron loss, brush friction, bearing friction and windage of both direct-current machines, and a negligible brush and armature resistance loss in the driving motor. These readings also included windage and the bearing friction of the synchronous motor. The machine run as a generator, on which measurements were being taken, was excited to give a terminal voltage equal to 125 volts plus the resistance drop in the armature winding, brushes, brush contact and machine leads. With the speed of the set held constant at 500 revolutions per minute, the power input to the motor was measured. Readings were also taken at several points on the saturation curve of the machine, but these do not enter into the calculations. As the driving motor was separately excited, the loss in its field winding cannot be included in these readings. Call this set of readings No. 1. The field circuit of the generator was then opened and the input to the driving motor again measured. Call this reading No. 2. The difference between No. 1 and No. 2 gave the net iron losses of the generator. All the brushes of the generator were then lifted and the

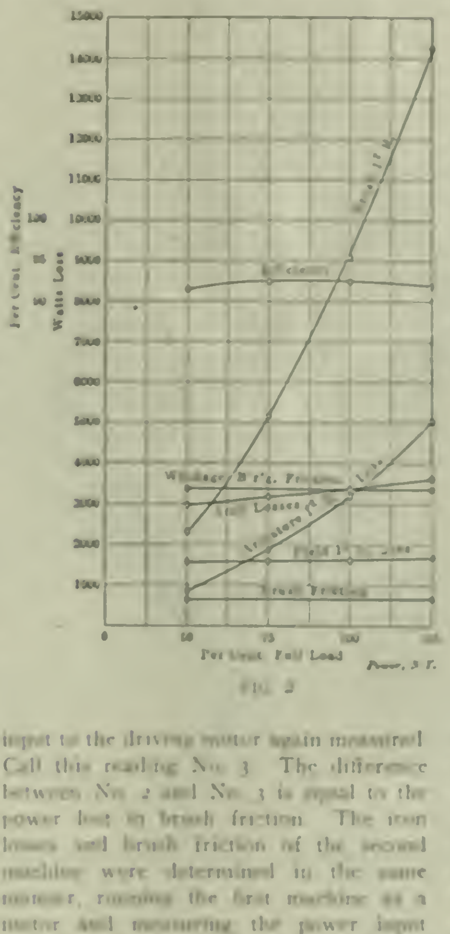


Fig. 2

input to the driving motor again measured. Call this reading No. 3. The difference between No. 2 and No. 3 is equal to the power lost in brush friction. The iron losses and brush friction of the second machine were determined in the same manner, running the first machine as a motor and measuring the power input as before. The readings designated as No. 3 include the windage and bearing friction of the whole set, and the net amount of this loss was obtained by subtracting from No. 3 the losses in the driving motor, consisting of brush friction, armature resistance loss, iron loss and brush contact resistance loss. The assumption was then made that the windage and bearing friction for each machine was proportional to its rated capacity. This assumption gives the loss for each 125-volt generator as being 25 per cent. of the net total loss as calculated from No. 3.

Efficiency Calculations

These calculations were based on hot resistances, the field-winding resistance as taken at the end of the full-load run and the armature resistance as taken at the end of the overload run after cooling to a temperature equal to that at the end of the full-load run; the brush contact resistance as taken at the end of the full-load run. Armature and brush contact resistance losses were calculated from the percentage of full-load current required. The iron losses for different loads were taken from a curve obtained from values of the terminal electromotive force corresponding to the load on the machines. The field-winding loss was obtained from values of field current corresponding to the original armature voltage used in obtaining the iron losses. Brush friction, bearing friction and windage were considered as being constant at all loads.

In the accompanying table are given the results of the test on one machine, and in Fig. 2 curves drawn from these tabulated values.

RESULTS OF THE TEST ON ONE MACHINE.

Load %	Arm. Current	Arm. I²R Loss	Field I²R Loss	Brush I²R Loss	Iron Loss	Brush Friction Loss	Windage and Bearing Friction Losses	Total Losses	Per Cent. Eff.
125	2,500	[illegible]	1,673	[illegible]	[illegible]	650	3,062	[illegible]	91.7
100	2,000	4,214	1,661	[illegible]	[illegible]	650	3,062	21,374	92.2
75	1,500	[illegible]	[illegible]	3,114	3,130	650	3,062	[illegible]	[illegible]
50	1,000	[illegible]	[illegible]	[illegible]	[illegible]	650	3,062	[illegible]	91.5

Note.—All losses given in watts.

Coal Consumption of Steam-Turbine Stations

By N. A. Carle

It is desirable to know the approximate number of tons of coal which should be consumed per day by a power station as a check on the actual figures. Sufficient information is usually available for approximating the desired result from data which has been obtained at various times by tests of the equipment. Records are on file showing the rate of evaporation of the boilers in pounds of water evaporated per pound of coal from and at 212 degrees Fahrenheit, the water-consumption rate in pounds per hour per kilowatt of the turbines and auxiliaries, and the load factor of the station. The installed capacity of the station is known and the factor of evaporation is calculated from the values of the temperature of the feed water, the steam pressure and the amount of superheat.

From the foregoing data the approximate coal consumption per day can be ascertained. The chart on page 1002 is designed to calculate the result graphically from this data.

Examples

(1) A power station with an installed capacity of [illegible] kilowatts has a load factor of [illegible] per cent. The turbines and auxiliaries require [illegible] pounds of water per hour per kilowatt and the evaporative efficiency of the boiler is [illegible] pounds of water evaporated per pound of coal from and at 212 degrees Fahrenheit.

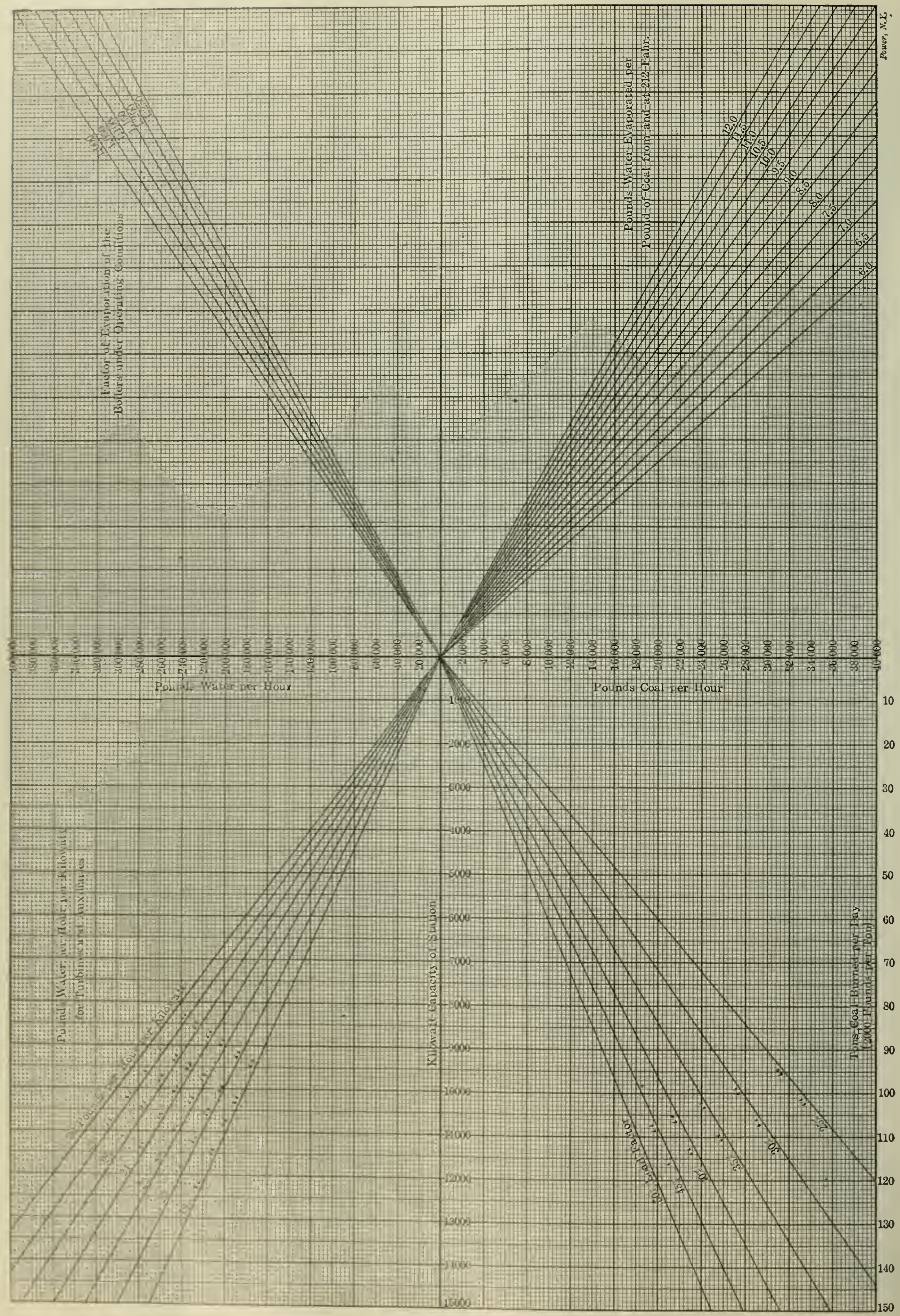


CHART FOR DETERMINING THE COAL CONSUMPTION OF STEAM TURBINE STATIONS

The temperature of the feed water is [illegible]05 degrees Fahrenheit, the steam pressure is 150 pounds per square inch, gage pressure, and the amount of superheat is [illegible]5 degrees Fahrenheit. What is the coal consumption per day?

The factor of evaporation for these conditions is approximately 1.100. Starting with 10,000 kilowatts, read up to 24 pounds of water per kilowatt-hour, then across to 1.100 factor of evaporation, then down to 10.0 pounds of water evaporated per pound of coal from and at 212 degrees Fahrenheit, then across to 35 per cent. load factor, and down to approximately 11 tons coal burned per day. This result is in short tons of 2000 pounds and can be reduced to long tons of 2240 pounds by multiplying by the constant .893. However, it will be sufficiently accurate to multiply by 0.9, as the result obtained is only approximate.

(2) A power station with an installed capacity of 12,000 kilowatts burns 150 short tons of coal per day. Tests show that the water consumption for the turbines and auxiliaries is 26 pounds per kilowatt-hour, and the evaporative efficiency of the boiler is 11.5 pounds water per pound of coal from and at 212 degrees Fahrenheit, under operating conditions which yield a factor of evaporation of 1.150. What is the load factor of the station?

Starting with 12,000 kilowatts read up to 26 pounds of water per hour per kilowatt, then over to 1.150 factor of evaporation, then down to 11.5 pounds of water evaporated per pound of coal from and at 212 degrees Fahrenheit and extend a horizontal line from this intersection to the left crossing the lines for load factor until it intersects a vertical line through 150 tons coal burned per day. The result gives a load factor of approximately [illegible] per cent.

The famous Wright brothers, the aeronauts, have been nominated "Doctor honoris causa" of the technical University of Munich, which is one of the largest and, perhaps the best in Germany. This is considered as a great honor.

Getting the Most Out of Gas Engines

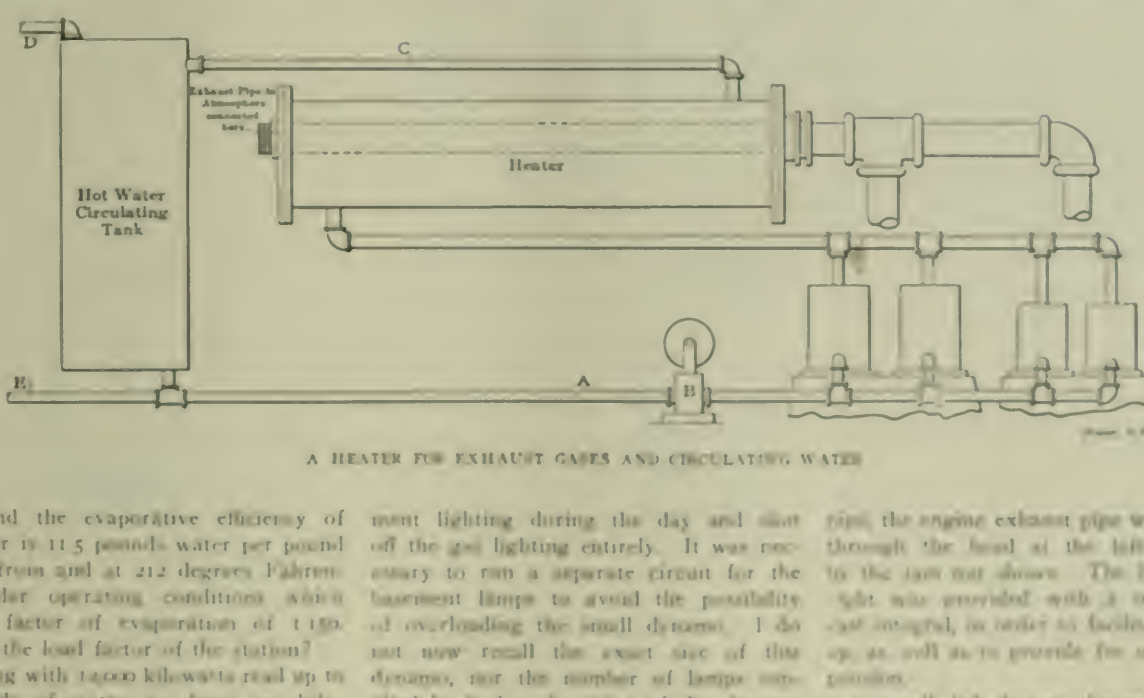
By E. G. Tilden

It was once my good fortune to be so placed that I could try some experiments on a gas-engine plant. The power outfit consisted of two vertical double-cylinder, four-stroke-cycle engines, one of 20 and the other of 40 horsepower and a direct-current generator for night lighting, belted direct from the larger engine, which also drove the machinery at night through shafting and belting. The 20-horsepower engine was used to drive the machinery during the day when lights were required only in the basement; this lighting was done with gas.

It was found by experiment that the smaller engine would almost pull the ordinary day load with one cylinder, showing that we had a large surplus of power. Consequently, we installed a second generator of proper size to handle the basement lighting during the day and shut off the gas lighting entirely. It was necessary to run a separate circuit for the basement lamps to avoid the possibility of overloading the small dynamo. I do not now recall the exact size of this dynamo, nor the number of lamps supplied by it, but the price of the dynamo was $125 and shutting off the basement gas meter, shut off a regular monthly gas bill of $60, while the amount of natural gas required for the engines for the month following the installation of the little generator was about 10 per cent. less than it was the previous month.

About the time the small generator was installed, experiments were being carried on with a view of finding the best timing of the igniters on the engines, and this was determined just after the installation of the extra machine. The apparent paradox of less gas consumption with more power was therefore due to the fact that the efficiency of the engines was improved by the ignition adjustment after the little generator in question had been put to work, and also by the larger load factor thereby obtained.

The plant equipment also included a boiler for furnishing hot water. In one part of the works we were buying water to cool the gas-engine cylinders, dumping the water, heat and all, into the sewer; while in another part of the building we were buying more water and burning "perfectly good" coal (that had to be paid for) to heat it up. A scheme for doing away with this double loss was finally developed. A heater, along the general lines shown herewith, was provided and connected up so that the exhaust gases from both engines passed through it, while the circulating water discharged from the engine jackets also passed through the heater and was heated for use in the hot-water system. The only loss was the hot water that was drawn off at the faucets, which was made up from the street main through the pipe A.



A HEATER FOR EXHAUST GASES AND CIRCULATING WATER

In making the heater, the body of which was a piece of ordinary 14-inch iron pipe, the engine exhaust pipe was screwed through the head at the left and held in the tank not shown. The head at the right was provided with a stuffing-box, cast integral, in order to facilitate making up, as well as to provide for unequal expansion.

A small belt-driven plunger pump B was used to insure proper circulation, its suction being connected to the pipe A and drawing the cooler water from the circulating tank. The discharge from the engine-cylinder jackets passed through the heater in contrary direction to that of the exhaust gases, back to the tank through the pipe C. The pipes D and E are the leads to and from the circulating system from which the hot water was drawn in the shops. The boiler was disconnected and permanently retired.

The cost of the heater, pump and piping was about $200, while the saving in cost of water and coal was just about that amount per year, to say nothing of the work and bother got rid of.

Some Useful Lessons of Limewater

An Interesting Chapter on the Chemistry of Sulphur; How to Make Hydrogen Sulphide; What It Will Do; Different Sulphur Forms

BY CHARLES S. PALMER

There are several matters connected with the chemistry of sulphur which we will take up, in order to get familiar with this common and useful substance and its compounds. The first thing is that innocent-looking compound, hydrogen sulphide, H_2S, or sulphureted hydrogen, as it used to be called. You may have heard of its bad-egg odor, but it is not really so unpleasant if it is handled right. The easiest way to make this gas (note that it is a gas) is first to make some iron sulphide, by heating together in an old iron pot some iron turnings and common brimstone. The iron and sulphur will unite with considerable heat; and when the operation is over, you can turn out the fused mass on the brick floor to let it cool. Break it into lumps, and you will note the dark bronze color of this iron sulphide, FeS. Fe stands for *ferrum*, the Latin for iron. When this iron sulphide is treated with dilute sulphuric acid, about one part of sulphuric acid to four or five of water, the action is like that shown in the following equation:

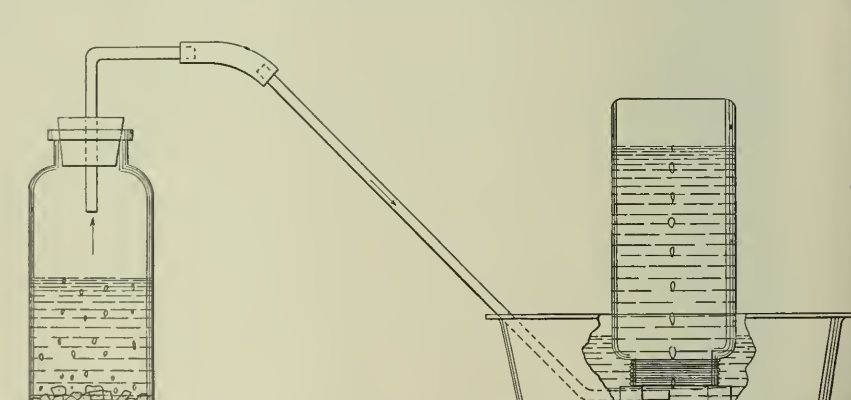
$$\underset{\text{Iron Sulphide}}{FeS} + \underset{\text{Sulphuric Acid}}{H_2SO_4} = \underset{\text{Ferrous Sulphate (Iron)}}{FeSO_4} + \underset{\text{Hydrogen Sulphide}}{H_2S}$$

Making Hydrogen Sulphide

This experiment of making the hydrogen sulphide is done in a common pickle jar, with a delivery tube, a common pneumatic trough and one or two fruit jars, as shown in the accompanying sketch. When you have collected several jars, take them out of the trough and set them mouth upward, covering them with cardboard covers. You will burn this gas, hydrogen sulphide, H_2S, and you will note that it burns readily, with a distinct and peculiar flame. The gas burns in the air, and the taper is extinguished when thrust up into the jar. You will not fail to note that as the gas burns it gives off the same kind of sulphur fumes, and with the same smell, as when you burn the common sulphur eight day match. You can see how all this happens by one glance at the oxidation table of sulphur given in a previous lesson; and here you will note the great advantage of having the compounds of each element given in order, from reduced, or hydrogen compounds, to oxidized or oxygen compounds.

Just why the burning sulphur stops at sulphur dioxide, or two-oxide, SO_2, instead of going over to the full oxidation form, SO_3, sulphur trioxide or three-oxide, is a curious matter, and one which has everything to do with the making of sulphuric acid, as we will see later. But you will miss half the game in studying this hydrogen sulphide, H_2S, the bad-smelling gas, unless you go on to some interesting experiments in analysis. So we will make several solutions of the common metals; such as sugar of lead (lead acetate), green vitriol (iron sulphate), blue vitriol (copper sulphate), white vitriol (zinc sulphate); and also some arsenic solution (common white arsenic dissolved in hydrochloric or muriatic acid), and some antimony solution (made by dissolving the metal in a mixture of hydrochloric and nitric acids (aqua-regia, or royal water, because this mixture of nitric and hydrochloric acids will dissolve gold). This solution of antimony you must not mix with much water because water will throw it out of solution. You will also want to add a few drops of ammonia to the solutions of iron and zinc; the rest will act best if left slightly acid.

You might almost mix these up, without labels, and even if the solutions were of the same color, the hydrogen sulphide would* pick each of them out for you. If you put some of each of these solutions of the various metals, each in a separate small jar, and lead in some of this gas, hydrogen sulphide, with the delivery tube, cleaning the delivery tube after using it in any solution, you will get this marvelous result: This same gas will throw down a black precipitate in the lead and the iron, but the lead solution is neutral or slightly acid; the gas hydrogen sulphide will throw down a yellow precipitate in the arsenic solution; it will throw down an orange precipitate from the antimony, a dark brown or black from the copper, and a white precipitate from the zinc solution. All this will take place right under your eyes, with the same gas, a colorless gas, hydrogen sulphide, H_2S, just as described: lead, black; copper, dark brown; antimony, orange; arsenic, yellow; iron, black; zinc, white. You can see that all this would be very convenient in telling what metal one had in solution. This set of tests is so useful and so remarkable that it will repay you to make some effort to collect the material for the tests and go through with them. It will give you much food for thought; and it will begin to show you how anyone can learn to test and analyze the common solutions of the common metals.



MAKING HYDROGEN SULPHIDE

At first one should begin with one metal in a solution, but after a time you can handle several metals, taking out each in its place and proving it up as you go along. Sometimes chemists speak of analyzing a solution of all the metals, but that is not quite correct, because it is not possible to have all of the metals in solution at the same time and in the same solution; but one may easily have as many as ten or fifteen of the common metals in the same solution; and one can learn to find each in its place, with the help of this gas, hydrogen sulphide. You will also note that it makes a difference in using this gas, hydrogen sulphide, to precipitate the metals, whether one sends it into a solution which is alkaline or acid in reaction. Thus, some of the metals will precipitate only in alkaline solution; others will precipitate in both acid and alkaline solutions.

Hydrogen Sulphide in Mineral Waters

This gas, hydrogen sulphide, occurs in many natural mineral waters. Some of the most famed of the health resorts owe their fame to the supposedly curative powers of the hydrogen-sulphide waters. The hydrogen sulphide is not the only substance in the waters, but as a rule there are several other ingredients, some salty in a broad and general sense, and some gaseous, like carbonic-acid gas. You can find out much about these waters by applying to the United States Geological Survey for a pamphlet called "Geo-Chemistry," by Prof. F. W. Clarke (Bulletin No. 330, Washington, D. C., U. S. Geol. Survey). It should be noted that this same gas, hydrogen sulphide, is what is called a reducer, that is, it can take oxygen, or its equivalent, out of bodies, bringing them down to a lower state of oxidation. Thus, if you lead some of the hydrogen sulphide into a dilute solution of nitric acid, you will note a yellowish or perhaps a milky white precipitate come down in the solution. This is only sulphur, which comes from the hydrogen sulphide, as it reduces the nitric acid to some lower form of nitrogen oxide. The gas, hydrogen sulphide, is quite soluble in water, and such a solution is often called "sulphydric acid," after the analogy of hydrochloric acid, although the old name, "sulphureted hydrogen," is still used also.

If sulphur is mixed with soda and fused for some time, peculiar dark-brown substances are formed, called "livers of sulphur," which are nothing more than sulphides of sodium. When these are treated with such acids as the sulphuric or muriatic, the same gas, hydrogen sulphide, is given off, and although you will always detect it by the nose, which is a perfectly legitimate reagent, it is handy to remember that a bit of filter paper moistened with any soluble salt of lead, such as lead nitrate, or lead acetate (sugar of lead), makes an excellent and easy test for the gas, the paper becoming dark brown or stove-polish black. One reason why good white lead paint often turns dark in the vicinity of drains is that the lead in the paint is colored dark by this same test; that is, by the foul gas, hydrogen sulphide, escaping from the refuse of the drain.

Different Forms of Sulphur

The next subject to study is sulphur itself. This comes into the market in several forms: First, as roll sulphur or common brimstone ("burnstone"). This is simply pure sulphur which has been melted and cast into thick sticks. When this roll sulphur, or brimstone, is crushed to a powder, it is called "flour" of sulphur. "Flowers" of sulphur is something quite different, however. It is made by condensing the vapor or fumes of distilled sulphur over water, or in a cool chamber, where it falls down as a soft fine powder, which is sulphur in a different condition from merely powdered brimstone. The "flowers" of sulphur is more than half in what is called the "amorphous" or gummy condition, while the powdered or "flour" of sulphur is mostly in the crystalline condition. We will see in a moment what these mean.

Take an ounce or two of brimstone and break it up so that it will slip down into a common test tube. The test tube must be held by a handle, either of wood or wire, as shown in a previous lesson, or at least with a loop of thick paper. Heat the sulphur carefully over a common flame or alcohol lamp. You will note that the sulphur melts to a clear thin liquid, of a magnificent yellow color. Pour some of this into a tumbler of water, and it will form hard yellow shot, which are made up of one of the two principal crystalline forms of sulphur. Now save most of the melted sulphur in the same test tube, and go on heating it. You will note that shortly it begins to get orange in color, then much darker, and soon it is so thick that you can hold the test tube upside down without its flowing out of the mouth of the test tube. Go on heating it, and in a short time, while still dark in color, it will get somewhat thinner, not as thin as it was when first melted, but thin enough to pour from the test tube.

This hot sulphur will also boil, and if you let the vapors that escape from the test tube fall quietly onto the surface of some water in a tumbler, you will note the beautiful light yellow skin or "pellicle" of "flowers" of sulphur. You can pick this up like a thin piece of sheet rubber, for its elasticity is remarkable. But while the test tube of dark-colored sulphur is still hot, pour it out in a thin slow stream into a tumbler of water, noting that it falls down much like so much molten rubber. You will get a little pile of this rubber-like sulphur at the bottom of the tumbler of water; and as soon as it is cool enough to handle, pick it up in the fingers and handle it. It is precisely like softened rubber. You can draw it out, noting its elasticity. But set it aside for some minutes, and you will see that it soon becomes brittle, and also somewhat lighter in color. This elastic form of sulphur is called "amorphous" sulphur; that is, elastic, gummy, noncrystalline. As it hardens and gets stiff it becomes crystalline and somewhat lighter in color.

Making Sulphur Crystals

Now look at the sulphur which is still left on the sides of the test tube. Even with the unaided eye you can see that it is largely made up of needle-like crystals. These are of what is called the monoclinic form. Take enough sulphur to fill a small cup, melt it and let it cool until it has just crusted over; then, breaking the crust, you will see the inside filled with a radiating nest of these needle-like crystals. They will show better if you pour off the still molten and not yet solidified sulphur. These crystals are of a beautiful golden yellow, but in a few hours, almost always after standing over night, they will lose their clearness, becoming opaque, and somewhat lighter in color. This change is due to a change in crystalline form, not in the outside form of the crystal, but in the inside of the crystals. The new form is called the ortho-rhombic, and it is the form in which natural sulphur crystals occur.

One can easily get some of these by making a solution of sulphur, as by dissolving it in the foul-smelling liquid called carbon disulphide. This carbon disulphide is frequently used as an exterminator of insects about flour mills and grain elevators. It can be obtained from any druggist, and if you work with it you must remember to keep it away from a flame as it is exceedingly inflammable. If you should get some of this, you could easily make a solution of sulphur, afterward pouring it out into a saucer and letting it evaporate, when the small orthorhombic crystals are seen to collect as the solution of sulphur in carbon disulphide, CS_2, evaporates. If you ever take the trouble to go up to some mineral cabinet you will see quite large crystals of this natural ortho-rhombic sulphur.

In summing up, we will notice that sulphur has several forms in the liquid state, and also several different forms in the solid state. In the liquid state there are three forms: First the thin, light, watery form, then the thick, dark-colored tarry form, and lastly the still dark but fairly liquid form which, poured into water, gave the amorphous form. In the solid state we found three forms, also: the two crystalline forms and the amorphous or rubber-like form. It is interesting to notice that sulphur carries out this tendency to exist in several forms, even into the gaseous state, as the vapor which we poured over the water is a very heavy gas, having the formula S_6, and if this is heated still higher it falls into a thinner vapor having the formula S_2.

This tendency for a substance to exist in several forms is called allotropism, and the different forms are called allotropic forms. There is no common element which can rival sulphur in the variety and perfection of these forms, nor in the ease with which they are made; although carbon can exist in the common form of coal, and also in the two crystalline forms of the diamond and of graphite, or lead-pencil ore, and common iron can exist in several forms. When we come to the chemistry of iron and steel you will hear much of the so-called "alpha" and "beta" forms (these words alpha and beta are the old Greek names of the letters A and B). Common oxygen also can exist in the form of common oxygen, O_2, and also of ozone, O_3. Similarly we shall find that some of the oxides of nitrogen have allotropic forms, as also does common carbonate of lime, in the forms of calcite and aragonite.

The next subject to consider is the first oxidized form beyond sulphur, namely, sulphur dioxide; but this is so closely connected with sulphur trioxide and the making of sulphuric acid that we will leave the subject to another lesson. Meanwhile just a word about the occurrence of sulphur. Until recent years most of the sulphur of commerce was obtained from the little island of Sicily in the Mediterranean sea, but some years ago, when boring for oil and gas in Louisiana, immense deposits of sulphur were found at a depth of only a few hundred feet. These deposits of Louisiana sulphur (which seem to be almost inexhaustible) occur in connection with a lime compound, gypsum or calcium sulphate; but the awkward thing about it was that the deposits were almost inaccessible from the fact that they were covered by thick and obstinate quicksands. All attempts of mining engineering to penetrate these quicksands and to reach the sulphur deposits by shafts failed, until Dr. Frasch invented a method of sinking several large tubes in series, one within the other. Through the outer tubes steam and hot water are forced down at a temperature and pressure sufficient to melt the sulphur in the gypsum beds, and this molten sulphur was then forced up to the surface in a liquid stream where it is allowed to flow into large tanks and harden naturally. As it cools, it is broken up and shipped without further treatment. This curious method of mining sulphur accidentally happens to result in furnishing a very pure and a very refined form of sulphur; in fact, over 99 per cent. pure; and this article has practically replaced foreign sulphur in the home market.

Steel Bands versus Leather Belts

By E. Hoffmeister

Successful trials have been made to replace leather belts by steel bands. Because they have nearly no thickness, they avoid the main evil—the slip—nearly perfectly (less than 1/10 per cent.) and have therefore an efficiency of more than 99 per cent. An especial friction layer is fastened on the pulleys in order to produce the necessary friction between the band and the circumference of the pulley. The length of the band is practically constant. The distance of the shafts may be small. The air resistance, which is very considerable at high speeds, plays no rôle with steel bands.

Band drive is exceptionally qualified for big drives and is very efficient, as well in regard to effect as to speed (to 330 feet a second). It is superior to rope drive by about 15 per cent., and is excellent for dynamos and motors and gas engines. The efficiency is nearly incredible. For example, at a trial a 1/8x3/128-inch steel ribbon ran at a speed of 190 feet a second, transmitting 146 horsepower.

To transmit 100 horsepower at 200 revolutions a minute, with 40-inch pulleys, the cost per year, everything included (interest and amortization), would be $700 with ropes, $400 with leather belts and $82 with steel bands.

National Gas and Gasolene Engine Trades Association

The National Gas and Gasolene Engine Trades Association will meet on June 22, 23 and 24, at South Bend, Ind., with headquarters at the Oliver hotel.

This association was organized some months ago to advance the interests of the gas- and gasolene-engine trade, and promote a profitable acquaintanceship among the various lines of trade interested in the internal-combustion engine. Anyone who is interested in this type of engine, whether manufacturer, dealer or user, is eligible to membership.

The program has not as yet been fully completed, but will include, among others, the following papers:

"The Suction Gas Producer for Small Power Plants," by C. J. Atkinson, Watertown, Wis.

"Storage Batteries for Ignition Purposes," by G. L. Chambers, Cleveland, O.

"A Running Test of a Gas Engine, with Data," by J. C. Miller, Chicago, assisted by others.

"Water, Its Uses and Abuses in Relation to Gas Engines," by H. W. Jones, Chicago, Ill.

"Some Accessory Items," by E. H. Campbell, Detroit, Mich.

"Compression Couplings," by William S. Noyes, Chicago, Ill.

"Advantages and Disadvantages of Selling Gas Engines Through the Jobbers and Dealers."

An invitation has been extended to the American Gas Power Society and the National Gas and Gasolene Engine Manufacturers' Association to attend this meeting.

By way of entertainment there will be a trolley ride from South Bend to St. Joseph, Mich., furnished by courtesy of Gas Power. The local Chamber of Commerce has also arranged for an automobile ride and inspection of the large and interesting factories of the Studebaker Manufacturing Company and the South Bend Watch Company. Everyone who is interested in the line of work of the association is invited to attend these meetings, whether members of the association or not.

Coal Analysis *

Coal-bearing rocks underlie three-fourths of Illinois, including 85 of its 102 counties. The coal area is estimated at from 36,000 to 42,000 square miles—the largest area of bituminous coal within any single State. There are approximately 1000 mines in the State of which over 400 are railway shipping mines. The work of the State Geological Survey is therefore very largely devoted to coal and the problems of the coalfields.

Illinois ranks second among the States in the production of coal. In 1907, 51,317,146 tons, having a total value of $54,687,382 were mined. The figures for 1908 are not complete but preliminary estimates indicate that Illinois was almost alone among the States in holding its production. While in the country as a whole the amount mined fell off from 15 to 20 per cent., Illinois mines produced as much as or possibly more than in 1907, a record year. Despite this gratifying fact it remains true that our mines are not working to anything like their capacity. In 1907 the average number of days worked was 218. It would probably be fair to assume 300 working days a year as possible. On this basis there was a loss of 30 per cent. of loss in our State. The reasons for this are complex. In part they lie in the nature of the coal, which prevents its storage without spontaneous combustion; in part, in the general ignorance as to correct methods of firing and the real value of the coal; and finally in part, in the present organization of the industry with excessive competition in selling. The net results are bad for the industry and therefore for the State as a whole. Cheap coal reduces manufacturing costs but allows wasteful burning. It also entails wasteful mining and even prevents the introduction of methods of safeguarding the men in the mines. It is a serious question whether we are not paying, in loss of life in the mines, in loss of efficiency in our plants, and in loss of interest and capital invested in the industry, more than the cheapness of the coal is worth.

The study of the coal and coalfields of the State has been carried on both in the field and office. The work has been directed toward:

(1) The solving of problems of stratigraphy, such as the distribution and correlation of various coal beds, together with the collection of all data relating to the origin and the mode of deposition of the coal and accompanying beds.

(2) A study of the composition and uses of coals.

(3) A study of the mode of occurrence of coal as relates to the methods and costs of mining.

*Delivered as an address before the Illinois Fuel Conference at the University of Illinois, Urbana, Ill., by Dr. H. Foster Bain, director Illinois State Geological Survey, March 13, 1909.

(4) A study of the preparation of the coal for the market, its transportation, its normal markets and the competitions which it meets.

The first step in the solution of the problems of stratigraphy is the making of accurate detailed maps and the compilation of drill records. This is now being done and considerable areas near Peoria, Springfield, Belleville and in the Saline and Williamson county fields have been surveyed in coöperation with the United States Geological Survey. These maps show the thickness and lay of the coal beds and from them it will be possible to tell quite exactly how much coal is present and to plan its economical working. At present it is possible only to guess at the original content of the field and these guesses vary from 136 billion to 240 billion tons. Either is perhaps sufficiently large for our comfort.

The study of the composition of the coal is directed especially toward the determination of its availability and the best means of using it. Samples are taken by uniform methods in the mine and in the market and in connection with the Engineering Experiment Station elaborate experiments are being made of the methods of storage, of handling the coal, and of burning it. We hope soon to take up the matter of gas production and coke making and have had under way for sometime certain preliminary experiments.

The mode of occurrence as relates to mining methods and costs has been barely touched. In my judgment it would be well if the State made separate provision for this work. In the absence of special provision we are attempting to gather such notes as we can in the course of our regular work. "It has been found impracticable at the present time, mainly owing to limitations of funds, to undertake certain highly desirable studies of the technology of the mining industry and of the geographical distribution of markets for Illinois coals. It is believed that much good would result from investigations along these lines and that certain portions of the work are well within the proper field of the State Geological Survey. It is now well known that there is, under present commercial conditions, an enormous waste in the mining of Illinois coal. In individual districts it has been estimated to amount to as much as 60 per cent., though of course such losses are not general. It would, however, probably be safe to say that in very many places 50 per cent. of the coal in the ground is left unmined or is ruined in the process of mining. In addition, the methods of mining introduced in recent years have greatly increased the production of fine sizes and have also, seemingly, increased the danger to life and property in the mines. The causes for all these losses are complex, and it is not to be supposed that either operators or miners willingly submit to them. Neither is it to be expected that the losses of life and property can be entirely done away with. At the same time experience has abundantly proved that careful and impartial investigations of such conditions will point the way to the remedying of some at least of the abuses, and in view of the enormous importance of the subject to the State and the public at large, such studies are believed to be amply warranted.

There has been no opportunity as yet seriously to take up the study of markets. The expansion of markets for Illinois coal is a matter of vital importance to the coal industry and indirectly to the people of the entire State. One of the most important means of promoting this expansion is by removing certain misapprehensions as to the quality of the coal and the pointing out of better means of burning, so as to increase its efficiency and decrease the smoke produced. This work has been taken up vigorously by the Engineering Experiment Station, which has published excellent bulletins on "How to Burn Illinois Coal Without Smoke," and other similar subjects. In addition to this valuable work, there should be investigations of the actual markets for the different grades of coal and of possible enlargements of these markets. There are large areas to the northwest within which Illinois washed coals might profitably supplant Eastern coals now being sold. There are other areas to the south and west where, with proper organization of transportation agencies, even in advance of improvement of the rivers, trade territory would be gained. Any widening of the market would be of large benefit to the local industry, particularly if the summer market could be increased. For this reason the studies now under way relating to weathering of coal and coal storage are especially important.

The Easton Gas and Electric Company's Plant

By Edward T. [illegible]

The Easton Gas and Electric Company's generating plant is situated in South Easton, Penn., on a strip of land between the canal of the Lehigh Coal and Navigation Company and the Lehigh river. This was originally a water-power plant receiving water from the canal and discharging into the river, the working head being about 20 feet. Up to 1905 the plant was operated in conjunction with a

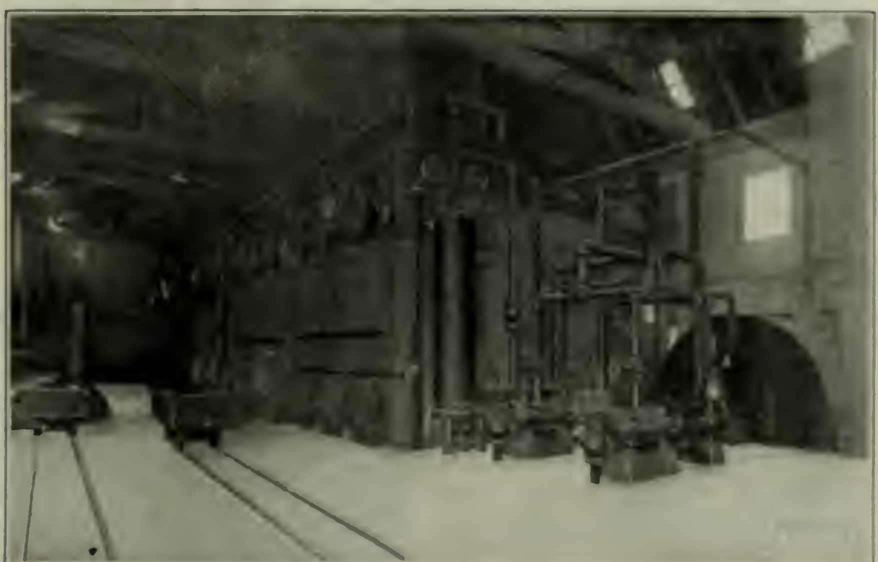


FIG. 1. THE BOILER ROOM

steam plant situated on Ferry street in Easton about 1½ miles away. In that year it was found advisable to abandon the steam plant and build a new one in the same building with the water-power plant in South Easton.

The New Steam Plant

In 1907 this new steam plant was enlarged 100 per cent. and the water-power completely remodeled. The present equipment consists of four prime units of a combined capacity of [illegible] kilowatts, capable of carrying continuously [illegible] kilowatts, and three water-power units rated at [illegible] and capable of carrying [illegible] kilowatts when there is sufficient water. The steam installation consists of four [illegible]-horsepower Babcock and Wilcox water-tube boilers and two [illegible]-kilowatt 60-cycle two-phase [illegible]-volt Curtis turbo-generating units running at [illegible] revolutions per minute. The boilers have selfficient capacity to carry 50 per cent. overload on the turbines. Each boiler is equipped with 180 four-inch tubes and with 80 square feet of Treadkill shaking grates. They are built for 200 pounds working pressure and have superheaters to give 100 degrees superheat. A low

FIG. 2. UNLOADING COAL FROM THE CANAL

grade of coal is used, forced draft being supplied by two 7-foot A B C blowers. Two steel stacks, 100x6 feet, furnish sufficient draft to carry half load on the boilers. Both the feed-water pumps and forced-draft equipment are controlled by automatic regulators.

Coal is received from canal boats and unloaded by clam-shell buckets. It is then carried and dumped in the storage yard by means of a Hunt automatic railway. Sufficient coal is stored in the summer months to last through the winter. A bucket elevator carries the coal from this yard to an overhead tank from which it is dumped by gravity into one-ton charging cars. These cars pass over scales before reaching the boilers, which are fired by hand directly from the cars. The ashes fall from the grates into the boiler ashpits, which have sloping bottoms, are loaded by gravity into ash cars and dumped on the low land back of the plant.

The turbines are equipped with Alberger surface condensers of the counterflow type, with automatic hotwells from which the water of condensation is delivered to a storage tank. From this tank the boiler-feed pumps obtain their water. Makeup water is added at the condenser by means of a bypass between the steam and water chambers. The cooling water is siphoned from the canal through the condenser and discharged into the river. The bypass used for the makeup water also keeps the siphon free from air.

The cooling water enters at one end and at the top of the condenser, and after traveling three times its length, is discharged at the bottom of the opposite end. Steam enters at the bottom and the dry-vacuum pump connection is made at the top. This arrangement insures that the air removed by the vacuum pump will be as dry and cool as possible and

FIG. 3. TURBO-GENERATING UNITS

that the hotwell water shall be at the highest possible temperature.

On the turbines, hydraulic valve gear and oil step bearings have been installed in preference to electric valve gear and water steps. The auxiliaries, including two-stage dry-vacuum pumps, hotwell pumps, step pumps, boiler-feed pumps and blower engines, are steam driven, and their exhaust is condensed in a closed feed-water heater. The 40-kilowatt exciters are motor driven and are controlled by a Tirrill regulator. A 35-kilowatt steam-turbine exciter is used to start the plant in case of a complete shutdown.

Foundations of both boilers and turbines consist of piers and reinforced-concrete girders. The fact that the plant had to be placed in an existing building through which passed penstocks and tail races, made the ordinary foundation impossible.

Hydraulic Installation

The hydraulic installation consists of two 1000-horsepower and one 180-horsepower units, each consisting of two runners on a horizontal shaft. The largest units have 48-inch runners and are direct-connected to 500-kilowatt two-phase 60-cycle 2400-volt generators running at 150 revolutions per minute, while the smaller machine has 24-inch runners and is belted to a 120-kilowatt 60-cycle two-phase 2400-volt generator. Lombard governors are used on the 1000-horsepower units.

On the electric end the steam and hydraulic plants are run in parallel, the object being to keep the hydraulic plant loaded at all times, and to handle any excess load with the steam plant. Power is distributed by eight sets of feeders. Three two-phase 2400-volt lines transmit power to the Ferry street plant which is used as a center of distribution for both alternating and direct current. By means of motor-generator sets power is converted to direct current for lighting and trolley service, a Gould storage battery with a booster being used to even up the trolley load. Six single-phase lighting lines with phase voltage regulators distribute power and light from this plant. Three two-phase 2400-volt lines transmit power and light directly from the generating plant to the adjacent portion of the city, and two 11,000-volt three-phase lines transmit power about eight miles to Nazareth and Bottown. At Nazareth it is stepped down to 2300 volts two-phase to supply power and light to the city, and at Bottown power is delivered to a synchronous converter for trolley service.

The company here is located in one of the best communities in the country for the development of light and power, especially the latter, as the city of Easton and surrounding territory are dotted with manufactories of various natures, prominent among them being a number of large silk mills which find electric drive particularly applicable to their work. During the past fall the company passed under the control of the Doherty Operating Company, of New York, and already, under Henry L. Doherty, it has gained a strong impetus and is rapidly forging ahead and will no doubt outgrow its present plant within the year. The combination of steam and water under which this plant operates, puts it in a particularly favorable position in competing for the power of the different industries in its territory, and an interesting development in this field is the use of electric motors in conjunction with water wheels in the numerous feed and flour mills, soapstone, paint and other mills which are located along the rivers and streams flowing into the Lehigh and Delaware rivers which unite here.

The power branch of the business has been developed to the point where a day load of 1400 kilowatts is carried on the plant continuously, and the field is only touched. In and around this company's territory is a possible development of over 7500 horsepower, which the company is making a strong effort to secure with exceptionally good success. The management of the company is invested in H. F. Cresson, formerly of the United Gas Improvement Company, of Philadelphia. His assistant, F. L. Franklin is to be credited with the unique and efficient equipment of the generating and distribution systems and the high standard of operating efficiency.

It is a case of leaping before looking when a boiler is immediately condemned because a certain horsepower is not being generated. The fault may lie in the engine rather than the boiler. Poorly adjusted valves are responsible for large consumption of steam by the engine and the engineer cannot always detect the cause of the increase without mechanical aid. It is good policy to make use of an indicator and learn from it the root of the trouble that is responsible for the undue consumption of steam.—*Engineering Journal of Canada.*

Inspection for New York's Low Pressure Boilers

By A. C. Rossary

In a previous article upon the supervision of the power of New York city exercised by the Sanitary Company, generally known as the Boiler Inspection Bureau of the Police Department, it was stated that only three times in 40 years had there been boiler explosions in the city. To those who glanced through the commissioner's report for 1908, this statement may seem to be in error, for a dozen accidents are reported as occurring to high-power boilers and a list of about 20 injured is given.

An analysis of the list of casualties shows that six of the twelve were caused by the blowing out of tubes. Of these, two were caused by defective metal, one by foreign matter found in the tube, and two were due directly to the crowding on of steam during the heavy traffic on the Brooklyn Rapid Transit in summer. Nine were injured severely, but none fatally, in these cases.

Of the remaining six explosions, one was caused by the bursting of a cap on an economizer and another by the blowing out of a defective gasket on a lower manhole plate. The gasket had been inspected after it had been twice repaired and passed by the insurance company. Seven cast-iron headers in the front of one boiler cracked for some unknown reason and caused an explosion, but no one was injured. One of the explosions reported was the breaking of a steam pipe in a dry dock caused by the raising of the dock with the tide; another casualty was due to the escape of steam on the second floor of a plant. The steamfitters making repairs disconnected the pipe before the steam had been shut off and were scalded.

Danger from Low-pressure Boilers

Having analyzed the use of the high-power plants, it will be interesting to consider those of the so-called low-power plants, particularly at this time, when an effort and a strong one, is to be made to bring them under the control of the Sanitary Company through an ordinance to be introduced before the board of aldermen.

It is contended by the Sanitary Company, that there are thousands of high-pressure boilers in New York, masquerading as low-pressure boilers, with the logical sequence of increasing the plants to incompetents, the discharge of licensed engineers and the incidental escape of the plant from the vigilance of the Sanitary Company.

In the Voss bill before the last session of the legislature, an attempt was made to define a low-pressure boiler as one not having more than 6 square feet of grate surface. At the rate of three horsepower to a square foot of grate surface, it practically permitted 18 horsepower instead of the 10 horsepower which the present law seemingly allows; only seemingly, observe, for it really allows any pressure the owner cares to put upon his boiler, as it is not subjected to test, inspection, compulsory employment of a licensed engineer or any kind of supervision, as long as the safety valve is set for 10 pounds.

There are low-pressure boilers in New York with 30 and more square feet of grate surface, absolutely immune from any kind of regulation by the fact that the valve is set for 10 pounds pressure. What happens when the safety valve sticks or some other dangerous factor arises is shown clearly in a tabulation drawn up for Deputy Commissioner Hanson to be presented to the board of aldermen as reasons for the passage of the ordinance bringing the low-pressure and portable low-pressure boilers under the care of the Sanitary Company. These casualties are only a few of those that occur yearly in New York. Others were not even reported to the bureau, being in many instances cases for the coroner. They are worthy of consideration by the authorities of every large city where low-pressure boilers are not subject to regulation.

October 22, 1908—Bernard Kolan, 23 years old, janitor, killed by low-pressure boiler exploding at 1075 Tinton avenue, the Bronx.

November 10, 1908—low-pressure boiler exploded, 203 Vanderbilt avenue, Brooklyn; no loss of life.

December 10, 1908—Fred Mundha, 37 years old, janitor, burns about the face and body. Removed to Swedish hospital. Mabel Mundha, four years old, fractured skull, removed to the Cumberland street hospital. Died in hospital. Elizabeth Mundha, five years old, lacerated chin and leg and general contusions. Removed to Cumberland street hospital. These were the net results of the explosion of one of those high-pressure boilers masquerading, legally too, as a low-pressure boiler in the basement at 110 Quincy street, Brooklyn.

April 29, 1909—Dr. William Niles, 45 years of age, 214 Lenox avenue. Killed in the basement of his residence by the explosion of a low-pressure boiler. He had forgotten to open the connections from the waterback, and the boiler naturally let go.

Only a few days before a similar low-pressure boiler gave way and killed a woman. When the case was before the coroner, it was discovered that the man who installed the plant had fled. It was not necessary for him to leave, for according to law he could not be punished. Was not the safety valve set for 10 pounds?

The Courts' Construction of Low-pressure Boilers

The courts of New York by their construction

struction of the word "and" in section 243 of the Greater New York charter, have effectually tied the hands of the police and granted immunity to owners or lessees who wish to run plants without engineers and beyond the jurisdiction of the inspectors. The word occurs in the clause exempting from the compulsory employment of licensed engineers on certain "boilers carrying not over 10 pounds of steam and not over 10 horsepower." According to the courts, the 10 pounds of steam and the 10 horsepower are interdependent, one hanging to the other.

Under this ruling, it is only necessary for the owner of a high-power plant to set the safety valve at 10 pounds to step out of the jurisdiction of the police, discharge his engineer and put a laborer in charge of a boiler which may have 35 square feet of grate surface and a capacity of, perhaps, 100 horsepower. The law, knowing nothing of the bearing of grate surface upon steam capacity, goes by the letter, and the result is that owing to the increasing use of electricity supplied by central stations, thousands of high-pressure boilers have been converted into so many menaces to the lives and property of the occupants and owners of buildings. There is as yet no means of heading off the danger.

A steamfitter tells an owner that if he has his safety valve set for 10 pounds, he can safely dispense with the service of his engineer and put on a laborer to handle the plant and take current for his motor and electric lights from an electrical company. That he need not have his boilers inspected and can refuse to make repairs. In addition, he will be freed from the trouble of sending in reports. Under the regulations of the Sanitary Company it was necessary to make twelve reports a year on the condition of the plant and the owner was forced to make repairs, the need of which he could not understand, not being an engineer. The proposition appeals to the owner. He keeps his boiler for heating purposes, connects all the radiators in the building and has the safety valve set for 10 pounds. Then he finds that his grate is too large and the safety valve is blowing all the time. The idea of selling the surplus steam to his neighbors is then conceived, and the result is three or four houses are heated by a single boiler; a boiler which, according to law is a low-pressure affair carrying only 10 pounds of steam and having a capacity of only 10 horsepower, when in reality this same boiler has a capacity much in excess of this figure.

Presently a warm day comes. The radiators in all the houses are shut off tight. The substitute for the licensed engineer is somewhere in the neighborhood. The indicator starts to spin and perhaps the safety valve sticks. Presently the substitute for a licensed engineer returns, looks at the meter, sees 150 pounds registered, wonders a little, but thinks it is all right because the valve has not gone off. There can be no danger; he opens the door and throws on a little more coal. Suddenly a tube gives, the substitute becomes a blistered parboiled object writhing on the floor in a cloud of steam. The owner is fortunate. The giving of the tube saved the building. He can get another tube and another substitute. No one is to blame, that is, criminally.

Hoisting-engine Menace

Another menace to life and property in the city that has developed and is growing rapidly, is furnished by the increased use of electricity for hoisting engines. Again the engineer's salary is an important element together with the dodging of repairs that should be made. The contractor does away with his boiler, sets up a motor, takes current from the street and a laborer is substituted for a licensed, skilled mechanic. It was just this penny wise and pound foolish policy that dropped one of the gigantic statues worth thousands of dollars as it was being swung into position on the front of the Hall of Records. It is liable to drop a ton of metal on the heads of pedestrians at any moment. And no one is to blame. The courts have held that there is no boiler and therefore no need for a licensed engineer, and the police department has no jurisdiction.

The ignorance of the average owner of the fact that the supervision of his plant is as much for his own good as for that of the general public is most appalling. Only recently a man came into town with a traveling crane. He demanded exemption from inspection of his boiler and the compulsory employment of an engineer, on the ground that his crane was a locomotive engine, because forsooth, it ran on rails. It took considerable time to convince him, first, that the bureau was not persecuting him, second that there was no graft in it, and third, that it was as much for his benefit as for that of the public that his plant be regulated. Then he was willing to obey the law.

The Voss Bill

This bill, known as Assembly No. 443, was an attempt on the part of the International Union of Steam Engineers, acting with the approval of Deputy Commissioner Hanson, to straighten out the kinks of the law and to do two important things. The first was to rip the mask of the law from the pseudo-low-pressure boilers, and the second was to obtain recognition for the ability of steam engineers to handle power other than steam. The increasing use of current from commercial electrical companies in large cities, particularly in hoisting plants, and the consequential discarding of boilers and discharge of licensed engineers and their substitution by laborers whose hands are untrained in the art of lifting, all combine to present a problem which engineers must solve with legislation. The Voss bill was an attempt to solve it so far as New York City was concerned.

The bill provided for the annual report of owners, agents, lessees, etc., and the inspection of every engine or engines, irrespective of motive power, in addition to the previously stated steam boiler or boilers, by the Sanitary Company. The company, as heretofore, to limit the pressure "or power to be applied to such engine or engines, irrespective of motive power." The certification of inspection to be precisely the same in all cases and the fee for inspection to be the same.

It will be noticed that these amendments would give the Sanitary Company practical supervision of the power in New York, as it states "irrespective of motive power," be it electrical, gas, gasolene, hot air, in addition to its present control of the high-pressure steam plants. The amendments are frankly directed at the control of hoisting engines where electricity is used.

In this connection, it might be pertinent to inquire the amount of expert knowledge the police department possesses of motive power other than steam. Its bureau of electrical service, consisting of 107 men, with 10 exceptions all patrolmen, operate 2000 miles of special police wires and make all repairs and maintain the electric light and power of the department.

It has even been said that there are inspectors in the Sanitary Company who are not practical engineers. A careful investigation failed to find one who had not a certificate as a licensed engineer, obtained before he entered the department, and the records of the bureau show that each man in touch with the practical work of the bureau passed an examination before the examiners on his ability as an inspector when he was drafted into the bureau. Further, each man has had his qualifications for the position certified to by three citizen engineers of good standing in New York.

It is in fact remarkable how many engineers, boilermakers and steamfitters are to be found among patrolmen. Recently ten were required to operate the harbor flotilla of gasolene launches. Thirty-five were drawn from the force and sent to the bureau for examination. A number were rejected as having no experience in that line of work, stationary men mainly, and 10 were sent to the harbor squad on probation. All of the 35 had certificates showing good standing as engineers, obtained, necessarily, before entering the department.

To continue with the bill, the amendments to section 343 exempted vehicles and chartered railway locomotives or boilers not carrying over 10 pounds of steam and "not having more than 6 square feet of grate surface," and here is where it hit those operating such plants, "or to operate any engine, irrespective of motive power, exceeding 10 horsepower," without a certificate. The remainder of the section ran as formerly, and at its conclusion the following addition, brought the crafts that ply around New York, under the supervision of the bureau, and in that way, under the engineers of the city:

"This section," it stated, "shall also apply to and include the operation and use of all boilers and engines in vessels used on the waters in the city of New York, not coming under the jurisdiction of the United States Government."

This refers to derricks, scows and non-passenger and nonfreight carrying boats, solely, for a later amendment eliminates motor boats, gasolene launches, etc., used privately.

New Ordinance under Way

The failure of this bill to win a favorable hearing at Albany, followed immediately afterward by the killing of Dr. Niles previously referred to, and the Schreyer decision were the motives for the drafting of a new ordinance for the regulation of low pressure boilers to be submitted to the board of aldermen. That the police department had no jurisdiction over boilers used for generating steam for heating purposes, regardless of the size of the boiler, had been the decision in the court of special sessions, April 29, 1909, in the case of John Schreyer, of 343 Central Park West.

At this address is a 20-family apartment house. The boiler is 12 feet long by 3 feet in diameter. Since 1902 it had been a licensed high-pressure boiler subject to annual test and inspection. But in 1908, Schreyer decided to run the boiler at low pressure. John Adams, found operating the plant without a license, was summoned to the West Side court and held for trial in the court of special sessions for violating section 343 of the charter. He was promptly discharged by that court, it being decided that the charter does not authorize the police department to examine boilers in private dwellings, although the danger of the 20 families arising from the combination of an unlicensed engineer running an unlicensed boiler was explained.

The ordinance as drafted by Lieutenant Breen and being considered by Deputy Commissioner Hanson for final draft and presentation, is as follows:

"All boilers used for generating steam for heating purposes in the city of New York are hereby placed under the jurisdiction of said police department which is hereby authorized and empowered to test said boilers. Such tests of boilers shall be conducted in accordance with the provisions of the Greater New York charter and laws of the State of New York as are applicable to boilers provided for in said charter and laws.

"The provisions of this ordinance shall not apply to the use of steam boilers for generating steam for heating purposes in any private dwelling which shall be intended or designed for, or used as, the home or residence of not more than two separate or distinct families or households. A violation of this ordinance is a misdemeanor."

It is expected that if passed the ordinance will be beneficial in two distinct ways. It will prevent the owners of large apartment houses from taking advantage of the Schreyer decision and run their boilers independent of engineers or inspections, and it may afford a chance to examine and bring under the system of the bureau the class of men now operating the low pressure plants, with the probable formation of a fourth-grade engineer authorized to run low-pressure plants only.

It is conceded by the bureau that to force an owner of a low-pressure plant, in a building where the rents are not high, to employ a licensed engineer of the third grade is a hardship. For the operation of these low-pressure plants a class of oilers, firemen and general assistants who have not completed their time for the third-grade certificate, might be secured, examined and attached to the bureau, and the same system of monthly reports and annual inspection be extended to them.

Cast Iron Fittings and Superheated Steam

By John Primrose

Articles have been appearing in engineering papers and manufacturers' publications in which superheated steam has been charged with being responsible for the failure of cast-iron fittings, and for trouble due to leaky valves in steam-pipe connections. In cases where there has not been time nor opportunity to investigate thoroughly, the result has been rather to militate against the use of superheat, and in many cases people have been afraid to avail themselves of the increased economy and other advantages of superheated steam. Statements to the effect that all cast-iron fittings and valves must be replaced by cast steel, if superheated steam is to be used safely, are most unfortunate at the present stage of development of superheated steam in this country, because the popular knowledge of the subject is such that the effect of such a statement is to picture untold troubles of all kinds with the steam equipment for which no possible increase in economy would be a recompense. It is a pity to block an advance in steam economy of such undoubted value unless, of course, there is some real danger in the way.

In a number of cases cast-iron fittings through which superheated steam was passing failed in various ways, and the conclusion arrived at was that superheated steam weakened the metal. The complete lack of a satisfactory theory or reason why superheated steam should weaken cast iron and make fittings and valves made of that material dangerous arouses suspicion of the correctness of the conclusion. Test bars were carefully cut from some of these fittings and the breaking strain compared with what it should be for an average run of iron. The metal of the broken fitting showed, in some cases, but half the tensile strength, and the conclusion arrived at was that superheated steam passing through a fitting reduced its tensile strength at least 50 per cent. The logic whereby the conclusion is obtained is not apparent. The fitting was evidently weak, otherwise it would not have failed; so that nothing has been learned by breaking test bars. Further, cast-iron fittings have been failing in saturated-steam lines since the metal was first used for the purpose, easily accounted for by the well known difficulty of making homogeneous castings and the difference in the tensile strength of castings from the same heat. It is not remarkable, then, that several cast-iron fittings have failed when passing superheated steam, and the cause is much more likely to be the original weakness of the metal rather than the effect of superheat. Cast-iron fittings carrying a fluid so far removed from superheated steam as water have been known to decrease in weight and fail in different ways. Certain it is that cast-iron fittings have failed in many ways before the advent of superheated steam in this country, and it seems unreasonable that a few subsequent failures should be considered proof that superheated steam is injurious to cast iron.

One manufacturer of cast-steel fittings has made elaborate tests, exposing cast-iron flanges to varying temperatures from 500 to 800 degrees Fahrenheit, for a number of weeks. The effect on a flange 12½ inches in diameter was to increase the diameter $\frac{1}{32}$ of an inch. Upon this is based a theory that a molecular change in the metal has resulted, the increased volume indicating loss in tensile strength, and that possibly the carbon silicon and phosphorus contents of the metal are so affected by the temperature that the strength is impaired. There are very many reasons why this latter is scarcely possible, but assuming for the sake of argument only that cast iron does "grow" and lose strength at these varying temperatures, why condemn superheated steam? If superheated steam were allowed to vary in temperature to any such extent as these tests, the damage to fittings and valves in the steam line would be quite inconsiderable compared with the difficulties in operating the engines or turbines.

Constant temperature is essential to economical operation whether saturated or superheated steam be used, and it is quite possible with properly designed superheaters to keep a temperature within 10 degrees either way of a determined point, or a maximum variation of 20 degrees. It is quite true that in some cases superheaters have been so designed that the temperature fluctuates and troubles have followed, but the troubles with the pipe-line fittings have been the least of these, and the cause has been not the temperature due to superheat, but the fluctuations in temperature due to the design of the superheater, in the same way that a fault in the design of a boiler, engine, or condenser is likely to be heard from.

So much has been charged against superheated steam that an investigation was started to find out what the people of most experience in the use of superheat in this country and abroad had found out concerning the effect of superheated steam on cast iron.

In Europe superheaters are always a part of a power plant of any importance and superheated steam has been in common use there for more than thirty years. If, in the few years during which superheated steam has been used in this country such destructive characteristics have developed, the Germans with their thirty years of experience ought to be in a position to tell us about it. A well-known German engineer was recently in this country, and the matter was brought to his attention. He was interested and surprised that he had not learned before of the effect of superheated steam on cast iron and promised to look the matter up on his return home. He has since written that he could not find anything in their engineering literature to bear out this contention, or anyone who believed that such a thing was possible This engineer's experience with superheated steam extends over twenty-five years or more and shows that highly superheated steam—600 degrees Fahrenheit—has no effect on cast iron. He uses fittings of gray-iron castings, except where the government specifications insist upon cast steel. The government insists upon cast steel at times, but with regard to the pressure of the steam rather than to the temperature, and is not influenced by the steam being saturated or superheated.

Investigations in England, where superheaters have been used for a much longer time than in this country have resulted in much the same information. A member of the engineering staff of one of the steam-users' associations corresponding to our insurance and inspection companies writes that he "has not found any reduction in strength of either cast iron or steel due to temperatures obtained in practice." As in Germany, cast steel is used for fittings above certain pressures, but it is because of the pressure and not at all because the steam is superheated. Different steam-users' associations in England have been consulted and they have all agreed that superheated steam does not weaken cast iron in their experience.

In this country there exist many proofs of the fallacy of the theory that superheated steam weakens cast iron. A number of superheaters built entirely of cast-iron pipes and headers were installed in 1901—eight years ago. These superheaters are located in the settings of Babcock & Wilcox boilers above the first pass of tubes, directly in the path of and surrounded by gases at 1000 to 1200 degrees Fahrenheit. These superheater tubes are, of course, cooled by the circulation of the steam at 175 pounds pressure, and superheated 150 degrees, but must be considerably hotter than the temperature of the steam, or than the usual temperature of cast-iron fittings, in steam lines distributing the superheated steam. These superheaters are still in successful operation and have cost nothing for repairs. About two years ago it was necessary to move one of the units containing one of the superheaters. The superheater had to be taken apart and was carefully examined. Absolutely no evidence existed of any deterioration in any way and the superheater was reërected in the boiler and went together as easily as when first installed. The superheater tubes are 7½ inches inside diameter, 12 feet 6 inches long, made of good gray iron, care being taken to secure sound castings. The people who built this superheater have changed the design of the superheater tube somewhat, although retaining cast iron as the best material to meet the hot gases and have installed upward of 1,000,000 horsepower of superheaters, and except in a very few isolated cases have used cast iron for all fittings connecting the superheater to the boiler and its various sections to a common outlet. Some of these fittings are in contact with hot gases, being inside the boiler settings, and have been in service since 1901. In not one single instance has trouble been reported in any of these fittings which could be traced in any way to the effect of superheated steam, and this company still continuous to use cast iron for all fittings and considers it to be the best material for the purpose.

The result of investigation at a plant where a large cast-iron fitting showed signs of weakness, and superheated steam was charged with being to blame, is interesting in this connection. The plant consists of 32 water-tube boilers arranged in two decks, 16 on the upper floor and 16 below. A steam header connects the boilers on each side of the upper boiler room and these headers come together in a tee at the end of the boiler room. This tee has an opening looking down which connects with a larger tee below, taking the steam from each side of the boiler room on the lower floor. The main steam line to the engines carrying all the steam generated starts from this tee. The large tee taking steam from the upper and lower boiler-room floors was the tee that failed. It showed surface cracks and was distorted. Investigation disclosed that only 14 of the boilers on the upper floor were equipped with superheaters, and that these superheaters were good for but 75 degrees of superheat. The superheated steam from these 14 boilers was mixed with the steam from 18 boilers furnishing saturated steam containing the usual percentage of moisture, so that the steam at the tee which failed could not have been superheated more than 30 degrees, and even the most ardent critics of superheat insist that more superheat than this is necessary to bear out their arguments. Further investigation disclosed other interesting facts. All of the fittings on the boiler and superheater outlets were of cast iron. The fittings on the boiler outlets downstairs (saturated steam) were all affected in the same manner as the large tee just described. The fittings on the superheater outlets upstairs (superheated steam) showed no such effect. The explanation is evident. The large tee most seriously damaged was subjected to varying temperatures, and consequently continually changing strains, due to the mixture therein of superheated steam with steam containing moisture. The fittings passing saturated steam only were probably attacked by some impurity in the feed water, while the fittings passing superheated steam escaped because all of the moisture was evaporated in the superheater and in this way were protected against the injurious action of the saturated steam. Here is a complete reversal of the situation, and yet this particular case has influenced many persons against superheat.

In addition to all this evidence exonerating superheated steam, and in order to be sure that at temperatures proper for use in engines and turbines it could have no possible effect on cast iron, a prominent foundryman, himself engaged in manufacturing steel fittings, and a well known metallurgist were consulted. Samples cut from cast-iron fittings on the inlet (saturated) and outlet (superheated) connections of a superheater in use for more than five years and superheating steam to 550 degrees Fahrenheit, were photographed under a microscope and carefully examined. The opinion of these experts is that there is no reason to expect any graphitic change in the iron at temperatures less than 700 degrees Fahrenheit. The only graphitic change which would seem possible in the metal would be the changing of graphitic to combined carbon, which would result in the hardening of the metal, slightly increasing its tensile strength. It is customary, in annealing furnaces to use a temperature in excess of 900 degrees Fahrenheit to produce any effect in gray iron. Micro-photographs taken of samples from the center of the cross-section of the inlet and outlet fittings showed no more difference in the amount of carbon present than would be expected at different points in the same cross-section, proving that there was no change in the carbon conditions by reason of superheated steam. Photographs of the edge of the polished cross-section were also examined, showing the close-grained iron which always occurs near the outlet surface, due to chilling contact with the sand in the mold. Here again the experts report no change in the condition of the carbon by reason of exposure to superheated steam. Photographs were also taken of the polished surfaces after being etched with acid of different samples from inlet and outlet fittings, but examination showed no effect of superheated steam.

The foregoing statements evidently prove that something more than superheat is necessary to destroy cast-iron fittings. Unusually high temperatures (it is possible to convey steam superheated as high as 1200 degrees Fahrenheit, and it is being done in this country) undoubtedly need special treatment, but for the ordinary steam-power plant the best results are obtained by superheating the steam to a final temperature not exceeding 500 degrees and in designing the superheater to maintain a closely constant temperature. At this temperature and under these conditions no ill effects need be feared from cast iron fittings, nor any other parts of the equipment. Sudden variation in temperature, or changes from superheated steam to steam containing large quantities of moisture are bound to result in troubles of all kinds, but the design of the superheat is to blame.

Efficiency

By F. L. Johnson

Someone had written an inquiry about the amount of water needed for the condensation of steam, and my thoughts turned toward general condenser problems. As I pictured in my mind one jet condenser after another, I dwelt longest on the one designed by Charles T. Porter. In his design there was a cone-pointed plunger running under water all the time, and attention has often been called to the point on the end, ascribing to it the cause of the quiet operation of the air pump.

As the plunger was submerged all the time I could not see that the shape of the end had anything to do with noise or lack of it. I could not understand that as long as the plunger was submerged it would matter whether the end was convex, flat or concave, and I was on the point of hunting up someone with fixed convictions as to the necessity of a pointed plunger in the Porter air pump when my friend Sawyer quietly entered. Handing me a cigar and a match, he said:

"I did not come in to stay long, for I shall be in the city a week or more and will see you often during that time. As I came down Broadway this morning I failed to see the wave-motor exhibit and that made me anxious to show you some sketches of wave motors that I attempted to elaborate during the first three or four years of my life in the East.

"The clotheslines, fence posts, sheave pulleys and cider barrels that traveled from our neighborhood to the beach at the end of the gas-house road to be used in the construction of wave motors would fill a junk shop. With my companions I built wave motors of all grades and types and every one of them would 'mote,' but they one and all lay right down as soon as any work was put on them; they took up a whole lot of room and worked to the 'queen's taste' until the load was put on. They seemed to lack in efficiency, and that reminds me that I recently attended a lecture on the subject of efficiency.

MAKING O'SULLIVAN HEELS FROM A NEW PUMP VALVE

"It was along slightly different lines from what I expected, as it related entirely to the efficiency of the human drudge, instead of the steam or gas engine, as I had hoped. But I do not think the time spent listening was entirely lost, for as the speaker described his particular plan for getting a big increase in the work done by a man for a small increase in the sum paid in wages, I could not help thinking of how he would tackle the modern power plant, how he would rate the different men employed and how he would decide which one of the many operatives was a man of one hundred per cent. efficiency.

"His talk was a description of one of the numerous different profit-sharing schemes which have been introduced in many manufacturing plants in the country, and if his program is applicable in one industry it should be in another. In the central station power is the product to which each worker contributes. Coal, water, oil and brains are among the articles of consumption and all are bought as cheaply as possible.

"Now, the question that bothered me all the evening was, how would the efficiency of the various brain purveyors in a steam plant be determined, for each worker is supposed to have enough intelligence to follow the lines of correct practice in small if not great emergencies. Of three or four subordinates in an engine room, each of whom attends to the same number of oil holes, wipes the same number of engines and polishes an equal area of bright work, can one show that he is more efficient than another?

"Then, at times a man is paid merely for being present in the plant, to be ready, like a cold chisel or a monkey wrench, for use if needed. How will such a man raise or lower his efficiency?

"In passing through the basement of a steam plant one day, all alone, I saw a man whose work at that particular hour I knew to be that of waiting for a signal to start the auxiliaries to a turbine. He was working at something. I looked over his shoulder to see what he was doing. He was making a pair of O'Sullivan heels for his shoes from a new pump valve. As the lecturer had said something about the question of efficiency being a moral one, I wondered how the moral attitude of the man who took supplies, which were bought for the purpose of keeping the plant in running order, for his private use affected his efficiency. And I would like to know, if I could, to what extent the economical practices of the amateur cobbler reacted on the efficiency of the man who lacked one valve the next day when he started to put a pump in order.

"In the discussion which followed the lecture, I put the question up to the speaker. He dodged it by saying that no man should be blamed for stealing if the opportunity occurred, provided he did not steal time that belonged to the employer, and that the management and not the men were responsible for petty thievery about a plant. These were not the exact words, but they convey the idea that he expressed. I did not ask any more questions, but I got a rather hazy idea of the lecturer's opinion of what constituted morality, when he stated that under his system wages could never be cut, but he admitted that they might under some circumstances be readjusted.

"Do you know that in all of the schemes that I have looked at (and they are not a few) for the betterment of conditions the viewpoint seems to be that of the owner and proprietor, and if anything comes to the men it is incidental and not a part of the original program? Unsightly but practically dustproof wood clothes closets are replaced by expanded metal lockers which allow more dust to settle on and into a man's street coat in a day than would be collected in a sea-of ordinary exposure on the primitive peg on the wall that satisfied my father. In these days of hustle and concentration my father's engine room, with its tallow-pot cylinder lubrication and red lead and hemp manhole gaskets, is pointed at as the horrible example of how things used to be before our day of the 'survival of the fittest.' I have noticed some differences that the molded gasket and the ready-to-wear packing salesmen overlooked.

"My father lived in his own house, were all-wool clothing and leather shoes, and ate good food, while his successor in the new engine room, with everything up-todate from the brass-bound, multiported valve engine to the expanded-metal locker through the meshes of which may be seen the premium lunch box, lives on a rented shelf in the side of a brick cliff, wears shoddy clothes and paper-soled shoes, and eats adulterated food.

"But I did not run in here to take up your time preaching discontent and I will cut it out right now, if you will tell me the difference between the rating of a boiler and its capacity."

THE MAN WHO LACKED A VALVE THE NEXT DAY

I said that I understood that the rating of a boiler was its capacity for doing work under prescribed or conventional conditions of grate area and draft, while its capacity may be made almost what is desired by varying the grate area and draft. Just here an inventor of a rotating-engine valve, which would never wear shoulders on itself or the seat because it traveled the same way all the time, was shown in and Sawyer, with just a hint of a wink, went out.

The California State association of the National Association of Stationary Engineers will hold its sixth annual convention during the week of June 14 to 19, inclusive, in the Auditorium, Page and Fillmore streets, San Francisco. In conjunction with the regular convention arrangements have been made to hold a mechanics' fair. The main floor of the Auditorium has been subdivided into booths which have been leased to all the great manufacturing firms doing business on the Pacific coast.

The Fuel Question in Texas

The question of fuel is a grave one in many parts of Texas. There is probably not a State in the Union where so many experiments are being carried on and where the methods of firing change so often as in Texas. Crude oil is preferred in the majority of places and seven out of twelve plants visited were equipped to burn oil—at the right price. But the price of oil in Texas is as changeable as the weather in Cleveland. In fact it is believed by many that a certain man in Cleveland has a great deal to do with the price of oil in Texas, but this was strenuously denied by an oil man with whom I talked the other day. Just at present the price of oil is soaring and this may or may not have some connection with the automobile full of Standard Oil money which was unloaded at the State capitol building at Austin a few days ago. Uncle Sam's big fine did not stick, but they do things differently in Texas. Perhaps Texas will pay it back in the long run. At any rate oil is up just now and several of the oil-burning traction plants are preparing to change back to coal.

Oil buying is a great gamble and the traction manager who can get in right at just the psychological moment can show beautiful decreases in his operating expenses as long as the contract holds good, but if his contract happens to expire at the wrong moment he is likely to find himself in a bad fix.

They say that the Chinese invented the idea of burning crude oil. At any rate the Chinese idea of selling goods has been adopted in selling oil. The Chinaman figures that if you buy a little, you don't need it very badly, but if you want a great deal of anything it shows you need it badly and the price increases correspondingly. It is so with oil in Texas. The oil man told me that the price on one car that day was 62 cents at the wells, but on a 100,000-barrel order the price was 88 cents. He explained that the price was regulated by the demand, and that usually the demand was greater than the supply. The benevolent oil company aims to let everyone have a bite; hence if you want a large supply you have to pay more for it. He also explained that some of the big steam roads were still buying under contracts made several years ago at around 27 cents, and the oil people shed tears every time they load a barrel of oil for this road. To make up for it, the people who want big supplies these days have to pay $1 and in some localities $1.25 for the same product. New fields are constantly being opened up and the price frequently fluctuates from 50 to 90 cents in a day or two. So the traction operator who burns oil usually sleeps with a ticker alongside of his bed. The oil man said that one barrel of oil was equal to one ton of coal, hence it was better to pay as high as $1.60 per barrel for oil than $5.50 per ton for coal, which is the price of good lump and slack in some portions of the State. A number of roads figure that $1 for oil is about the breaking point.

The best coal used in Texas comes from the McAlester district in Oklahoma. It is cheap at the mines, but the freight rates bring it up to from $4 to $5.50 in the southern part of the State. McAlester coal deteriorates rapidly when exposed to the air and is subject to spontaneous combustion if stored in large piles, so that it is difficult and undesirable to store it in large quantities.

The power stations at Temple and Austin are arranged to burn either oil or lignite. Lignite is a half-grown coal found in that immediate neighborhood. It shows fixed carbon 25.2 per cent., volatile matter 46.2 per cent., ash 9.5 per cent. and moisture 19.1 per cent., and it has a specific gravity of 1.32. It costs 75 cents at the mine, or $1.30 delivered at Temple, and in steam-producing properties it requires about 1.8 tons of lignite to equal 1 ton of McAlester coal. There is little ash and no clinkers, but the item of labor is largely increased on account of its free burning properties. The ash produced is high in acid and must be removed frequently.

At Abilene they burn lignite mixed with a high-grade oil, while the company at San Angelo uses lignite in a gas producer and uses the gas in a gas engine. The company at Texarkana has its plant arranged for either natural gas or crude oil and at present uses gas.—George S. Davis in *Electric Traction Weekly.*

Society for Promotion of Engineering Education

It has been decided to hold the seventeenth annual convention of the Society for the Promotion of Engineering Education at Columbia University and Pratt Institute, in New York and Brooklyn, on June 24, 25 and 26. These dates immediately precede those of the meetings of the American Institute of Electrical Engineers, the Society for Testing Materials and the American Society of Civil Engineers, and New York City is very near the geographical center of the meeting places of these three other societies.

An unusually attractive program has been arranged which will include the report of the joint committee of engineering societies on engineering education, by Dugald C. Jackson; a report of the committee on technical books for libraries, by Arthur H. Ford; a report of the committee on engineering degrees, by William F. M. Goss; a report of the committee on entrance requirements, by Robert Fletcher; besides contributed articles.

Real Relation of CO_2 to Chimney Losses

In Which Is Shown How Unreliable Is the Percentage of CO_2 in Determining Chimney Losses without Considering Hydrogen, CO and Moisture

BY JAMES E. STEELY

There has been considerable work done recently relating to the economic combustion of coal, and it is possible that the average engineer is led to believe that to secure a high economy it is necessary to get a high percentage of CO_2 in the flue gas. Under a very few conditions a high CO_2 and a low flue-gas temperature will indicate a high economy or at least a low chimney loss, but it is not to be supposed that these factors always indicate such a condition. It is an easy thing to get a continuous record of both the temperature and the percentage of CO_2 in the flue gas, as continuous recording machines are on the market, some of which will give as accurate an analysis as could be obtained with an Orsat apparatus. However, the fact seems to have been overlooked that while the percentage of CO_2 is a very desirable thing to know, it cannot be used with certainty in calculating chimney losses, and in most all cases it affords only a crude approximation, while in many it is 20 or 30 per cent. off the true loss.

Proximate and Ultimate Analyses

In spite of modern educational advantages the ordinary engineer has not the chemical foundation so helpful in the managing of a boiler house, and a little time devoted to the explanation of some boiler-house chemistry will no doubt be well spent. When a sample of coal is sent to a chemist for analysis, two reports usually come back with it as follows:

Proximate Analysis

Moisture	3.74
Volatile combustible	41.96
Fixed carbon	42.89
Ash	11.41

Ultimate Analysis

Hydrogen (H)	4.61
Carbon (C)	[illegible]
Oxygen (O)	[illegible]
Nitrogen (N)	0.87
Sulphur (S)	0.20
Ash	16.42

The proximate analysis is a sort of an arbitrary one. The moisture is the moisture or water in the coal. The volatile combustible is those gases which distil off when the coal is heated without access to air. This comprises all the hydrogen, some carbon and part of the sulphur.

When the coal is fired the volatile matter distils off first and burns with a long flame. If insufficient air is present or if the flame hits a cold surface such as a boiler tube, smoke is formed. Thus it will be seen that continuous firing, as with automatic stokers, would keep a little of these volatile gases coming off all the time, while hand firing would distil off a large quantity of combustible gases at once, which would only partly burn, thus causing loss and smoke. The remaining substance is nearly pure carbon mixed with the ash. The combustible in the ash and refuse from the boiler is also carbon. The hydrogen, nitrogen, part of the sulphur and oxygen have been burnt or distilled off.

Chemical Elements in Coal

In the ultimate analysis there are a series of chemical elements. Hydrogen is a combustible gas, but it exists in coal as a complex hydrocarbon. When the coal is heated it distils off as CH_4 or marsh gas. In burning, hydrogen combines with one-half of its volume or eight times its weight of oxygen, and as oxygen exists in the air to the extent of about 21 per cent. by volume or 23 per cent. by weight, the amount of air necessary for its combustion can be calculated.

Carbon is an amorphous solid which can burn to CO using 16 weights of oxygen to 12 of carbon, or it can burn to CO_2 using 32 weights of oxygen to 12 of carbon. The former is a combustible gas and is the principal constituent of producer gas, while CO_2 is the final product when CO burns as well as when the carbon burns completely.

A hydrocarbon is a compound consisting of hydrogen and carbon, which may be gas, a liquid or a solid. When a hydrocarbon burns with insufficient air, the hydrogen burns off and deposits the carbon as soot. This also happens if the flame is cooled.

Oxygen is a noncombustible gas, but it is the best known supporter of combustion. It exists in the coal in combination with the carbon and hydrogen, but exists in the air in a free state in the proportions previously given.

Nitrogen is noncombustible and does not support combustion. It is the most inert of the elements. It exists in the form of a gas and the air contains 79 per cent. of it by volume and 77 per cent. by weight. In the coal it is found in combination with the carbon and hydrogen.

Sulphur exists in coal as sulphide of iron or pyrites and also as sulphate of lime. The sulphur as sulphide will partly burn off. When sulphur burns it combines with an equal amount by weight of oxygen, forming SO_2. This is an acid when mixed with steam or water and will rapidly corrode iron and many metals. The ash in coal is the noncombustible mineral matter.

Mention might be made of chemical symbols and statement of chemical reactions. For abbreviation chemists use a kind of shorthand for representing elements. Thus the letter H represents the element hydrogen; C, carbon; S, sulphur; N, nitrogen; O, oxygen; CH_4, a hydrocarbon, etc. Now, when carbon burns as previously stated, it unites with oxygen to form CO and CO_2. This would be represented as follows:

	C + O = CO
Parts by weight	12 + 16 = 28
Parts by volume	– ½ 1

or

	$C + O_2 = CO_2$
Parts by weight	12 + 32 = 44
Parts by volume	. 1 1

The weights represent the combining weights of the elements and the volumes represent the volumes used or formed, as found by applying the well known law of Avogadro.

Theoretical Combustion

Combustion proper may now be treated from a theoretical standpoint, using the figures 21 per cent. by volume of oxygen and 79 per cent. of nitrogen as the composition of air.* If pure carbon was burned with the correct amount of air, a mixture of nitrogen and CO_2 would be obtained, which would analyze nitrogen 79 per cent. and CO_2 21 per cent. by volume, as oxygen in combining with carbon forms its own volume of CO_2. This is impossible under furnace conditions, but if there were nothing else in the coal and it were burnt, the percentage of CO_2 and O would always add up to 21 per cent. by volume, and the per cent. of CO_2 could be used accurately to determine chimney losses. However, there are a large number of reactions which take place, all of which remove the CO_2 farther and farther from the true indication.

Taking some of these reactions up separately, the effect of each can be seen. When hydrogen burns, it forms water, or steam if the temperature is above 212 degrees Fahrenheit. If pure hydrogen were to be burned with air in the exact amount, the resulting gas, when cooled, would be 100 per cent. nitrogen, as the hydrogen

*To be more exact it is 20.9 and 79.1.

would combine with all the oxygen and form water when the sample cooled. The same thing happens when the hydrogen in coal burns. When the flue-gas sample is taken, the steam condenses and the analyzed sample shows a slightly higher percentage of CO_2 than is really in the flue. Taking a coal with 75 per cent. carbon and 5 per cent. hydrogen, the flue gas, using theoretical amounts of air, would analyze as follows:

Steam by volume	0 69 per cent.
CO_2 by volume	20 59 per cent
Nitrogen by volume	78.72 per cent.

The sample which the chemist would get would analyze.

CO_2	20 73 per cent.
N	79.27 per cent.

on account of the condensation of the steam. This error, however slight, is actual, and the higher the percentage of hydrogen in the coal or fuel, the greater it is. Any steam moisture in coal or water put in the fire will also serve to dilute the chimney gas, but will not interfere with the calculation of the heat losses except insofar as it uses up heat in raising the moisture to the temperature of the flue gases. It will not cause error in the analysis of the gases actually caused by the burning of the coal. Even if it is decomposed by the fire, it will liberate the same heat as was used in decomposing it and also return to exactly the same amount of steam by weight.

The sulphur in the coal burns to SO_2, and this is easily absorbed by the potash solution which is used for absorbing the CO_2, thus tending to indicate a higher CO_2 than the true amount. CO also influences the result. Supposing that a flue gas containing 10 per cent. of CO_2, contains 0.2 per cent CO. The analysis of the CO_2 would indicate the following:

CO_2	10 per cent.
O	11 per cent.
N	79 per cent.

while the true analysis would be

CO_2	10.00 per cent.
O	10.88 per cent.
CO	0 2 per cent.
N	78.92 per cent.

These errors are ordinarily slight, but in extreme cases may be appreciable. They actually exist, no matter how carefully the CO_2 is determined.

Actual Analyses Show CO_2 Erratic

Taking some actual results and working out the losses, the percentage of CO_2 may be shown to be very erratic. The following two analyses were made by the U. S. Geological Survey at the fuel-testing plant in St. Louis. The coal used was New Mexico No. 1, and both samples were taken during the same test at different times:

Sample 1.		Sample 2.	
CO_2	8.7	CO_2	10.1
O	10.4	O	8 6
CO	0 0	CO	2.1
N	80.9	N	79.2

From the percentage of CO_2 it would be reasoned that Sample 2 was very much better, i.e., the chimney loss much less. The coal analyzed as follows:

	Combustible.	Coal.
Carbon	78.5	70.77
Hydrogen	5.51	4.97
Oxygen	14.01	12.63
Nitrogen	1.28	1.15
Sulphur	0.70	0.63
Ash	.....	9.85
	100.00	100.00

The ash and refuse analyzed: Carbon, 42.98, and earthy matter, 57.02, or 7.42 per cent. of the original combustible. Correcting the combustible in the coal for this, the theoretical analysis of the combustible as burnt is obtained as follows:

Carbon	76.96 per cent.
Hydrogen	6.04 per cent.
Oxygen	15.33 per cent.
Nitrogen	1.29 per cent.
Sulphur	0.38 per cent.

Supposing one-half the sulphur remains in the ash. Now, to burn one pound of this would require the following quantities of air:

0.7696 lb. carbon to CO_2	8.9196 lb. air
0.0604 lb. hydrogen to H_2O	2.1007 lb. air
0.0038 lb. sulphur to SO_2	0.0164 lb. air
Theoretical amount of air	11.0367
Correcting for oxygen in coal	0.6665
Theoretical amount of air	10.3702

This combustion would produce 11.3702 pounds of flue gas of the composition by volume as follows:

	By Volume.	By Weight
CO_2	16.88	24.80
CO	.....	.....
O	.....	.....
SO_2	0.13	0.28
Steam	7.96	4.78
Nitrogen	75.03	70.14
	100.00	100.00

On a dry-gas basis it would analyze:

CO_2	18.44
SO_2	0.14
N	81.42
	100.00

Since the SO_2 would be estimated as CO_2, add the SO_2 and CO_2, and call it CO_2. This would give,

CO_2	18.58
N	81.42
	100.00

It would be well to compare this with the original analysis and thereby note how the errors due to hydrogen and sulphur affect the CO_2 percentage. But in the analysis given the percentage of CO_2 was only 8.7. Calculating to this basis, the theoretical analysis of the gas is:

CO_2	8.7
O	11.0
CO	....
N	80.3
	100.0

This is almost identical with the analysis given.

Taking the other sample, or No. 2, 17.48 per cent. of the total carbon burns to CO. Thus we would have:

0.6371 lb. carbon to CO_2	7.3839 lb. air
0.1325 lb. carbon to CO	0.7685 lb. air
0.0604 lb. hydrogen to H_2O	2.1007 lb. air
0.0038 lb. sulphur to SO_2	0.0164 lb. air
	10.2695
Correcting for oxygen in coal	0.6665
Theoretical amount of air	9.6030

This would produce 10.603 pounds of flue gas of the composition:

	By Volume.	By Weight.
CO_2	14.22	21.23
CO	3.09	2.93
N	74.09	70.37
SO_2	0.15	0.31
H_2O	8.45	5.16
	100.00	100.00

On a dry basis this would be by volume:

CO_2	15.54
CO	3.37
SO_2	0.16
N	80.93
	100.00

On adding the CO_2 and SO_2 the percentages by volume would be:

CO_2	15.70
CO	3.37
N	80.93
	100.00

Figuring this down to the 10.1 per cent. CO_2 basis would give:

CO_2	10.1
CO	2.2
O	8.1
N	79.6

This also compares favorably with the original. In figuring the gas to a lower CO_2 percentage, the calculated amount of air is added, thus introducing some oxygen. The above will show how the errors compensate one another, so that the actual error might not be great in some cases. However, if the above gas still had its steam in it, the percentage of CO_2 would be 9.6 per cent. by volume instead of 10.1 per cent.

Heat Losses

The heat losses, which are more important, will now be given attention. Taking Sample 2, the analysis of the diluted gases by weight would be something like the following:

CO_2	13.71
CO	1.90
SO_2	0.19
H_2O	3.33
N	45.43
Air	35.44
	100.00

One pound of fuel would produce 16.31 pounds of flue gas. To make one pound of this mixture would require 0.938 pound of air. Supposing the air to be 72 degrees Fahrenheit and the flue gases to be 600 degrees Fahrenheit, the heat balance would be somewhat like the following:

	B.t.u.
Total heat in 0.1371 lb. CO_2 at 600° F.	16.89
Total heat in 0.0190 lb. CO at 600° F.	2.66
Total heat in 0.0019 lb. SO_2 at 600° F.	0.16
Total heat in 0.0333 lb. steam at 600° F.	44.60
Total heat in 0.4543 lb. N at 600° F.	62.73
Total heat in 0.3545 lb. air at 600° F.	47.80
Total heat above 32° F. in 1 lb. flue gas at 600° F.	174.84
Total heat above 32° F. in 0.938 lb. air at 72° F.	8.91
Loss due to hot flue gas	165.93
Loss due to unburnt CO	83.50
Total heat lost in 1 lb. flue gas	249.43

Calculating the heating value of the combustible from the theoretical analysis, gives 13,615.55 B.t.u. per pound, and as 1 pound makes 16.31 pounds of flue gas, the heating value of the amount necessary to make one pound of flue gas would be:

$$\frac{13,615.55}{16.31} = 834.8 \text{ B.t.u.}$$

As 249.43 B.t.u. are lost in the chimney, the loss in fuel would be 29.88 per cent.

Taking up Sample 1 and treating it in a similar manner, the diluted flue gas will analyze by weight,

CO_2	11.63
SO_2	0.13
H_2O	2.24
N	33.79
Air	52.21
	100.00

This mixture requires 0.959 pound air to make one pound. Taking the temperatures as in Sample 2, the following heat balance is obtained:

	B.t.u.
Total heat in 0.1163 lb. CO_2 at 600° F.	11.28
Total heat in 0.0013 lb. SO_2 at 600° F.	0.11
Total heat in 0.0224 lb. steam at 600° F.	33.01
Total heat in 0.3379 lb. N at 600° F.	45.38
Total heat in 0.5221 lb. air at 600° F.	71.78
Total heat above 32° F. in flue gas	161.56
Total heat above 32° F. in 0.959 lb. air	9.10
Total heat lost	152.46

One pound of fuel makes 24.26 pounds of this gas, therefore the heating value of the fuel required to make one pound of flue gas is 561.2 B.t.u., and the loss in fuel in this case would be 27 per cent.

The reader has no doubt noticed that in these two cases the highest economy was obtained with the lowest CO_2. If the sample with the highest CO_2 had been free from CO, the loss would have been but 18.06 per cent., or over 10 per cent. of the total fuel. This is an error of over 50 per cent. in what would be calculated from the CO_2 percentage alone. The fireman is urged to get a high CO_2. He gets it, but how much CO does he get along with it? His CO_2 determinations tell him he is saving 10 to 15 per cent. or more fuel, but possibly the complete analysis might show that he is merely adding to his losses.

Some types of boiler setting cause more loss and lower CO_2 than others. Thus, if the gases are cooled below the temperature at which combustion takes place before they are completely burned, there will be low CO_2 and some CO loss. At the St. Louis fuel-testing plant samples were taken of the gas over the fire and the gas at the rear of the combustion chamber. The analysis in test No. 360 are given as follows:

	Over Fire	Rear of Combustion Chamber
CO_2	6.1	11.4
O		7.1
CO	17.6	
H	1.3	
CH_4	2.8	
Other hydrocarbons	0.3	

Thus it will be seen that it is possible for a low CO_2 to be the cause of the boiler setting, and that it would be impossible for the fireman to raise it, and to see anything of the enormous loss of fuel attending.

Some may say that the examples given above are extremes. It may be true, but how is it known whether a certain case is an extreme or not? If the percentage of CO_2 is known and the percentage of CO is known, then the remainder of the analysis can be calculated from the analysis of the coal as above. If this article is followed carefully it will be seen how unreliable is the percentage of CO_2 when used alone, to calculate chimney losses. When a boiler test is made and the heat balance made up, the loss due to hydrogen in the coal and to the CO formed is always taken into consideration as well as moisture in the coal and the steam admitted into the fire. While these last two items add to the chimney losses, the only loss is the heat required to raise them up to the temperature of the flue gases.

Catechism of Electricity

1061. *Describe a modern direct-current generator of moderate or large output.*

Figs. 294 and 295 show two modern types of direct-connected generators, the former a 100-kilowatt machine with its field-magnet frame split vertically at a and c, while in the latter is a 250-kilowatt machine with the field-magnet frame split horizontally at v and x. In both cases the halves of the frame are provided with flanges at the joints to facilitate bolting them together. The magnet poles are built up of sheets of soft annealed steel and pressed together under pressure, after which they are bolted in place. The bolts as shown at d, Fig. 295, pass through the yoke and are fastened by lock washers on the outside; they are threaded and screwed well into the pole pieces, so as to give them a firm hold. The bolted-in pole construction allows the removal of any one of the field-magnet poles and its coil without disturbing any other part of the machine. The magnet pole-tips are spread to give a better commutating field under the pole tips and the extensions serve to support the field-magnet coils.

The shunt coils S, Fig. 295, and the series coils s are separately wound and insulated; an air space is provided between them for cooling purposes. The series coils are forged copper conductors of rectangular section carefully insulated. The shunt coils are machine wound and are taped and treated to make them moisture proof.

The brush-holder mechanism is carried by brackets mounted on a rocker ring l, Fig. 294, concentric with and carried on a machined seat on the front end of the field-magnet frame. As no part of the supporting ring projects over the commutator face, the brush holders and com-

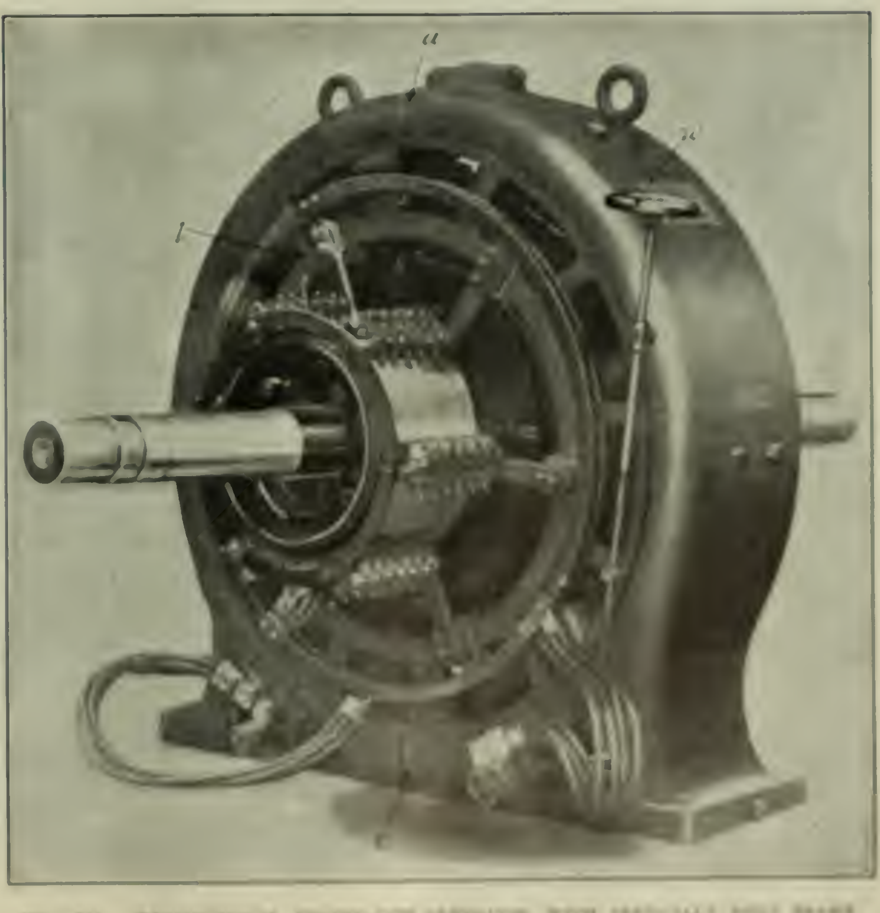


FIG. 294. WESTINGHOUSE ENGINE-TYPE GENERATOR, WITH VERTICALLY SPLIT FRAME

FIG. 295. FIELD FOR WESTINGHOUSE ENGINE-TYPE GENERATOR, WITH HORIZONTALLY SPLIT FRAME

mutator are readily accessible at any point. The rocker ring is operated by the hand wheel *w*. Copper-plated carbon brushes are used, and all brushes of the same polarity are maintained at the same potential by means of equalizing connections.

1062. *Why is it necessary to use equalizing connections in order that the brushes of the same polarity may be of the same potential?*

In the operation of large multipolar direct-current machines with parallel-wound armatures, such as the one being considered, it is difficult to secure exactly the same magnetic strength in all the field-magnet poles. Consequently, the potential generated in the conductors under one pole sometimes exceeds or is less than that generated in the conductors similarly situated under another pole of the same polarity, the result being a slight difference of potential between brushes of similar polarity which cause currents sometimes of considerable magnitude, to flow from one brush to another and from one section of the armature winding to another, attended by annoying and wasteful heating of the conductors and sparking at the brushes.

1063. *Explain the method used to correct this.*

A number of points in the armature winding which should be normally of equal potential are connected by leads outside the winding, through which currents may pass from one section to the others with which it is connected in parallel. These currents circulate through the armature conductors and are alternating in character; they lead or lag with reference to their respective electromotive forces, and thereby increase or decrease the strength of the field-magnet poles automatically so as to produce the necessary balance between them.

1064. *Do the equalizing connections serve any other purpose?*

Yes; they are advantageous in reducing any excess of magnetic pull on one side of the armature, should it get out of center by wear of the bearings, and also prevents the sparking which would be caused under such a condition, by the inequality of field-magnet strength due to the difference between the airgaps on opposite sides of the armature.

1065. *Are not the magnet poles of large direct-current generators sometimes cast into the yoke frames?*

Yes; some manufacturers employ this method of construction in all of their machines. Fig. 296 shows a six-pole belted direct-current generator of this construction. The base, field-magnet frame, magnet poles, all of one pedestal and part of the other pedestal are cast in one piece. The upper part *a* of the pedestal at the commutator side is a separate casting, but with this exception the entire frame is a single casting.

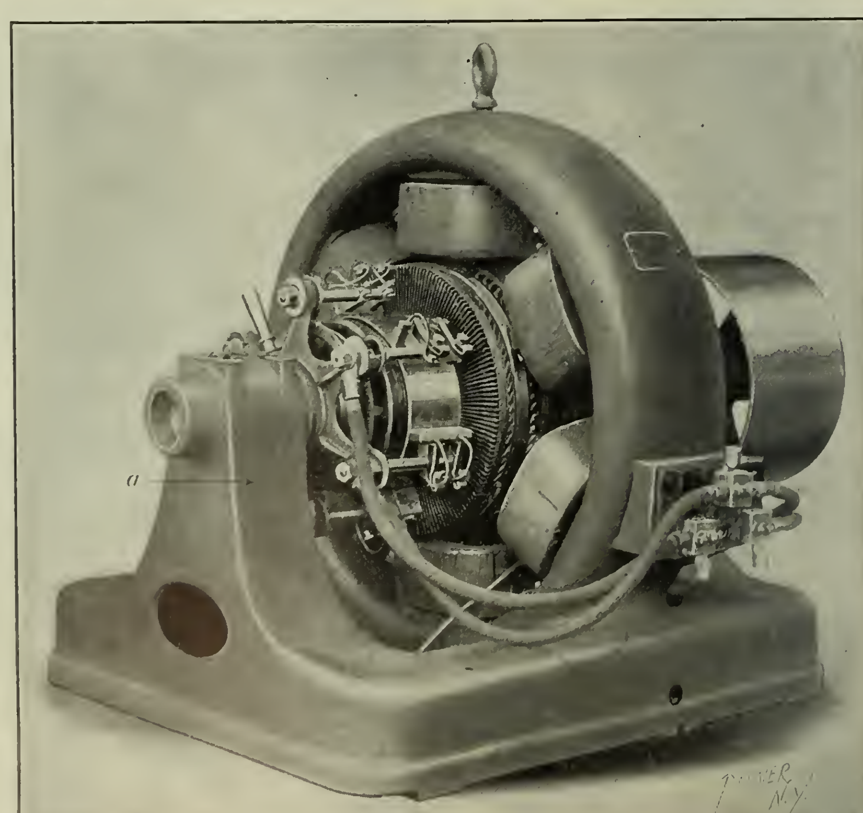


FIG. 296. FORT WAYNE BELTED MULTIPOLAR GENERATOR, WITH POLE PIECES CAST IN WITH THE FIELD FRAME

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Inaccuracies of Indicator Diagrams

The article entitled "Inaccuracies of Indicator Diagrams," which appeared in the March 16 number, recalls some experiences not entirely satisfactory. I have used the spring calibration apparatus described in that article and have sometimes had trouble to hold the desired pressure steady owing to vibrations of line or exhaust pressure. To avoid this annoyance and enable attention to be concentrated on the work of calibration, I designed the combined weight table and regulating valve shown herewith.

Before steam is turned on, the plunger occupies its lowest position in the cylinder and its two ports register with the counterbore A, Fig. 1. When steam is admitted to this space, it surrounds the plunger, thus balancing the pressure on all sides. Passing through the ports, the steam flows down through the hollow plunger and into a reservoir on which the indicator is mounted.

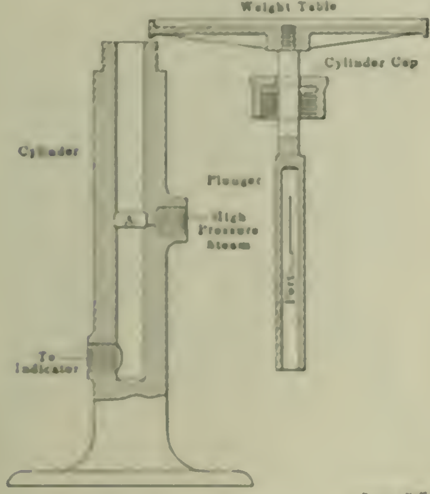


FIG. 1. REGULATING VALVE FOR INDICATOR-SPRING TESTER

The pressure rises until it is sufficient to push up the plunger, but as in doing the ports tend to pass beyond the counterbore and thus cut off the steam. Cutoff would actually occur were it not for the reduction of pressure due to condensation and leakage at the indicator. In its working position the valve remains open an appreciable amount in order to make up for these losses.

To prevent "hunting," it is desirable to make the cutoff as gradual as possible. This is accomplished by making the necessary port area of such shape that its dimension in the line of plunger travel is very large in comparison with the other dimension. Under these conditions, a given movement of the plunger will produce a minimum change of port area. The area required for initially raising the pressure is provided by the great length of port which is uncovered when the plunger occupies its lowest position.

To increase the pressure at the indicator, the proper weights are placed on the weight table, thus causing the plunger to descend. This produces a large port opening and consequently the desired pressure is promptly reached.

The lowering of pressure in the reservoir would be slow if dependent upon condensation and leakage; to obviate this, a pet cock on the reservoir is opened and the result is quickly obtained.

FIG. 2. COMBINED WEIGHT TABLE AND REGULATING VALVE

To secure records with rising pressure, it is necessary only to open the indicator cock *slowly*, thus preventing a "kick" of the indicator mechanism with probable overtravel of the pencil. To make a diagram with falling pressure, we proceed as follows: After placing the proper weights on the weight table, press it down with the hand for an instant, thus causing an excess of pressure. A gradual drop to normal will then follow as the result of leakage and may be hastened by use of the pet cock.

In the apparatus described, the plunger was finished [illegible] inch in diameter and the ports were cut with the thinnest available milling cutter 1/64 inch thick. The removal of condensation is conveniently provided for by a Durham trap.

On account of the smallness of the ports and the close fit of the plunger, I have found it desirable to protect the apparatus from damage due to scale and dirt by a strainer and settling chamber. Fig. 2 shows the apparatus connected up with an indicator.

J. B. Faulks, Jr.

Syracuse, N. Y.

Eccentric at Ninety Degrees

In regard to W. E. Crane's article in the March 30 number, I do not wish to discredit his statement, as he claims to have had experience, but when he says he can get a three-quarter cutoff with the eccentric set 90 degrees ahead of the crank, it needs some further explanation to show how he does it, as it looks to me like a physical impossibility.

Neglecting the angularity of the connecting rod, suppose we start with the engine on the center and the eccentric 90 degrees ahead of the crank. It is plain that the eccentric will reach its extreme travel at one-half stroke, after which it will be impossible to get a cutoff, as the trip lever will be moving away from the cam; consequently, the valve cannot be tripped off.

L. [illegible]

Concord Junction, Mass.

Hydraulic Information

Referring to the inquiry of William E. Piper, in the April 6 number, I presume Mr. Piper refers to miner's inches for the quantity of water mentioned, and without stating the miner's inch used the quantity is a little indefinite.

A number of western States in the last few years have passed laws legalizing a flow of $1\frac{1}{2}$ cubic feet per minute as a miner's inch, or 1 cubic foot per second to equal 40 miner's inches. In this section a miner's inch of 9 gallons per minute, 1 cubic foot per second, equalling 50 miner's inches, has been used by engineers for a good many years and is yet used more than the legalized miner's inch.

However, figuring on the legal miner's inch, 360 inches would be equal to 540 cubic feet per minute, and with a 150-foot fall would be equal to 153 theoretical horsepower. Allowing for loss in the pipe line and the efficiency of the wheel, it probably would not be practical to deliver more than 75 per cent. of this power to the generator, and if an automatic governor was applied to the wheel, it might be well to figure on not over 70 per cent., which would be equal to about 105 horsepower. For this head and quantity of water I should recommend an impulse wheel of the Pelton type, and about a 20- or 22-inch riveted steel pipe line. If the quantity of water is as stated in the foregoing, this would easily handle one thousand 16-candlepower incandescent lamps.

G. A. Reichard.

Los Angeles, Cal.

By reducing his available water supply to miner's inches, where 1 square inch of opening under a 6-inch head equals 11.655 United States gallons per minute, Mr. Piper has 180 inches, or 2097.9 gallons, or $279\frac{2}{3}$ cubic feet per minute. Now, as he has a fall of some 140 feet, 500 feet from proposed location of his plant he can figure the volume of water giving approximately 80 horsepower at the falls, using an 8 inch wheel at 1262 revolutions per minute.

As the velocity in feet per second for a distance of 500 feet should not exceed 2 to 2.2, it would be necessary to use a pipe of not less than 20 inches diameter for carrying the water from the falls to the plant. With this size pipe, the velocity and volume of water, he must allow 0.140 foot as a loss of head by friction in pipe for each 100 feet in length, or a total of 0.7.

As regards the grade of pipe to be used, I suggest that he use the best spiral riveted pipe, as being the most durable and economical for this class of work. As for the style of wheel best adapted for the conditions he enumerates the inward-flow turbine would be better than most any other form. This wheel has what is known as double-curve buckets, first inward then downward, thus retaining the water until it has received practically all of its initial power, and it will deliver at least 5 to 7 per cent. more efficiency than the outward-flow style of wheel, which receives its water near the axis, thence flowing outward through curved blades and delivering in an almost radial direction.

What is known as the impulse turbine is practically the best turbine yet devised, especially for great hights, say from 250 to 350 feet, or over, but for falls much lower than this they are not much more efficient than the inward-flow turbine. The impulse wheel depends for its energy solely upon the velocity of the water directed by means of a nozzle, or a set of nozzles, against a series of blades or vanes arranged on the periphery of the wheel, and the buckets or blades never stand full of water, as in the case of the first two wheels described.

Allowing about 20 per cent. of the estimated horsepower for friction of machinery, belts, pulleys, etc., and for loss of efficiency through his circuits of current distribution, Mr. Piper can figure safely on eight hundred and ninety 16-candlepower lamps.

J. L. Bradshaw.

Memphis, Tenn.

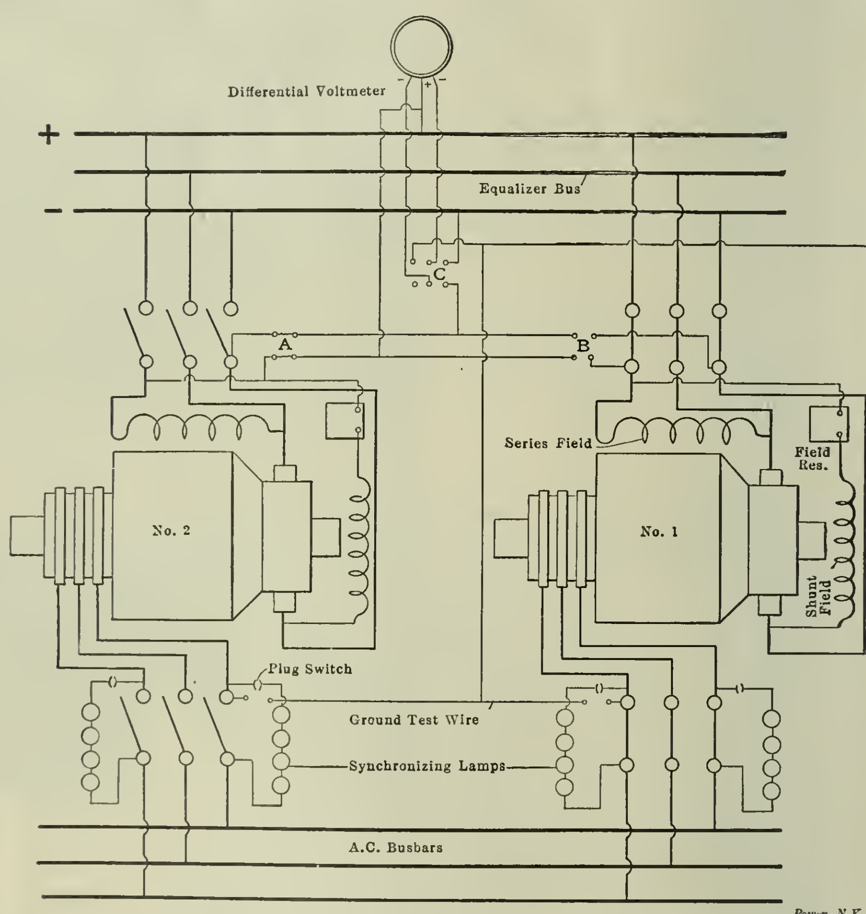
In the April 6 number, William E. Piper asks for hydraulic information. Assuming that he is speaking of miners' inches regarding the flow of water, the power which could be developed by a wheel should be in the neighborhood of 145 horsepower, which is capable of carrying approximately one thousand seven hundred 16-candlepower lamps, after making due allowance for generator and transmission losses. It would require a 20-inch wood-stave pipe and a wheel of either the modified Francis or impulse type.

Henry D. Jackson.

Boston, Mass.

A Peculiar Synchronizing Trouble

In the issue of April 20, there is an article entitled, "A Peculiar Synchronizing Trouble," by C. L. Greer. As I understand the conditions, he has, when plug *A* is in place, a circuit through the main line, through No. 1 rotary to the direct-current busbar, through switch *A* to No. 2 rotary, the plug switch and line, so that under these conditions he will get a blinking of the synchronizing lamps. The reason they probably burn at greater brilliancy than normal is because when the machines are not in synchronism, the voltage may be additive, making a considerably higher than normal voltage across the lamps. I should judge that at the time No. 2 rotary was thrown in, the machines were out of



CONNECTIONS OF ROTARY-CONVERTER INSTALLATION step, and probably directly out of step, that is, the voltage of No. 2 was added to the line, thereby putting far too great a voltage on the switch at *A* and temporarily unbalancing the entire system, putting too high a voltage on the direct-current side of the circuit, making No. 1 and No. 2 flash over.

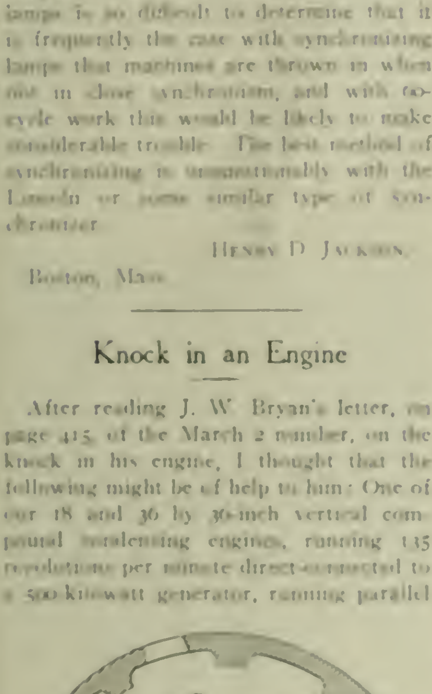
Synchronizing by lamps is by no means as satisfactory as synchronizing by voltmeter. It takes a very short time to get used to the lag in the voltmeter, and after a little practice no difficulty will be found in bringing the machines up to synchronism and putting them on the circuit. The dark period with lamps is so long and the actual dark period of the lamps is so difficult to determine that it is frequently the case with synchronizing lamps that machines are thrown in when not in close synchronism, and with 60-cycle work this would be likely to make considerable trouble. The best method of synchronizing is unquestionably with the Lincoln or some similar type of synchronizer.

Henry D. Jackson.

Boston, Mass.

Knock in an Engine

After reading J. W. Bryan's letter, on page 415 of the March 2 number, on the knock in his engine, I thought that the following might be of help to him: One of our 18 and 36 by 36-inch vertical compound condensing engines, running 135 revolutions per minute direct-connected to a 500-kilowatt generator, running parallel



WHAT CAUSED THE KNOCK IN THE ENGINE

with another engine, was shut down all right one night for the following morning, when started up, it had a knock or click something like Mr. Bryan speaks of, but at the head end only. As our load is varying, it would come and go at different loads, and would last for three or four revolutions, stop for awhile and then start again.

I came to the conclusion that the trouble was in the piston, and sure enough, after taking the cylinder head and follower plate off, I found the dowel or guide of the steam ring broken, as shown in the sketch; the ring was also badly worn. I put in a new ring and dowel. When everything was replaced and the engine started, the click was gone.

Thomas Sherman.

Pittsfield, Mass.

Safety of Pipe Fittings

In reply to the letter of I. A. Tenger, in the April 27 number, what I intended to say was that when the pressure on the under side of the valve bonnet equalled that due to the pressure caused by the screwing down of the cap screws, the pressure between the bonnet and the valve was balanced, or there was no pressure between them, unless it be such as is due to the weight of the valve bonnet and other parts supported by it.

Up to this point the steam pressure has been acting to relieve the pressure of the bonnet on the valve due to the tension of screwing down the cap screws, and until it equals this tension, or, more correctly speaking, exceeds it and tends to lift the bonnet from the valve body, there is no stress added to the initial stress on the screws, but when the steam pressure exceeds that due to the screws, by so much is the stress on the screws increased. Mr. Tenger, or anyone who doubts this, can very easily prove whether it be true or not, in the following manner: Secure two spring scales, of 25 pounds capacity, and suspend one of them from any convenient place overhead, attach a strong cord to the hook of the scale and tie a ring in the cord a few inches below the scale, put a screweye in the floor below the scale and pass the end of the cord through the eye and tighten until the scale shows 15 pounds, and make fast.

Now there is a stress or pull of 15 pounds on the cord between the scale and ring, which we will let represent the stress on the cap screws after tightening.

Take the second scale and hook it in the ring and pull down until it shows 10 pounds on the scale. If Mr. Tenger is correct in his statement that the two pressures should be added, the upper scale will now read 25 pounds, but if I am correct it will read 15 pounds, the same as before, and will continue to do so until a pull of more than 15 pounds is exerted on the lower scale, after which it will increase with the increased pull.

This is very plain if one stops to think how it acts. In the first place, the screweye and cord are sustaining a pull of 15 pounds and when a pull is exerted on the second scale hooked in the ring, it merely decreases the pull on the screweye and therefore adds nothing to the total pull, until it exceeds the pull which the eye sustained at first, 15 pounds.

Don't attach a 15-pound weight to the first scale, and then add a 10-pound weight and because the total then equals 25 pounds say I am wrong, for by doing so the conditions will be totally different from that of the valve bonnet and cap screws.

W. M. Perkins.

Bristol, Conn.

Dashpot Trouble

I have been greatly interested in the replies to Ellsworth Dale's appeal for assistance in connection with his dash-

SHOWING CAUSE OF DASHPOT TROUBLE

pot trouble. H. E. Scribner, in his letter on page 685, of the April 13 number, very frankly admits that he has failed to cure the dashpot at the head end of his engine of hanging up on a light load and causing consequent early cutoff with 125 pounds initial pressure.

On the high-pressure side of our cross-compound engine I had the same difficulty and did a number of things before I finally located the cause. In the meantime the working pressure was raised from 125 to 150 pounds, which, according to Mr. Scribner's theory, would make a bad matter worse. The dashpots of this engine are of the compressed type with the muffle case internally threaded and screwed down upon the externally threaded base, the threaded portion of the base has openings chipped with a "round-nose" chisel, across the threads from the vents in the lower cylinder of the pot. The threaded portion of the muffler case has similar openings, which, when the case is screwed home, are to coincide with those in the base, forming a passageway between the dashpot and the annular space inside the case. Investigation of the "bucking" dashpot revealed that the openings in the case were past those in the pot, enough to close the passages almost entirely, as shown in the illustration. New openings were made in the case and the dashpot works as well as the one at the crank end, although we are carrying 150 pounds pressure on an engine built for only 125 pounds.

M. E. Conway.

Alton, Ill.

What Would Happen If the Belt Came Off

In the issue of April 20, H. B. Adcock asks the consequence of an exciter belt breaking where two alternators are run in parallel, each having its own exciter, belt-driven from its shaft. The arrangement he describes would be a very bad one, as the alternator, deprived of its field charge due to the exciter belt breaking, or any other cause, would constitute a dead short-circuit on the other machine, and if not promptly disconnected by a fuse or automatic switch it would burn out one or both of the alternating-current armatures. A better arrangement would be to provide a direct-current busbar and connect both exciters to it, using a small breaker with a reverse-current release which would open in case one exciter failed to generate.

The alternator field coils should be connected to the busbar and a rheostat in its field to adjust its field charge, using the exciter rheostat to regulate the division of the load between the direct-current machine and to raise and lower the voltage of the alternating-current system as a whole.

Some years ago the writer operated a plant under conditions as stated by Mr. Adcock, except that the alternators were in stations a mile apart. The exciter of each machine was belted to its shaft and of course the distance prevented running the direct-current machines in multiple. After a burnout, due to a dog's tail being caught in the exciter belt and throwing it off, we installed automatic switches on the outgoing lines of each station, with reverse-current relays to open on heavy reverse current only. Fuses or overload breakers might have operated at both stations in case one machine lost its field charge, while the reverse-current relay would discriminate between heavy output or input.

Another experience of the writer was in a large two-phase light-tension station in New York City. The alternators were 750-kilowatt engine-driven units, operated in parallel and excited from a common busbar to which were connected four engine-driven 75-kilowatt exciters, without fuse or breaker. While in full operation and at the peak of the load the voltage of the system began dropping and the lights gradually went out, there being no flashing nor noise to indicate the cause. A hasty examination by lantern light showed that one of the exciters was not running but was acting as a short-circuit on the others, killing their fields. All the machinery was running at its normal speed, but all the voltmeters were down to zero and the system was "dead," the writer expected to synchronize and parallel all of these machines; but when the switch on the disabled exciter was opened, the lamp began to redden and the ammeter showed that the machines were pumping violently. After about a minute they steadied and the system became normal, the machines having forced themselves together with but four out of eleven becoming disconnected. The cause of the trouble was a valve disk which became loose from its stem and dropped onto its seat. The exciters were equipped with reverse-current breakers to guard against any further trouble.

LEWIS C. REYNOLDS.

Willard, N. Y.

Let us assume that the exciter of alternator *A*, Fig. 1, stops while both *A* and *B* are connected to the line. Then as the voltage of *A* decreases, current will flow from *B* through the busbars to *A*. The only impedance of this cross current is the synchronous reactance of the two armatures in series. Because of the high reactance, the current will lag strongly with respect to *B*, and have an equal lead with respect to *A*. This lagging current will react on the field of *B* and lower its voltage. At the same time the current

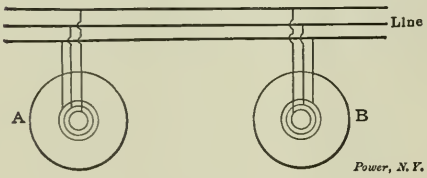


FIG. 1

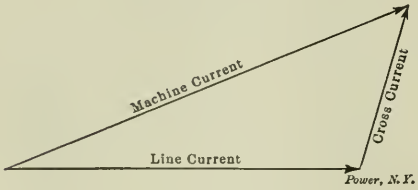


FIG. 2

through *A*, being leading, will induce a voltage in *A*. The result will be that both machines will divide and carry the load as before, but the line electromotive force will fall a few volts.

The current through the machines will be the sum of the line current and the cross current between the machine, Fig. 2. Since the cross current is nearly 90 degrees out of phase with the line, the total current through the machines will be increased only a few per cent. The cross current is so nearly wattless, that it means practically no loss of power.

The field of *A* may be even built up in an opposite direction to *B* and still carry load, but the cross current will be very heavy.

I have myself, tried this experiment and can vouch for its correctness.

EARL R. FILKINS.

Chicago, Ill.

I believe the plant would be thrown out of service, temporarily at least. The loss of the exciting current in one machine would prevent further generation of electromotive force by that machine. The two machines being connected to the same busbars would leave the armature windings of the disabled machine across the terminals of the live machine, therefore subjecting the latter machine to a short-circuit. Due to the resistance and self-induction of the winding of the disabled machine, I do not think the short-circuit would be of quite so severe a nature as though something of practically no impedance should fall directly across the terminals of an operating machine. The disabled machine would offer the impedance of its windings and with its field circuit being open would have, to a certain slight extent, an action quite similar to that of a transformer working with an open secondary. However, the self-induction of this winding would not be sufficient to prevent the flow of an abnormal current, quite comparable with that caused by a dead short-circuit. This rapid rush of current produces a condition in the live machine which would take it out of service.

As already stated, the current in the live machine rises to an abnormal value, and the first tendency of this suddenly rising current is to act on the voltage and flux of the machine. The induction of the winding is, however, greater than the resistance of the circuit; therefore, the resultant current caused by the short-circuit will be lagging and demagnetizing, and the effect will be immediately to pull down the flux and consequently the voltage of the machine to zero. The flux of the machine will be practically diminished although enough will be left to force full-load current or more through the impedance of the disabled machine.

After the switches controlling the disabled machine have been opened the remaining machine will immediately build up to full voltage and can be restored to the line. While all alternators should be able to stand such a performance it is undesirable, as short-circuits are racking on a machine and might result in displacement of coils or other disastrous effects.

J. A. LEES.

Quincy, Mass.

In the first place, unless the inductance of the machine is heavy, the machine which loses its field will take a very heavy current, and may cause trouble to it and to the other generator. The engine will probably tend to run away, but with a good governor this would not cause trouble. It might be that the poles of the generator without field might be sufficiently magnetized by the rotating field of the windings so as to operate as an induction generator. This, however, would be very unlikely. It would, therefore, appear that the principal trouble would be practically a short-circuit on the second machine.

HENRY D. JACKSON.

Boston, Mass.

Bracing Dome Heads

Referring to the article on bracing dome heads, on page 633 of the April 6 number, I should like to suggest another form of bracing for that part of the boiler shell to which the dome is attached.

As stated in the article, that part of the boiler shell surrounded by the dome shell is a neutral surface, that is, with equal pressure on both sides. The forces due to the internal pressure act radially, but the resultant forces will be on the projected area shown in Fig. 1. From this it will be seen that the tendency will be to distort the dome shell and cause a leaky joint.

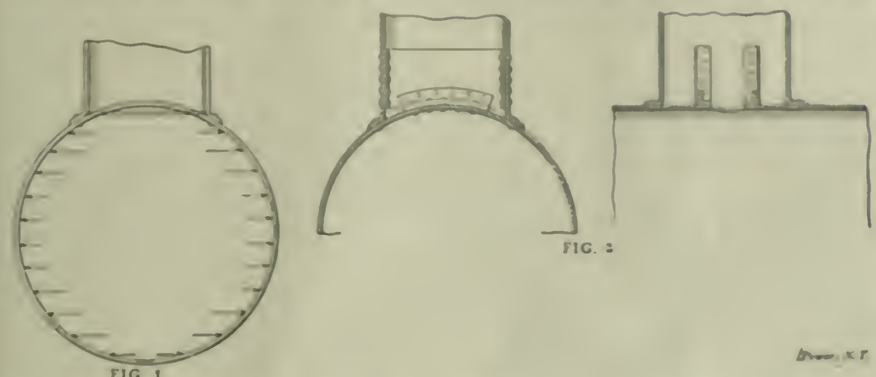


FIG. 1 FIG. 2

The most rational way to prevent such distortion and keep the original shape of the boiler would be to use a bracing such as shown in Fig. 2. It consists of a boiler plate riveted to the sides of the dome shell and an angle iron riveted to the lower edge, the angle iron to fit the outside of the boiler shell and bolted securely to it.

C. E. BOHMAN.

Auburn, N. Y.

Experience With Gas Power

On page 617 of the March 30 number, appeared an article by H. B. Messenger, giving an experience with gas power in displacing a steam plant driving a grist mill.

We have seen the statement in print that steam engineers are prejudiced against gas power, and that they are not fit for gas-engine operators. This may or may not be true, but it is certain that if engineers are opposed to gas engines it is up to them to run their plants so that there will be little gained in making the change. Gas-engine practice is not yet such an ideal proposition but what the average power-plant owner will require some very substantial reason for tearing out his steam plant and substituting gas power. Considering power alone, we know that even the best managed steam plant cannot compete with the gas engine in the way of economy, and in the case referred to it seems that the owner was well satisfied with the change.

The main reason for throwing out the 110-horsepower steam engine and substituting an 85-horsepower engine was lack of power.

In a mill like this the load would vary considerably, but to be on the safe side let us call it 85 horsepower continuously eleven hours per day. Half a ton of anthracite is used for the gas power, as against two tons of best Georges creek soft coal for steam, per day, at maximum load. A heat value of 13,000 B.t.u. would be a safe estimate for good soft coal. Now any engineer would undertake to put 65 per cent. of this heat into the boiler. As the feed water entered at "nearly the boiling point," let us say 210 degrees, it required about 1006 B.t.u. to every pound of steam and the evaporation would have been

$$\frac{13{,}000 \times 0.65}{1006} = 8.4.$$

pounds per pound of coal, or 33,600 pounds of steam in eleven hours, or about 36 pounds of steam per horsepower per hour. A "good automatic engine" would not fall down on this amount of steam if kept in good condition; besides, there was ample boiler capacity to care for occasional peak loads.

The saving in fuel is the difference in price between half a ton of anthracite and two tons of soft coal, but from this must be deducted the interest on the money paid out for the gas installation; still another deduction must be made for the coal burned during the cold season to heat the mill and office, evidently necessary judging from the fact that the gas-engine operator "comes into the office to get warm" at times. When everything is considered the saving may be so small that had the power not failed in the first place the steam plant may have held its own in this case, as it is likely to do in most places where the exhaust steam can be utilized at least six months of the year.

R. CUMMINS.

Gary, Ind.

Repairing a Center Crank

Reading Dennis Hanlon's letter, "Repairing a Center Crank," in the March 30 issue, page 600, brings to mind an old form of crank shaft that has been used in steam vessels in the merchant marine of Great Britain. While it is as "old as the hills," it may be new to many readers, and of value in such cases as Mr. Hanlon refers to. The accompanying sketch makes clear all that is requisite to an understanding of the idea.

Even under the most favorable conditions center-crank shafts have to endure severe stresses, and when the bearings wear out of line the stresses are intensified, so that it is only a question of time when something must yield. The crank in the sketch will yield and respond to ordinary inequalities met with in practice without breaking, as would happen eventually if the crank were solid throughout. The crank-pin connections are strong enough to transmit the power to the propeller on the end of the shaft. Why could not this form be applied to stationary work as well as to marine engines? It is all in the conical joint, which I think makes it a little better than the method adopted by Mr. Hanlon, although the surrounding conditions dictated his course of action to a great extent.

CHARLES J. MASON.

Scranton, Penn.

MARINE CENTER-CRANK SHAFT

Firing Boilers

The article which appeared in the April 6 number, by Victor White, is very interesting, viewed from more points than one. The working of boiler fires where there is any difficulty of getting steam is almost wholly a matter of practical experience. The rules are few and very elastic and it takes years of practice on different kinds of jobs with different kinds of coal to get them by heart. To learn firing by reading articles written thereon not only in periodicals, but in textbooks, is like learning to play the violin by carefully studying the make of the instrument and reading the tutor from cover to cover.

Taking a grate, say, 9 feet from the furnace door to the bridge and 3 feet 6 inches wide, Mr. White says eight or ten shovelfuls are sufficient. They are sufficient to stop the engine on the center on some jobs, but he does not mean it that way. Is this one of the rules of which he speaks?

A job where a man can fire heavily enough to get a quarter of an hour's spell and keep steam is not worth discussion. A man from the farm could do it with three days' apprenticeship. Any fireman worth his salt will tell you that he goes on duty to make steam, not fires. He resents any interference with the shape of his fires or whether they are light or heavy, and very properly, too, if the job is a stiff one, unless the engineer who interferes can show him that his way will also keep the steam.

The prime consideration in firing boilers is to raise steam, to prevent waste is a secondary one. Yet the whole trend of Mr. White's article seems to deal with the latter. Little information is proffered about the former, and that, in some instances, is very misleading.

A thin even fire is not essential in using small coal. He admits it, and treads very gingerly on his ground wherever he goes.

The lighter the load on the boiler the more can a man build up the fire until it is twice as heavy as it would be were the load at its heaviest. This would stop the draft struggling through so fast, and also keep the steam steadier, as the fire has more body. Frequent firing of slack coal on a thin fire acts like a flash in the pan, one moment a fierce heat, another moment all gone, with perhaps cold air struggling through a particularly thin place over the bars.

A very thin fire of 3½ or 4 inches, while necessary at times when the load is heavy, must be very carefully handled with the slice bar so as not to get the black coal upon the bars; if this occurs, goodby to the steam.

If a fire is dirty with clean hard clinker on the bars it is not necessary to slice this up every time the fire is sliced, only occasionally. When in the judgment of the fireman the draft is falling off, slice over the clinker and under the fire usually. If the slack coal cakes, don't break the slice right through to the boiler surface, but withdraw it when almost through the crust. This avoids mixing the fire up, getting black coal in between live char.

An easy job can be fired by anything in trousers, and it matters little what the shape of the fire is, level, piled up on the bridge, or like the waves of the sea, provided it is a fire and the load on the boiler is light enough.

To fire a grate, first one side and then the other might be an ideal way of causing smokeless combustion, but would it get the steam? According to Mr. White's statement the draft is the strongest through the least resisting places, therefore, the half of the grate not fired would get most of the draft. How much draft would the half get where he had just put the coal? Yet this is the side where it is most wanted. I assume he wants coal to burn or he would not have put it there.

Let us see if my way is the better one: Rake your fire on the slant, say, 3 or 4 inches at the bridge, slope up to 7 or 8 inches at the deadplate or even more if the heaviness of the fire warrants it; serve them all the same and then fire No. 1 boiler and don't throw any of the coal farther back than half way in the furnace, or say past the first set of bars. When all are fired, slice No. 1 boiler and then all the others in the same order, if the slice is necessary. Then glance at the steam gage and use your judgment as to the exact moment when the best results have been received from the sliced fires. Then rake again. When raking, however, notice which fire is lightest and always fire this one first, but try and get all of the same bulk.

If on a stiff job, never throw any of the coal into the back of the furnace, unless the coal is lumpy and a good wind is blowing and the draft is extra good; then a couple of shovelfuls extra may be thrown back. On no account throw dusty slack into the back of the fire if you would keep the steam up.

Don't fire too soon after raking, as this smothers a fire which is perhaps at its best, and take notice when raking if the fire feels hard and solid; if so, give it an extra slice up the middle and up each wing.

Mr. White takes a whole lot on his shoulders when he suggests that one man with a machine can do the work of four men firing by hand. I question very much the "entire satisfaction" and would like to know something more definite about the matter. Also, where is his authority for stating that when a boiler is taken out of action and not required again the proper course is to draw ash and clinker and quench them? Does he not know that this is a most prolific cause of tubes leaking? Would it not be better to leave the boiler shut up until the next day?

Let Mr. White give us the types of boiler which burn best with the different kinds of coal. I have fired with many kinds of anthracite from the big lumps on the west coast at Vancouver to all kinds of Welsh on different kinds of boiler, and have yet to find the long flaming coal.

W. Bowden.

West Toronto, Ont.

I have read the article entitled "Some Notes on Firing Boilers," by Victor White, which appeared in the April 6 number, wherein he conveys the idea that firing boilers is more a matter of practical experience than of theory. I should say that practice is applied theory, and when practice and theory do not agree it is because of the improper application of the theory. It follows from the universal law of nature that under the same circumstances cause and effect have the same relation, irrespective of time or place.

Regarding the subject of water in the ashpit, I believe that a certain amount of moisture in the coal is necessary for perfect combustion. Unquestionably there is a point beyond which the advantage ceases and, as stated, the loss would be that of superheating the steam at atmospheric pressure or thereabout.

I believe that the water is decomposed and the oxygen in the nascent state combines with the carbon with a considerably greater affinity than the free oxygen, whereas the hydrogen can combine with the oxygen in the free state with ease, the benefit being the combination of the precipitated carbon from the hydrocarbon gas distilled from the coal.

In general, smokeless combustion of coal is a problem that must be settled by applying the proper remedies for the particular characteristics of the firing. To my mind it is a function of three conditions: temperature, percentage of volatile matter and rate of combustion.

Raising the temperature means a shorter flame, large volatile percentage means a longer flame. The rate of combustion may mean a longer flame if the resultant temperature is not raised, or it may mean a shorter flame if the amount and distribution of the air are such as to satisfy the first requisite of high temperature.

The problem of designing a smokeless furnace is not so much a problem of furnace volume as it is of furnace length. Some fires give off a flame 20 feet long and should be reduced, and the baffles so arranged that the heating surface does not come in contact with the yellow flame, as this causes the precipitation of carbon, due to the cooling effect of the boiler tubes. This can be arranged for by using horizontal baffles on, say, a Babcock and Wilcox boiler, or by constructing a dutch oven of sufficient length to produce the same result. The air supply must be adjusted for every change in rate of combustion. The disadvantage of horizontal baffling, as is generally known, is due to the deposit of ashes on the heating surface.

An experiment with a bunsen burner will illustrate this. Suppose we allow the flame to burn yellow. The hydrocarbon gas loses its hydrogen first, in the process of combustion, and precipitates the carbon that at the resultant temperature renders it incandescent and hence luminous. Intercept this yellow flame with a cold piece of porcelain, for instance, and soot will immediately be deposited. The boiler presents a similar condition, and the soot will go up chimney, and we call it smoke.

Change the flame, by opening the holes at the bottom of the burner, and the flame burns blue. The cold porcelain will have no soot deposited on it, if placed in the flame. Were this to occur in the boiler, no smoke could possibly be formed. If it were possible to imitate the bunsen burner in boiler furnaces, we would have perfect combustion and a flame of no luminosity and absolutely smokeless.

In conclusion, one must not lose sight of the fact that heavy smoking is not a serious waste of coal, possibly not more than 1 per cent. The evil lies in its uncleanliness and the fact that its existence is so prominent.

ALPHONSE A. ADLER.

Brooklyn, N. Y.

In the April 6 number, Victor Wilson gives some good points on firing boilers. I do not agree, however, that a thin fire should be carried when burning small coal. It has been my experience to carry between 8 and 12 inches of fire to obtain the best results.

I had charge of a plant containing five boilers, each having 80 square feet of grate surface. When using bituminous screenings, we always carried 10 or 12 inches of fire, with good results. I do not believe that two men could have cleaned one of these furnaces in 10 minutes; in fact, it took just three hours to clean the five furnaces, and two men had to go some to do that and attend to the regular firing, as the boilers were generating about all the steam that could be got out of them with hand firing.

LOUIS B. CARL.

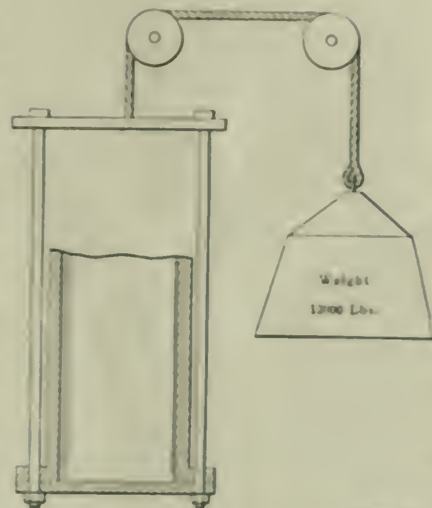
Marshfield, Wis.

Will the Load on the Bolts Change?

I once tried to follow the elaborate calculations of a very able writer who undertook to show in a similar case that part of the load, due to the pressure in the cylinder, is taken up by the bolts, causing additional stress in them, but I cannot say I was convinced of the truth of his figures. The way I look at the question is this:

Placing the cylinder in a vertical position and running the bolts on the outside of the cylinder, as shown in the accompanying sketch, will not affect the problem any. The weight will hold the head against the end of the cylinder, and at the same time produce the required stress of 1000 pounds in each of the twelve studs, as given in the problem.

The inside area of the head is given as 120 square inches and a pressure of 100 pounds per square inch, as set forth, will give a total weight or pressure of 12,000 pounds on the head.



Power, N.Y.

MR. CORRSBOOM'S SUGGESTION

Suppose we pile 12,000 pounds of scrap inside the cylinder instead of putting pressure on it, this weight of scrap resting on the head would represent the given condition, and being just sufficient to counterbalance the weight of 12,000 pounds, there is of course no additional stress on the bolts, only the original 1000 pounds apiece. If we have a ground joint or elastic packing between the flanges will not change conditions as far as I can see. When the pressure of 100 pounds per square inch is applied on the tank, the head will no longer be set up tight against the end flange, just merely touching the gasket and, as arranged in the sketch, a fraction of a pound added to the 12,000 pounds of scrap will cause the head to drop away from the cylinder entirely. If pressure was applied the gasket would blow out, as there is no compression to hold it in place. The studs themselves are elastic and of course will stretch a little under a load of 1000 pounds, and it may have been better to assume each one of the bolts to be a spring-balance scales registering 1000 pounds, but even then it is evident that the springs (studs) will not stretch any more, and consequently will not register any more until the load on the head exceeds 12,000 pounds. If the load should exceed 12,000 pounds the head will have a tendency to move away from the cylinder, the studs will stretch a little more and the additional load will show on the scales, but not till then.

B. CORRSBOOM.

Gary, Ind.

I should say that in the case of the ground joint the stress in the studs after the pressure has been turned on will be equal to the initial pressure, i.e., 1000 pounds, provided the bending of the flange of the cylinder head is neglected, as may be done in all practical cases, the design of the ground joint being assumed to be that shown in the illustration.

In the case of a joint with a gasket the stress on the studs will be the sum of the pressure of the steam plus the initial pressure on the gasket, i.e., 2000 pounds.

Although the problem is an impractical one, because the initial stress on a gasket joint should never be as high as the one on a ground joint, it leads to a very practical reflection on the screwing up of cylinder heads.

The most elastic medium holding cylinder and head tightly together with a ground joint is the body of the stud. The compression of the flange and joint of the cover may be neglected, as compared to the elongation of the stud, on account of their far greater sectional area.

Any pressure in the cylinder will decrease the pressure of the ground joint on its seat. In the case mentioned by Mr. Glick the pressure has been decreased to zero, and the least addition to the cylinder pressure would show a leak. It is, therefore, not practical to have the initial stress in the studs equal to the working pressure on the cylinder head, but about one-quarter more, and this addition should be taken into consideration when these details are designed. This initial stress once put on will remain unchanged, whether the cylinder is working or not.

The most elastic part in a gasket joint

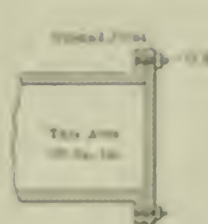
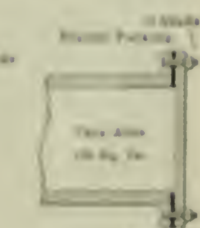


FIG. 1



Power, N.Y.

FIG. 2

(Exaggerated)

is the gasket, and the elongation of the studs and the compression of the flange may be neglected. Any pressure in the cylinder lengthens the studs, so little, however, that the expansion of the gasket on account of this elongation does not appreciably decrease the initial pressure on the surfaces of the cylinder and flange and, through the latter, on the nuts of the studs. Therefore, the cylinder pressure added to the gasket pressure is transmitted to the nuts through the flange of the cylinder head.

The pressure on the gasket remains constant and, therefore, does not need to be as high as the working pressure in the cylinder, as was the case with the ground joint, but about one-half of it. During operation of the cylinder the stress on the studs will vary from ½ to 1½ times the total cylinder pressure, a condition which should be admitted only when absolutely necessary.

If the cylinder heads in each of Mr. Glick's cases had been screwed on as herewith described the studs of the ground joint would have been submitted to a constant stress of 1250 pounds; the stress on the studs of the gasket joint would have been between 500 and 1500 pounds.

RULOF KLEIN.

New York City.

Interesting Indicator Diagrams

Under the above caption, Mr. Berry in the April 6 issue, stated in his opening paragraph that the diagrams "were taken from the same engine under the same conditions of working, but with different valve setting." If the engine is carrying the same load in each instance, then Mr. Berry must have made a mistake somewhere.

If one takes the trouble to estimate the mean effective pressure of the different cards, it will be found that there is actually negative work done in Fig. 2, representing the low-pressure cylinder before changing the valve setting; so that this would leave the total work, or useful power, to be developed in the high-pressure cylinder. The constant for this cylinder is about 3.04 which, with a mean effective power of 24 pounds (in illustration) gives 72.96, say, 73 horsepower.

Computing the power of this side of the engine again after changing the valve setting, we get a mean effective pressure of 19.6 pounds, which would give 59.5 horsepower. In addition to this there is the power from the low-pressure cylinder to be added. The constant of this cylinder is about 8.7, which with the mean effective pressure of Fig. 4, gives

$$6.4 \times 8.7 = 55.7$$

horsepower, or a total of

$$59.5 + 55.7 = 115$$

horsepower. Hence, there is a difference of

$$115 - 73 = 42$$

horsepower to be accounted for between the two different valve settings. Of course there can be no question but that Mr. Berry's final cards are an immense improvement over the first ones, but there are some of us in this neck of the woods who would like an explanation of the running conditions.

J. A. CARRUTHERS.

Bankhead, Alberta

An Engine Accident

As to the defects in the diagrams of Mr. Sheehan, page 562, March 23 number, I consider them fairly good. The cutoff could be made a little earlier in the head-end diagram of the low-pressure cylinder. This diagram has the largest area and the greatest horsepower, showing that the greatest amount of work is on the low-pressure engine, head end. The total horsepower developed is 299.45. The receiver pressure will be governed by the load on the engine and the terminal pressure in the high-pressure cylinder. I cannot see what effect the receiver pressure would have in relation to the breaking of the high-pressure piston rod at the root of the threads.

I believe this break was due to a defective spot in the piston rod. A Whitworth thread on a piston rod is preferable to the sharp V-thread.

The diameter of the piston rod of the low-pressure engine seems a little small. Surely 3½ inches or 3¾ inches would be considered better practice. According to the *Engineering Bulletin* issued by the University of Wisconsin the average diameter of a piston rod for a 30-inch cylinder of a slow-speed Corliss engine should be about 3⅞ inches.

Occasionally it becomes necessary to put all the load on the low-pressure side of an engine, possibly just for a day or two, until the broken parts of the high-pressure side are repaired, and it is at such times that a good-sized piston rod on the low-pressure side would not do any harm.

JOHN I. BAKER.

Allentown, Penn.

Leaky Discharge Valves in Air Compressors

W. E. Turner, on page 726, says that he "can hardly agree" with me that leaky discharge valves in air compressors are not a cause of abnormal heating of the air and consequently of explosions which occur in compressed-air pipes.

Mr. Turner says: "If on account of leaky discharge valves the intake, or suction valve on that end does not lift, is it not an evident fact that as the piston moves back and forth there is a continual displacement, or churning, of air going on?"

In that case the compressor ceases to be a compressor. If it heats the air it does not deliver it, or send it along into the discharge pipe. In an indicator card from an air compressor in normal condition, when the return stroke begins, the reëxpansion line drops to atmospheric pressure very quickly and for the intake stroke the line is slightly below the atmosphere, showing that the cylinder fills with free air to be compressed and delivered upon the next stroke, and yet we know that explosions occur with compressors which thus indisputably take in and deliver merely a cylinderful of air for each stroke.

Mr. Turner should submit some indicator cards from the alleged compressors in which the intake valves cannot and do not open, as he assumes, an account of the freaks of the discharge valves. I am not clear as to how the same air can remain and play back and forth in the cylinder and become intensively overheated and at the same time be flowing along the discharge pipe.

FRANK RICHARDS.

New York City.

Compound Engines

G. W. Harding has a letter on compound engines in the April 20 number. It seems that he has the wrong idea of compounding. He states: "If we have two cylinders with a high-pressure cylinder giving 100 horsepower and the low-pressure 100, we have a 200-horsepower engine." Then he asks: "If we remove the low-pressure cylinder, do we still have a 200-horsepower engine?" We certainly do not, but if we remove the high-pressure cylinder and apply the same pressure of steam to the low- that we did to the high-, and carry the expansions of the steam in this low-pressure cylinder through the same extent that we carried it in the compound engine, we would have a 200-horsepower engine.

It certainly is cheaper to build a 200-horsepower simple engine than a 150-horsepower compound; but there are other points to consider than first cost. The principal advantage of a compound engine lies in the reduction of loss due to the difference in temperature in the cylinder between admission and exhaust, doing away with cylinder condensation. There are other advantages and very large reduction in the size of the castings, etc., as the low-pressure cylinder has so much lower steam pressures to carry.

A compound engine cannot be made to do twice the work of a simple engine, if the simple engine has the same diameter cylinder as that of the low-pressure cylinder in the compound; but it will be more economical, whether running condensing or noncondensing. The addition of a low-pressure cylinder to a simple engine gives more power because it adds to the range of pressures through which the engine works economically, and also adds a larger surface on which the steam pressure may act.

HENRY D. JACKSON.

Boston, Mass.

Official Report of Coal Consumption Tests of the New Scout Cruisers

The Navy Department has issued the memoranda shown in the accompanying table of the recent coal-consumption tests of the scout cruisers "Birmingham," "Chester" and "Salem." The "Birmingham" is equipped with reciprocating engines, the "Chester" with Parsons turbines and the "Salem" with Curtis turbines.

The first test, at 10 knots speed, began at 9:30 a.m., March 21, and ended at 9:30 a.m., March 25.

The second test, at 15 knots speed, began at 9:45 a.m., March 29, and ended at 11:45 a.m., March 31.

The third test, at 20 knots speed, began at 1 p.m., April 3, and ended at 3 p.m., April 7.

The fourth test, at maximum speed, began at 10:45 a.m., April 12, and ended at 10:45 a.m., April 13.

As stated in the May 11 number, the "Salem's" turbines were examined at the Fore River Shipbuilding Company's works, subsequently to the tests, and the Navy Department states that the examination showed that the buckets of the fifth stage of one of the turbines were very badly damaged (as shown in the May 18 number), apparently by a bolt which came in contact with them and injured them so seriously as materially to affect the performance of that turbine. Other damage, more or less serious, was found in this turbine, and also in the other, apparently caused by lack of rigidity between the turbine casings and the thrust bearings. Some of the nozzles were also found in a condition which indicated that they had been injured by small pieces of the buckets or by material of some kind which had been left in the turbine in process of manufacture.

The Navy Department further states that these defects are all being made good by the Fore River Shipbuilding Company and upon their completion it is the intention to repeat the water-consumption tests of the "Salem," and these may be followed by coal-consumption tests on the "Birmingham," "Chester" and "Salem," but final decision on this point has not been reached. It is probable that the "Salem's" tests will not be made until after she makes a trip to the coast of Africa, to join the other scout cruisers and return with them.

A press despatch stated on May 22 that "the 'Salem' will probably stay at the yard of the Fore River Shipbuilding Company three weeks longer. The original repairs contemplated to the turbine have been practically completed. The Government has, however, ordered the nozzles on the turbines changed to the new improved pattern, such as are being used on the 'North Dakota.' Under the old style, when a nozzle were out or needed repairing, it was necessary to send the vessel to the navy yard and knock her engines down. By the improved pattern the old nozzle can be taken off and a new one put on inside of 10 minutes."

MEMORANDA OF COAL CONSUMPTION TESTS OF SCOUT CRUISERS "BIRMINGHAM," "CHESTER" AND "SALEM"

	Test No. 1, 10 Knots. Duration of Trial, 96 Hours			Test No. 2, 15 Knots. Duration of Trial, 50 Hours			Test No. 3, 20 Knots. Duration of Trial, 98 Hours			Test No. 4, Maximum Speed. Duration of Trial, 24 Hours.*		
	"Birmingham"	"Chester"	"Salem"	"Birmingham"	"Chester"	"Salem"	"Birmingham"	"Chester"	"Salem"	"Birmingham"	"Chester"	"Salem"
Mean displacement	3964	4040	4022	4002	3978	3964	3960	3974	4030.5	4030	3964	4029
Coal used, total tons	126.35	161.77	215.4	148.38	178.4	223.4	626.6	641.8	825.0	187.86	416.7	415.7
Coal used, tons per day	31.74	40.44	53.85	71.23	85.62	107.23	153.47	157.15	202.03	375.72	416.7	415.7
Revolutions per minute: Shaft No. 1	S.F. 73.92	S.F. 192.08	S.F. 138.22	S.F. 111.88	S.F. 293.65	S.F. 209.3	S.F. 149.81	S.F. 403.95	S.F. 282.3	S.F. 189.11	S.F. 558.1	S.F. 342.9
Shaft No. 2	P.A. 73.92	S.F. 216.02	P.A. 138.18	P.A. 111.96	S.F. 343.50	P.A. 209.33	P.A. 149.81	S.F. 410.1	P.A. 282.3	P.A. 189.88	S.F. 563.5	P.A. 357.5
Shaft No. 3		P.A. 215.72			P.A. 330.51			P.A. 462.17			P.A. [illegible]	
Shaft No. 4		P.A. 181.00			P.A. 281.43			P.A. 403.2			P.A. [illegible]	
Mean of all shafts	73.92	203.71	138.19	111.92	312.04	209.31	149.81	419.85	282.3	189.5	558.05	350.2
Revolutions per minute for that speed from standardization curve	74.00	203.00	139.7	111.90	312.30	210.6	151.25	422.00	281.5	24.00	25.08	24.32
Speed corresponding to actual revolutions taken from standardization curve	9.88	10.03	9.9	15.00	14.98	14.91	19.85	19.9	20.25			

*Due to accident, the "Birmingham" discontinued the test at 10:45 p.m., April 12, making the duration for this ship 12 hours instead of 24.

Good Record by a Suction Producer and Hit-and-Miss Engine

By Wesley E. McAmbel

Having seen in a recent number of Power a description of a producer plant, and observing that others are having experience along the same line as myself, I have jotted down a brief recital of some of the queer situations and conditions that I have encountered in a brief twelve months' experience with a producer outfit.

There is located in Brooklyn, a gas producer power plant which supplies light and power to a machine shop and a handkerchief factory, the latter requiring a very steady power; variations in speed are not allowable because every fluctuation shows up on the finished product. The machine-shop people don't care how fast it goes as long as it keeps going, as it is a comparatively easy matter to speed up or down a lathe or other tool.

The engine is of the four-stroke-cycle horizontal type, with a 24-inch stroke and a bore of 6 inches; it is rated at 60 horsepower. Hit-and-miss governing is employed with a semi-automatic intake valve. It drives a 45-kilowatt bipolar compound-wound generator, by a belt. The current, at a voltage of 118 to 120, is distributed all over the building, there being about 150 amperes devoted to the lighting circuits and about 200 amperes taken by the various motors.

The engine, before the advent of the producer, ran on city gas at an average cost of $225 per month for gas and half of the wages of an attendant (who put in a large part of the day on other duties), which was $60 per month, the other half of which was borne by the machine shop in return for various services rendered by him.

With the producer, we use 10 tons of pea coal per month, costing $41. The man in charge of the plant receives $84 a month and devotes half of his time to other duties ranging from putting a lock on a door to repairing an automobile. The saving is the difference between $225 plus $30 and $41 plus $42. This saving effected by the producer amounts to about $2000 a year.

One minor defect which we remedied was a tendency the vaporizer had to run dry; this resulted in gas deficient in hydrogen. A common tank with a ball float in it corrected this difficulty and we have forgot that the plant contains such a thing as a vaporizer.

When the charge was made to producer gas, the compression of the engine was increased from 90 to 145 pounds, and an air compressor was installed in conjunction with a moderate-sized tank to replace the old hand pump used to force a mixture of air and gas into the cylinder to start up. An interesting fact is that the engine can be started up at present on 130 pounds of air pressure in spite of the fact that the engine has a compression of 145 pounds. This is possible because the air is delivered to the piston throughout the full length of the stroke, while the maximum pressure of 145 pounds is obtained only at the end of the compression stroke.

It was also found expedient to dig a well and use a larger quantity of water in the scrubber, for the reason that with a one-inch stream running through the engine jacket, another just like it doing business at the scrubber, and the vaporizer getting its quota, the water bill was almost as great as the coal bill.

We altered the ignition system because fine particles of ash would be carried along with the gas and deposited on the steel contacts of the make-and-break igniter. We have no difficulty with the present spark plugs; the jump-spark coils are operated by storage cells charged from the house current and every time the timer wipes by its contact, we know we are getting a spark in the cylinder.

The plant is operated by one man with ease, his duties being light. He gets to work three-quarters of an hour before the factory has to be running. He rakes out the fire in the producer until he has a bed of about six inches of good hot fire on the grates. He puts on the blower (formerly a hand blower, but now operated by a ¼-horsepower electric motor), dumps in a charge of 50 pounds of coal and proceeds to get the engine ready, filling up oil cups, testing the batteries, and so forth. Some ten minutes later he dumps two more charges (100 pounds) of coal on the fire. Soon the gas makes its appearance at one of the test cocks. A valve is then thrown over and the gas, urged along by the blower, drives out the air in the scrubber and in a minute or two the engine is ready to start. Starting the engine consists of getting it on what would be, if running, the power stroke, with the crank just enough above center to insure the engine turning over in the right direction; shutting off the blower at the producer; retarding the spark, and admitting air to the cylinder by means of a manually operated valve located in the exhaust passage between the exhaust valve and the cylinder proper. The piston moves forward, the exhaust valve opens and at the end of the exhaust stroke the gas is sucked in, compressed, exploded, and usually the engine runs right along without any trouble; if, however, it stops, it is due to insufficient blowing of the fire or too thick a bed of coal to suck the air steam through. The remedies are quite obvious.

During the day coal is charged as required. The usual method of handling the producer is as follows: After the engine has been running for a few moments, 100 pounds of coal is charged and half an hour later, 150 pounds more, this making in all about 300 pounds of coal, which is enough until 11:30, when another charge of 50 pounds is dropped. At noon, as soon as the load is off, the man gets to work at the producer with a poker and rakes out what is left of the fire carried over from the previous day. The fuel bed is then poked down through one of the poke holes in the top, and another charge of coal dumped in. Sometimes the engine slows down, but picks up again at once and is ready for the load at 12:30. At 1 o'clock, 150 pounds of coal is charged and this is usually enough for the afternoon; however, on dark days or in the winter, we usually give another charge at 4:30 and this carries the plant through the day.

Running on a load of 250 amperes, the producer consumes about 550 pounds per day. On dark days and during the winter the consumption is correspondingly greater. The coal consumption of the plant is approximately two pounds of coal per brake horsepower-hour.

In conclusion I would say that we have had some trouble, but it was due to lack of knowledge, the apparatus not being at fault. There have been discouraging times, it is true, when various troubles have arisen, such as a cracked vaporizer, unsuitable coal, leaky producer lining, and a thousand little things, but it has been well worth while to change from city gas to producer gas when one considers that the producer, which cost $1600, more than paid for itself the first year.

Lest the reference to the Foster fan-regulating valve in connection with the accident at the Concord (Mass.) Reformatory, on page 886, of our issue of May 18, be misunderstood as implicating the Foster valve in the responsibility for the accident, it is desired to state that the writer had been misinformed and that there was no Foster valve in use in the plant, and had there been and had it operated as was stated, it could not have been claimed that it contributed to the accident. By those connected with the plant, it was thought the accident was caused by the water carried over by the priming of the horizontal boiler, which was being crowded to the utmost at the time of the accident.

Recently contracts were let by the Government for what is expected to be the most powerful wireless station in the world. It will be erected in Washington, and when in working order it will be able to communicate with naval vessels 3000 miles away.

Depreciation of Power Plant Equipment

By F. H. Neely

This subject is one upon which few set ideas prevail. Practice appears to be as varied as power plants themselves. Directors, owners and operators are loath to regard this important item except in an abstract and unintelligible way, realizing it exists, but neglecting to analyze their own particular cases and making provision accordingly. It must be recognized that depreciation should enter into the cost of developing power just as surely and consistently as the monthly labor, coal, water and maintenance bills. No net profits can legitimately be declared earned, until the proper depreciation is deducted from the gross earnings. It will be argued that when by constant repair a plant is kept in first-class condition, no depreciation is necessary. This, of course, is a false theory, for the plant would then have an indefinite economic life. An occasional appraisal by a disinterested party will bring the owner to the realization that some consideration must be taken of this matter and that it must not be disregarded in the yearly financial adjustment of a severe burden is to be avoided in the end.

Some private and, unfortunately, a great many municipal plants make no depreciation provision whatsoever from their earnings. The ultimate result is to call on the stockholders for additional capital where replacement is necessary; in municipal plants, as a rule, bonds are issued for building and replacement. How often are 30- and 50-year electric-light and waterworks bonds issued, when it is known that the economic life of the plant built with this money cannot be over 25 years?

In order to arrive at the annual figure by which the gross earnings must be debited to care for depreciation, it is necessary to settle the number of years which will pass before the apparatus in a plant will arrive at a scrapping state and require renewal. In determining the efficient economic life, the engineer in charge of the plant should be looked to for the best judgment and advice. Segregation and grouping are necessary, for everyone realizes the inaccuracy that would come from considering all apparatus to have the same life. The engineer is in a position to know the relative life of a slow-speed, well-built Corliss engine as compared to a large, intricate gas engine having a multitude of moving parts. With a knowledge of the kind of boilers and the water and service, he can most intelligently determine the life of the boilers. Similarly, with due consideration of service, usage, mechanical makeup and obsolescence, the engineer should be able to assign a very close economic life to all of the machines and auxiliary equipment.

Fractional Method

Depreciation is commonly disposed of by charging, i.e., reducing the asset account an equal fraction yearly of the original cost of the productive plant based upon its estimated economic life. It is often that companies without any estimate as to the true life of machines or equipment will write off yearly 10 per cent. of the original cost, thus disposing of the total value in 10 years. It is argued that the machines are obsolete after 10 years' service owing to improvements in design, whereas some equipment is good for from 20 to 25 years.

Reducing-balance Method

This method of charging off for depreciation is at first sight rather deceiving, the charge falls toward the end of the period. The following example will show its action for a $1000 investment.

Years	Expense Outlay Charged Off	Interest Credited	Burden
1	$121.6	$ 40	$ 81.6
2	"	36	85.6
3	"	32	89.6
4	"	28	93.6
5	"	24	97.6
6	"	20	101.6
7	"	16	105.6
8	"	12	109.6
9	"	8	113.6
10	"	4	117.6
	$121.6	$220	$ 996.0

Here, of course, the interest, 4 per cent., is paper work, no real value developing as in the sinking-fund method following.

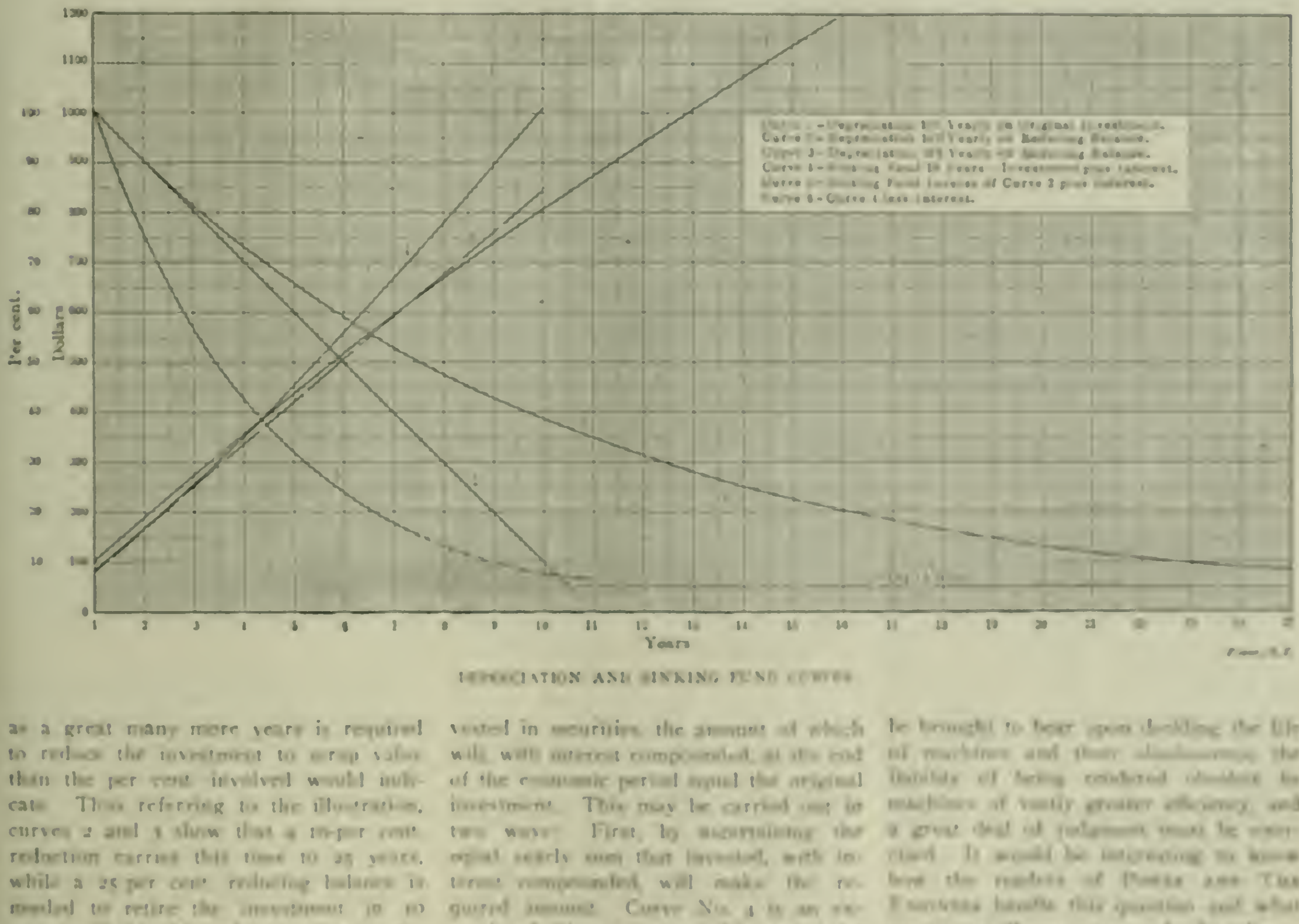
Sinking Fund

Here an annual sum is laid aside or invested in securities, the amount of which will, with interest compounded, at the end of the economic period equal the original investment. This may be carried out in two ways: First, by ascertaining the equal yearly sum that invested, with interest compounded, will make the required amount. Curve No. 4 is an example of this. A 10-year life period for $1000, interest 4 per cent., requires a yearly investment of $84.75, or 8.475 per cent. The second means of handling these payments is by having a yearly reducing investment, curve 5, where the investment corresponds to the yearly depreciation of the 10-per cent. reducing-balance method. The total original investment, $1000, is reached in less than 13 years, interest 4 per cent., which shows that the reducing-balance method used for determining the annual payment to the sinking fund is not of such long duration. This would appear to be the most just method of determining annual payments to the fund, as it must be realized that the upkeep, or maintenance cost rises as the apparatus gets older, so that it would seem only fair to gradually reduce the depreciation burden.

Replacement and Extension

In many instances it is difficult to distinguish between a replacement and extension. Very often new machinery is bought of a larger capacity and more improved design. The Massachusetts Railway Commission allows the value of the new apparatus less the estimated cost of exact replacement of the old machinery to be credited as increased assets, while the estimated cost of replacement is charged to renewals.

There are a great many points that may be brought to bear upon deciding the life of machines and their obsolescence, the liability of being rendered obsolete by machines of vastly greater efficiency, and a great deal of judgment must be exercised. It would be interesting to know how the readers of Power and The Engineer handle this question and what provisions, if any, are made for depreciation.



DEPRECIATION AND SINKING FUND CURVES

as a great many more years is required to reduce the investment to scrap value than the per cent. involved would indicate. Thus referring to the illustration, curves 2 and 3 show that a 10-per cent. reduction carries this time to 25 years, while a 25 per cent. reducing balance is needed to retire the investment in 10 years. Under this scheme a large proportion of the depreciation comes when the machine is new.

Annuity Method

In this method equal yearly sums are charged off sufficient to provide at the expiration of a stipulated life an amount equal to the original investment plus the interest on the capital remaining invested therein. The amounts which annually represent the interest are credited in yearly diminishing sums, so that the burden of

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The announcement has just been made that Adolphus Busch has purchased, for cash, the patents, patent rights, good will and all unencumbered physical assets of the American Diesel Engine Company, and has established general offices in the South Side Bank building, St. Louis, Mo. It is Mr. Busch's intention to organize and finance a company in St. Louis in the near future.

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A Change of Heart

It is gratifying to notice that one of the principal American railroads has announced its intention to give the public through the newspapers prompt and accurate information regarding any accident which may occur on its lines.

There is a disposition upon the part of industrial concerns, as well as of railroads, to attempt to cover up any mishap which occurs in their plants and to refuse particulars even when forced to admit that there has been trouble. POWER has frequently sent a man across several States to investigate a report of a flywheel accident or a boiler explosion, only to be informed that the accident was a trifling affair, much exaggerated in the newspaper account, and that there was absolutely nothing to give out concerning it. If investigation is allowed and substantiates this view of the matter we are always glad to say so. If not, we publish what we can find out and emphasize the fact that information was refused.

The natural inference is that the facts if published would not look good for the management, or for the apparatus which failed. We are not responsible for the inference, if they wish to adopt that attitude. The usual excuse, when any excuse is given, is that every accident brings around such a flock of vultures in the shape of shyster lawyers and others seeking to profit from the misfortunes of the victims that absolute secrecy is the only safe policy. There is also a kindly disposition to shield the makers of the wrecked apparatus in view of negotiations for its replacement. Neither excuse is valid. If there has been such negligence as to entitle victims to damages, nobody can have any sympathy with the policy which locks the gate until such evidence can be destroyed. If the facts are such as to relieve the management of responsibility, an investigation of the accident by a trained observer will help to bring them out. If the boiler or engine is faulty in design or construction, or if it has been operated in such a way as to lead to destruction, the public is entitled to know it. If the fault is inherent in the type it should be exposed and corrected, if it is incidental to the individual machine or apparatus and could not have been avoided by ordinary care and inspection there can be no harm in making it known. If it was the result of faulty operation or use, an exposé of the condition might warn others against the same malpractice. If it was the result of poor design, cheap construction and wilfully hidden defects, it ought to be advertised.

No manufacturer likes to have his errors or misfortunes held up for analysis, but a reputation based upon a lot of concealed faults and blanketed failures is of no permanent worth, and the manufacturer who has faith in his apparatus and knows that it has failed only because of some exceptional reason, who faces the case like a man and satisfies himself and the public that he has found the cause and eradicated it, is the one who will win confidence and ultimate success.

Coke from Illinois Coal

To coke Western coals and obtain a product suitable for metallurgical use has for a long time been considered an impossible proposition, due to the fact that these coals contain only the lighter volatiles, and after driving off these constituents it was believed the result would be nothing more than coke breeze. The experiments made by the technological branch of the United States Geological Survey at the St. Louis exposition apparently verified this conclusion, for their tests did not result in any degree of success. It remained for Dr. R. S. Moss, an English expert on the subject, to prove that any Illinois coal would make a satisfactory coke.

From a study of Eastern coals, Dr. Moss discovered that their readiness to coke was due to the heavy hydrocarbons contained in them. To break up the lighter volatiles and produce these heavy hydrocarbons in Illinois coal was the problem, and the solution rested in quickly getting a high temperature and continuing the coking process for a period of much shorter duration than given to Eastern coals. Where forty-eight hours was formerly required to produce furnace coke and foundry coke was given seventy-two hours, a period of twenty-four to thirty hours sufficed for Illinois coal. When the coal last mentioned was coked according to the usual schedule, the result was invariably coke breeze, and it was found that the quicker the process, the better the quality and the more satisfactory the coke.

Aside from the advantages accruing to the furnace and foundry interests from such reduction in the time element, the discovery may have some bearing on the fuel question in Western cities, where the production of smoke from the use of bituminous coal has long been a matter of serious contention. No figures are available on the cost of production, but with a cheap fuel to begin with and the time of manufacture reduced by half, the price of the coke per ton should not be exorbitant. It might also be possible to follow the precedent of the New England Gas and Coke Company, of Everett, Mass., in selling the gas as a byproduct, and in this way materially reducing the cost. The coke produced by the new process might then be used to advantage under boilers for the purpose of eliminating the smoke nuisance, for heating and domestic purposes, and in suction gas producer plants instead of the anthracite now utilized. Such possibilities are worthy of investigation, which might well be undertaken by the Geological Survey in the interest of power users.

Futile Attempt to Secure New Boiler Inspection Bureau

For some time it has been the opinion of a number of engineers in Greater New York that the bureau for inspecting steam boilers and licensing steam engineers should not be under the control of the police department, and that a new bureau should be created which would be entirely independent of other departments of the city. While the New York charter commission was preparing its report and drafting the new charter, it was rumored that a change was contemplated in the sections pertaining to boiler inspection and engineers' licenses. To forestall any unfavorable legislation and to present their side of the question, the combined N. A. S. E. associations of Brooklyn drew up a bill, which in reality was a revised edition of the old La Fetra bill originally drawn up by the A. S. N. E., and invited the combined associations, ten in number, of Manhattan and the Bronx to coöperate with them. The various orders of the International Union of Steam Engineers in the city were also invited to coöperate, although they had not extended the same courtesy when preparing the Voss bill for presentation to the legislature. They, of course, could not agree with the proposed bill, and only two of the ten N. A. S. E. associations in Manhattan and the Bronx voted to support the Brooklyn movement. This was largely due to a feeling that with written examinations conducted on the civil-service plan instead of the oral examinations now given, the bureau might better be left under the control of the police department. The combined Brooklyn associations and the two of New York previously mentioned, however, presented the bill to the charter commission, offering it as a suggestion to amend the charter and for the creation of a new bureau to control the operation of steam boilers and the licensing of engineers and firemen.

According to the bill it would be the duty of the chamberlain to select a superintendent of boiler inspection who was a resident of the city and a citizen of the State of New York, and had been for ten years immediately preceding the date of his appointment an engineer engaged in the operation of steam engines and boilers under a license issued to him by the city of New York. All the powers and duties conferred upon the corporation of the city of New York or upon any board or any officer relating to the inspection or operation of steam boilers, or the examining and licensing of engineers and firemen were to devolve upon this superintendent, who was to appoint the examiners, boiler inspectors and other clerical and executive force necessary for carrying on the work of the bureau. Every subordinate engaged in carrying on this work was to be subject to the provisions of the civil service law of the State of New York and appointed from an eligible list prepared and certified by the municipal civil service commission of the city. An examiner must have had ten years' experience in the operation of steam engines and boilers under a license issued to him by the city of New York and the same length of service under the same conditions was imposed on the inspectors. The qualifications of applicants for examination and the general rules for inspection were much the same as the present law, and also the provisions for keeping records.

The suggestion was considered by the charter commission, but it was not incorporated in the report to the legislature. No amendment was made to this division of the old charter, and as the complete report of the charter commission was tabled, at least for the time being, by the legislature, the suggestion of the engineers, even if it had been incorporated in the new charter, would have received the same fate. Neither the Voss bill nor the recommendations of the combined N. A. S. E. receiving favorable attention, conditions are just the same as they were a year ago. The bureau of boiler inspection and licensing engineers is conducted by the police department as described in an article by A. C. Rowley in the April 20 number of POWER AND THE ENGINEER. A more recent article by the same author, which appears on page 1029 of this number will throw some light on the Voss bill and the recent attempt of the police department to secure an amendment giving them control over the low-pressure heating boilers of the city.

Switchboard Arrangement in Isolated Plants

In designing a switchboard layout for an isolated plant, almost the first point which has to be settled is the location of generating, measuring and distributing panels with respect to one another. Space conditions often limit the installation so much that the best results cannot be secured; but whether the amount of room at hand is small or large, a wise selection of panel locations will reduce the cost of installation and facilitate both the handling of the plant in service and its extension in the future when the load requirements call for the installation of additional machinery.

The majority of isolated plants supply electrical service for both lighting and power uses, the same generators being employed on the busbars and operated in multiple without regard to the actual distribution of the energy in the feeder system. The question of putting the generator panels in the middle or at the end of the board is important. If they are located at the end the plant may often be extended with more freedom, if the maximum installation is not determined at the time when the machinery is first put in. The entire current generated or the whole plant energy, if desired, can easily be measured on a bus panel in such a case. With a bracketed voltmeter or a synchroscope at the end of the board, the work of throwing generators into multiple operation is somewhat easier because greater accuracy can be obtained with the instruments near the generator panels than when a switchboard operator has to strain his eyes to see just where the voltage or phase pointer is located. In many cases where the board cannot be centrally located in the plant, it follows that the installation of the generator panels at one end makes the average cable run shorter between the dynamos and the board, although, in a symmetrical installation, the shortest cable run is obtained when these panels are in the middle.

Under favorable conditions, where a reasonable amount of room has been allowed for the generators and switchboard, and where the ultimate capacity of the plant can be known when the apparatus is first laid out, it is probable that the location of the generator panels in the center of the board results in maximum economy of cost and operation. With the lighting distribution panels on one side and the power panels on the other, the generators feed each way, and consequently the busbar sizes needed are reduced to the minimum consistent with the current passing across the board, and there will be required less copper for a given output in amperes than with a board where the generators are located at the end, since in the latter case an extra run of busbar will be required to feed the more distant sections of the board. If the lighting and power loads are of the same volume of current and operated at the same voltage, with half the board devoted to each service, fifty per cent. more bus copper will be needed for an installation of generator panels at the end, than when they are located centrally.

In the actual handling of the board in service a central location of generator panels facilitates operation, because the switchboard man has to travel only a minimum distance in making any changes in the connections. Where there are instruments located in the distribution circuits, a better watch can usually be maintained from a central point. Temporary connections and adjustments can be more quickly made, and the operations of throwing machines in multiple can be handled with reasonable ease if the normal voltage point is specially marked on the bracketed voltmeter scale.

Test of a Peerless "V" Belt Drive

Belt drives with short centers are always to be avoided if possible; yet there are cases where for lack of sufficient room, or for other good reasons, it becomes necessary to install a drive in the smallest possible space and overcome the attendant difficulties as well as may be under the circumstances. Such a condition ex-

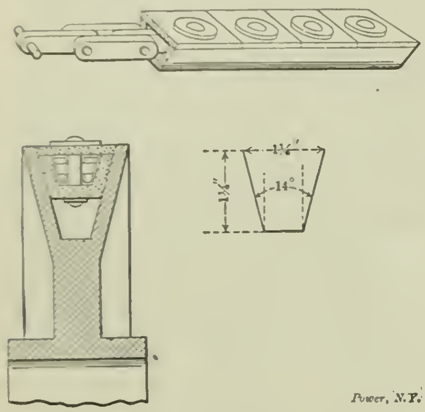


FIG. 1. DETAILS OF PEERLESS "V" BELT

isted in the engine room of the Chicago Savings Bank building, where some interesting data have been collected regarding belt drives on short centers. The equipment in question consists of three Laidlaw-Dunn-Gordon triplex hydraulic pumps, with 3½x12-inch single-acting water cylinders, furnishing a water pressure of 900 pounds per square inch for the operation of elevators. These pumps were all equipped with 50-horsepower motors having 11-inch pulleys at each end of the shaft and driving the pump by means of two 12-inch belts of double thickness, each belt having a 230-pound idler to increase the arc of contact on the driving pulley. As the diameter of the pump belt wheels was 9 feet, and the ratio of the driver to the driven pulley was approximately 1 to 10, with 11-foot centers as installed, the drives were far from being ideal.

Some time ago one of the drives was replaced by a new chain belt, made by the Peerless "V" Belt Company, 215 South Clinton street, Chicago, details of which are shown in Fig. 1. The core consists of a chain made of pack-hardened machine steel, V-shaped in section, incased in a continuous strip of specially prepared rawhide, which covers the bottom and two sides of the chain, giving a frictional surface to transmit the power. The upper part of the casing is a sectional strip of frictional material, one section to each link of the chain, and cut at an angle so as to continue the frictional surface of the sides. Each section is fastened to the link by a rivet passing through it, the head of the rivet also serving to bind the two side elements of the chain together. The belt is thus in effect a continuous wedge running on pulleys grooved at the same angle.

It will be noticed that the belt does not touch the bottom of the groove, as this would destroy the wedging effect, and as the rivets on top and bottom are not subjected to any wear, the belt is held together permanently. Besides affording a frictional surface for the belt, the rawhide casing protects the chain from dust and grit, and also effectually retains the chain lubricant.

Before changing the drives a test run of six days was made with the two 12-inch flat belts, weighed down with 230-pound idlers as previously described. It was found that one pump under these conditions could not do the work. When the accumulator descended to a certain point it was arranged to cut in another pump, and this intermittent starting materially increased the total current consumption. In the six days it was found that 3176 kilowatt-hours were consumed to run the elevator cars 401.5 miles, an expenditure of 7.91 kilowatt-hours per mile.

With the "V"-belt drive installed, Fig. 2, one pump carried the entire load and in a test run for six days, 2746 kilowatt-hours were consumed to run the cars 387 miles, giving an expenditure of 7.09 kilowatt-hours per mile; a saving of 0.82 kilowatt-hour per car mile, or 10.36 per cent. During the second run 14.5 miles less was made than in the first test. Adding the 102 kilowatt-hours necessary to make this mileage at the rate of 7.09 kilowatt-hours per car mile to the total of 2746, still leaves a net saving of 328 kilowatt-hours per week, or 17,056 kilowatt-hours per year, the cost of which would be more than sufficient to pay for the "V" belt.

Driven by flat belts, with the motor making 650 revolutions per minute, the speed of the driven pulleys should have been

$$\frac{650 \times 11}{108} = 66$$

revolutions per minute. In reality the revolutions were only 62, showing a loss of 6 per cent. of the total power through slippage. In changing drives the diameter of the driving pulleys were changed to 11.75 inches, and the driven pulleys to 109 inches. It was then found that the speed of the driven pulleys was raised to 70 revolutions per minute. Theoretically the number of revolutions per minute should be,

$$\frac{650 \times 11.75}{109} = 70.07,$$

which indicates that practically all slippage has been eliminated. As the drive may be run very slack, it follows that the journal friction is reduced to a mininum. Operation is entirely noiseless and considerable saving is found in brushes and controllers.

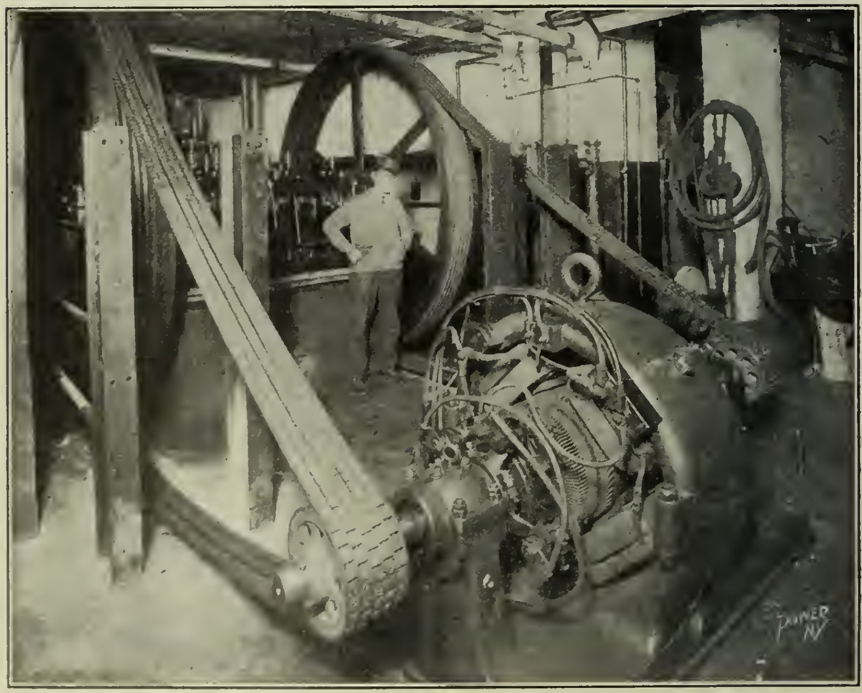


FIG. 2. PEERLESS "V" BELT DRIVE IN CHICAGO SAVINGS BANK BUILDING

Snoqualmie Falls provides the electric power for the Alaska-Yukon-Pacific exposition which opened June 1 at Seattle. Of the power brought down from the falls 10,000 kilowatts is delivered at the substation at the fair grounds. Of this the exposition takes 2500 kilowatths.

Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

A 42-inch Hydraulic Lift Gate Valve

This valve, two designs of which are [shown i]n Fig. 1, is of the Kennedy double-disk [p]arallel-seat gate type, operated by [h]ydraulic cylinders. When the valve on [th]e hydraulic piston is to be opened, the [fi]rst movement of the steam releases the [c]ams, Fig. 2, which have inclines in opposite directions on the faces coming into contact with similar inclines in opposite directions on the inside, or back of the disks, and owing to the abrupt pitch of these inclines, the disks at once fall away from any contact with their seats, thereby preventing any dragging against or grinding of the faces of the valve seats or disks in the opening of the valve.

In the closing of the valve these operations are reversed, the disks bearing the cams and cam rods there until opposite the ports, when the cam rod is brought to a stop by lugs cast on the inside of the body of the valve, bringing into operation the abrupt opposite inclined surfaces of the cams and disks, and at once closing the valve without injuring the faces.

This size of valve is made with bronze-mounted trimmings, the hydraulic cylinder being lined with bronze. The aggregate weight is 15 tons. It is manufactured by the Kennedy Valve Manufacturing Company, Elmira, N. Y.

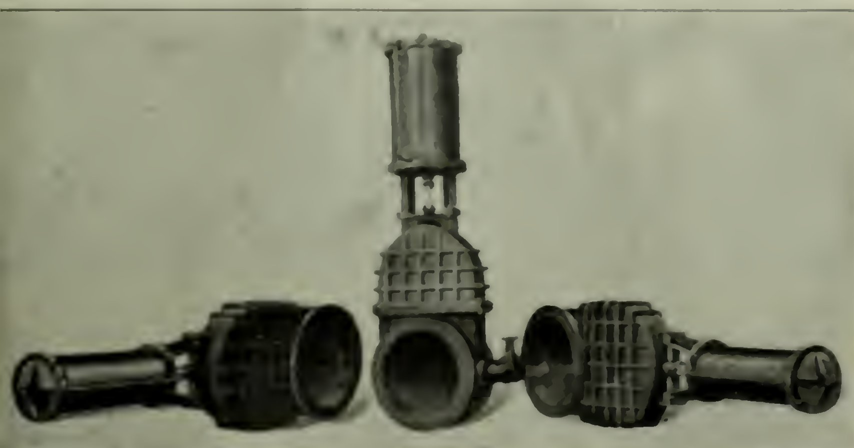


FIG. 1. KENNEDY DOUBLE-DISK GATE VALVES

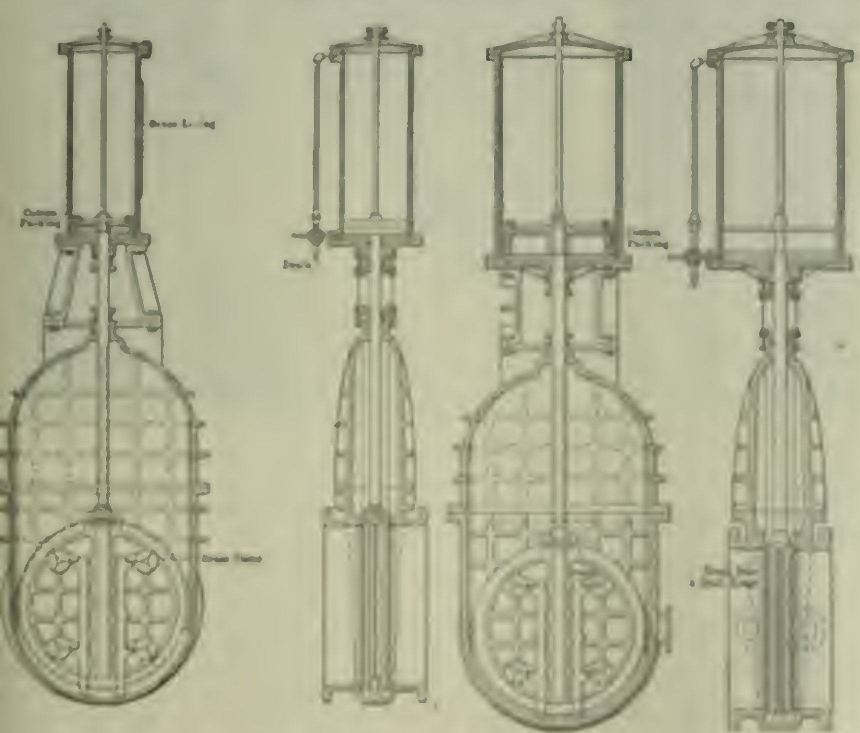


FIG. 2. SECTIONAL VIEWS OF HYDRAULIC VALVES

Grease Lubrication for Cylinders

The Ohio Grease Lubricator Company, Loudonville, Ohio, manufactures a cylinder sight feed grease lubricator, which is illustrated herewith.

Its action is shown in Fig. 1. It keeps the grease in a melted state, feeding it by direct hydrostatic pressure, and forces it into the steam pipe and sprays or atomizes it, so that the steam can carry it to all parts of cylinder and valves.

The superheating is accomplished by a combining tube which, passing through the grease in the head portion, sets up a

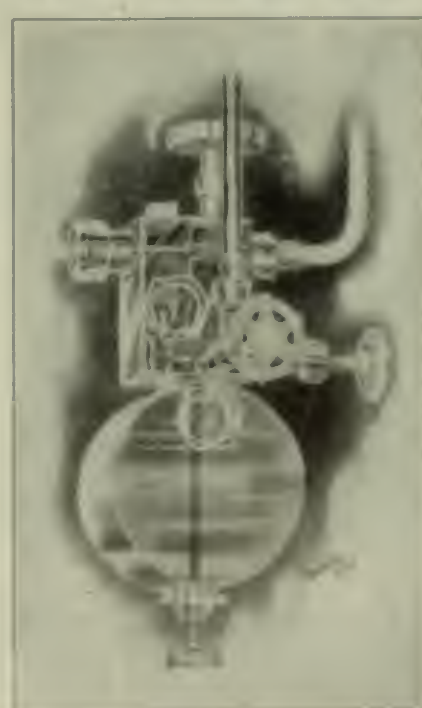


FIG. 1. [illegible]

circulation of the lubricant, and very quickly induces a uniform temperature of about 190 degrees, it is said.

The second function, developing pressure by condensation, is performed as usual by the condensing tube, and the

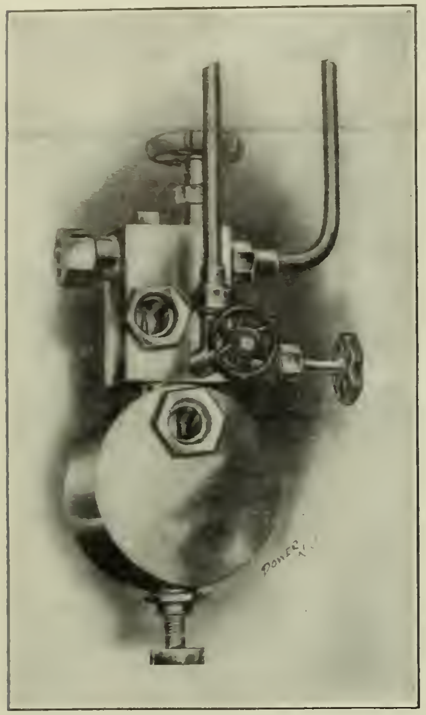


FIG. 2. EXTERIOR VIEW OF OHIO GREASE LUBRICATING COMPANY'S DEVICE

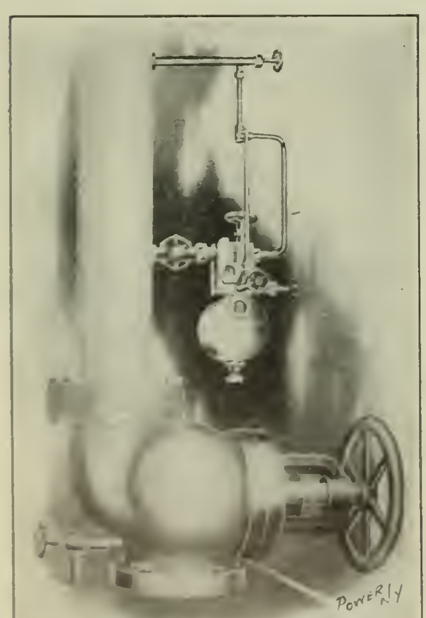


FIG. 3. METHOD OF ATTACHING LUBRICATOR TO STEAM PIPE

third function, forcing the grease into the steam line and atomizing it, is performed by the combining tube, which permits a stream of live steam to strike the heated and expanded drop of grease after it leaves the jet. Figs. 2 and 3 show respectively an exterior view and the method of attaching to the steam pipe. These lubricators are not sold, but are leased free of charge.

Welded Steel Headers

Robbins, Gamwell & Co., Pittsfield, Mass., manufacture welded steel headers on which the nozzles for outlets are

FIG. 1. NOZZLES WELDED TO STEEL HEADER

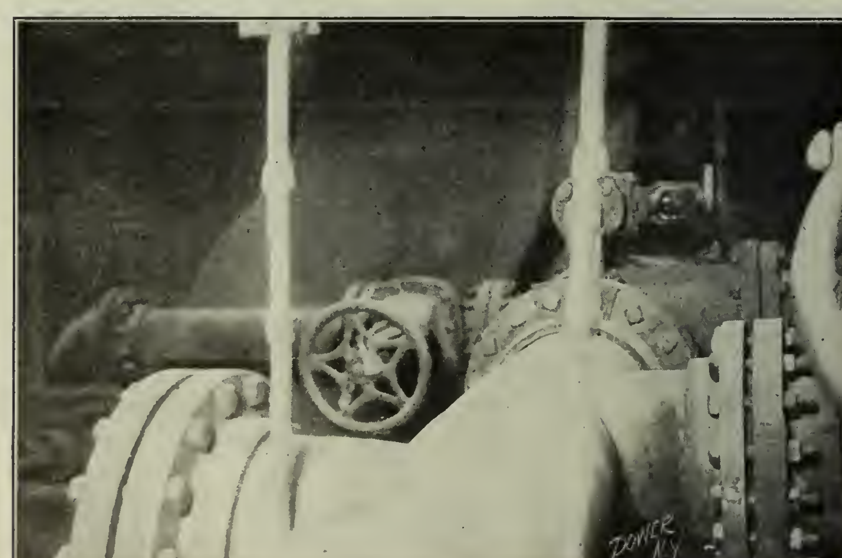


FIG. 2. ANOTHER SAMPLE OF NOZZLES WELDED TO HEADER

welded, by a special process of their own, directly to the pipe with which connection is desired, thus accomplishing the same results as obtained with fittings. A sample of such work is shown in Fig. 1, while Fig. 2 shows a welded steel header which is carrying 175 pounds steam pressure at 200 degrees superheat.

It will be recognized at once that this method has its advantages, as the number of joints and gaskets is considerably reduced and fittings are entirely eliminated, thus doing away with the possibility of faulty castings. In this work wrought steel, which is considered best adapted to withstand the high temperature of superheat, is used throughout. Pipe lines made up in this manner are, as a whole, lighter, owing to the omission of fittings, and the number of joints being reduced lessens the cost of installation. The only feature that prevents the length of run is the facility of shipping and convenience in erecting.

In welding flanges, the same method is employed as in welding the nozzles. The flange is made of the same material as the pipe itself, thereby producing a homogeneous metal of the pipe and flange. After a flange is welded to the pipe, it is faced and drilled and the faces back-machined.

The Lamson joint as made by this

company is made by lapping the pipe itself over on the face of the flange and the inside being faced there is no chance for leakage. The flanges swivel on the pipe, a point which is appreciated by the erecting men.

All the work sent out by this company is tested to 1000 pounds hydraulic pressure before shipment and is guaranteed for the conditions for which it is designed.

The Twiss Corliss Engine

In Fig. 1 is shown the general lines of the Twiss Corliss engine manufactured by Nelson W. Twiss, 28 Whitney avenue, New Haven, Conn. The frame is of the well-known Corliss girder type, the cylinder, frame and pillow block being cast separately and bolted together. The cylinder is provided with four double-ported Corliss valves, the exhaust valves being of the plug type with exhaust ports cored through them, thus securing a minimum amount of clearance. The steam valves are constructed to raise from their seats whenever the pressure in the cylinder exceeds the pressure in the steam chest. The valves are driven by means of suitable lugs or projections on the valves and corresponding recesses in the valve stems. The exhaust valves are operated by arms keyed to the outer ends of the valve stems, the arms being connected by an adjustable rod and operated through suitable connections, as is usually found in the Corliss type of engine.

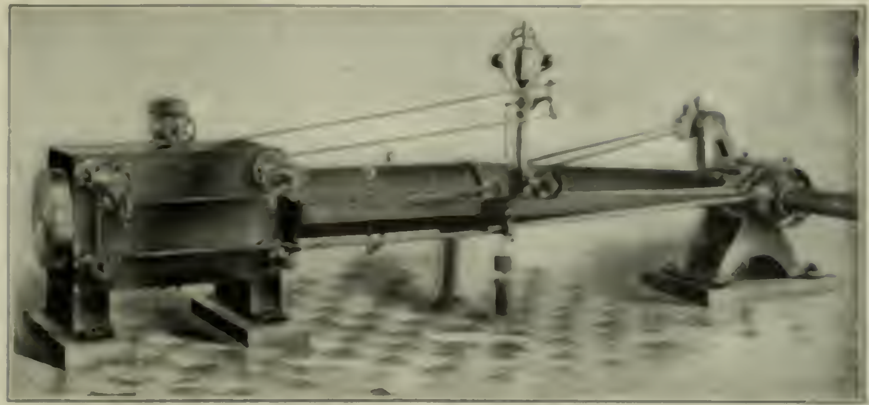


FIG. 1. VALVE-GEAR SIDE OF TWISS CORLISS ENGINE

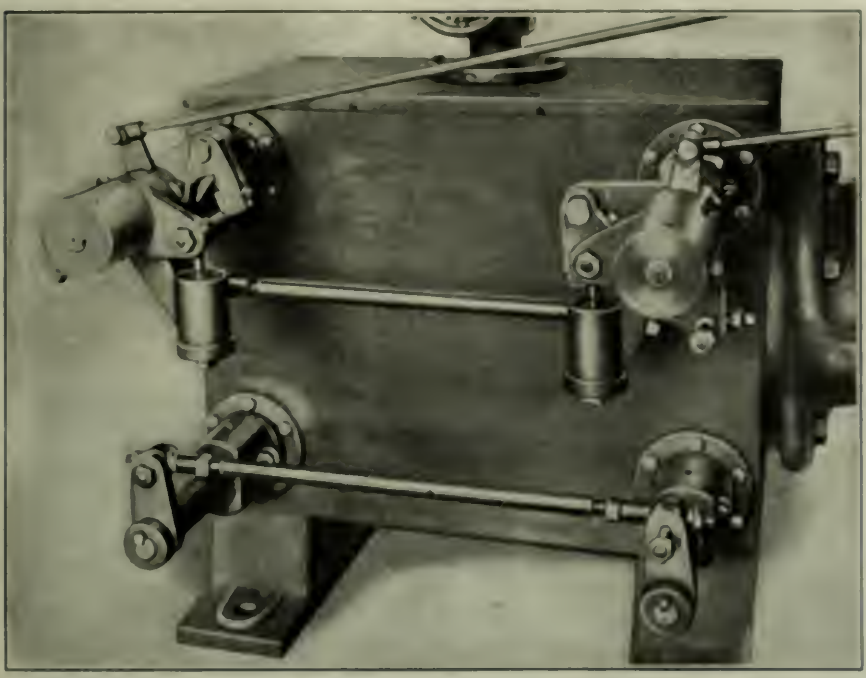


FIG. 2. NEAR VIEW OF VALVE GEAR

The main feature of this engine is the construction of the steam-valve gear, which is shown in Fig. 2. In Fig. 3 are shown all of the parts found in the valves and valve-gear construction. An explanation of the valve gear follows:

On a fixed extension of each steam bonnet, a bell-crank lever is journaled, the two being connected by an adjustable rod and operated by means of an eccentric rod; the eccentric rod not being shown in Fig. 2. On the arm of each bell crank is pivoted the steam hook which engages with the steam arm keyed to the valve stem. The bell-crank levers engage the steam-valve hook as is usual with Corliss engines; that is, when one of the steam hooks is engaged with the steam arm it opens the steam valve until the inner leg of the hook comes in contact with the trip toe on the knockoff lever, when it is disengaged and the valve immediately closed by a spiral spring on the extension of the valve stem. The inner end of each spring is connected with the outer end of each steam bonnet, the outer end being connected to the cap which covers the spring and is secured to the valve stem by set screws. This provides a convenient method of adjusting the tension

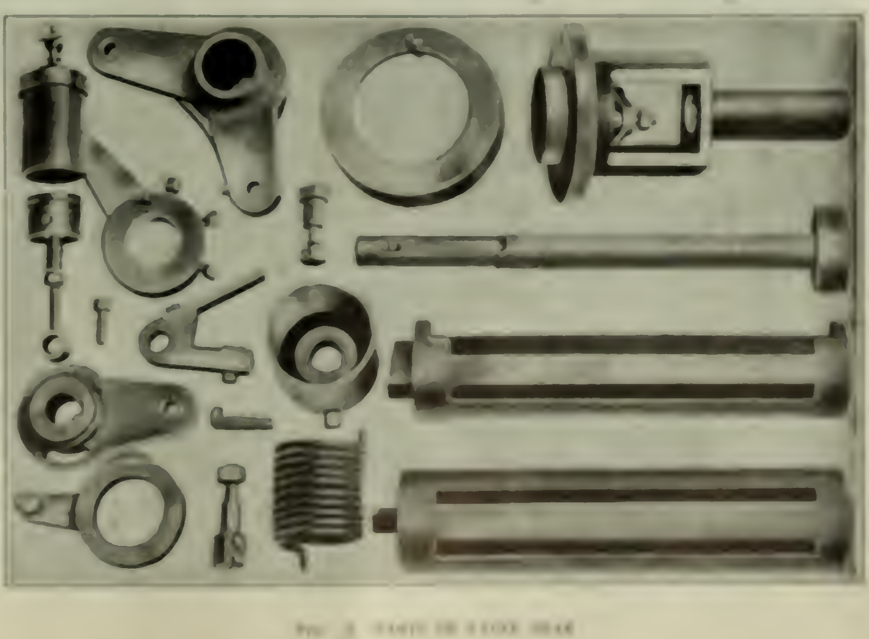


FIG. 3. PARTS OF VALVE GEAR

of the springs, and in order to do this it is only necessary to unscrew the set screws, shown in the cup, and with a small rod placed in the hole, shown on the right-hand valve, move the cup in the desired direction to adjust the spring with either more or less tension, as the case may demand.

On the Twiss engine no dashpots are employed, as the valves are closed by means of the wound spring, shown in Fig. 3, which is inclosed in the cup, shown at the end of the valve gear, Fig. 2. To insure noiseless closing of each steam valve, an air-tight piston is secured to the steam arm of each, as shown, fitted with a suitable adjusting snap ring and fitted in the cylinder which is supported by a bracket secured to the outer end of each steam bonnet. The bottom of each air pot is fitted with a leather washer, having a hole in it communicating to the pet cock screwed in the bottom. In the side of the air cylinder, not over ½ inch from the bottom, is drilled a ⅛-inch hole which is covered before the plunger reaches the bottom of the cylinder, but as the plunger is raised above the hole, air is admitted which permits the plunger to travel the rest of its movements without undue force being exerted upon it. As the spring closes the valve, the plunger is forced down into the cylinder with a free, easy movement until it passes the hole in the bottom of the cylinder, when air is entrapped and is then compressed, thus preventing any shock in the seating of the steam valve. The amount of air confined in the cylinder and compressed is regulated by a pet cock screwed in the bottom, but not shown in Fig. 2. By adjusting this pet cock the valve can be made to close practically noiselessly.

The knock-off levers are connected with the governor which regulates the point of cutoff as in all Corliss-engine construction. The exhaust valves are operated by a separate eccentric.

This valve gear can be placed upon any Corliss engine without making other changes. It is simple, does away with the cumbersome dashpot and admits of high speed for Corliss-engine operation.

Iowa State N. A. S. E. Convention

With more than one hundred delegates and visitors registered, the sixth annual convention of the Iowa State association of the N. A. S. E. was called to order May 21, 1909, at Cedar Rapids. President Abner Davis opened the proceedings by introducing Mayor J. T. Carmody, of Cedar Rapids, who is an active member of the association. In introducing His Honor, President Davis reviewed the history of the mayor, who worked himself up from machinist and fireman to the most prominent position in the city. At the close of President Davis' speech, Mayor Carmody welcomed the delegates and visitors to the city of Cedar Rapids and spoke of the untiring devotion to duty of the members of the local association in bringing No. 9 into sufficient prominence to entertain the State convention of Iowa. Mayor Carmody also had a good word for the commercial travelers and supplymen, whom he said had done more for the advancement of industrial progress than all the money and securities of the financiers. In closing, the mayor turned over the keys of the city to the visitors and said that everything possible would be done for their entertainment and comfort.

President Davis next introduced Fred. W. Raven, national secretary, of Chicago, who responded to the mayor with one of his characteristic speeches. Mr. Raven's talk was followed by a short address of welcome to the convention from its president, who then called the business session of the convention to order "for the purpose of the transaction of any business that may legally come before us, the work to be done in a fraternal spirit

DELEGATES AND VISITORS, IOWA STATE N. A. S. E. CONVENTION, CEDAR RAPIDS, MAY 20-22 and with a view to promoting the best interests of the order, treating each other as brothers and observing that strict consideration for the views and wishes of others to the end that harmony must prevail."

At the Saturday afternoon business session, after attending to many detail matters of importance in regard to facilitating the business of the order, Waterloo was chosen as the next place of meeting. Election of officers was then in order and resulted as follows: A. C. Wilford, of Waterloo, president; Ernst Bailey, Des Moines, vice-president; J. A. Coulson, Sioux city (reelected), secretary; G. H. Beebe, Marshalltown (reëlected), treasurer; H. Yust, Ottumwa, conductor; L. J. Shramek, Cedar Rapids, doorkeeper. The new officers were installed by National Secretary Raven.

Educational matters were not neglected. At the Friday afternoon session, F. W. Laas read a paper entitled, "Furnace Construction in Its Relation to Fuel Economy." This paper was illustrated with many sketches showing boiler settings and other details having to do with this question. During the discussion which followed, several engineers from the local association were called upon to give their experiences with various types of boiler setting installed in their plants. The discussion brought out many points in regard to economical boiler practice and was closely followed by all present.

Another interesting event on the program was a lecture on "Boiler Feed Waters, What They Contain, and Why They Cause Trouble," by W. A. Converse, of Chicago. During this lecture the process of feed-water analysis was followed out with apparatus in the same manner as when a sample is sent to the laboratory for test. The various constituents of the water were precipitated, and methods of determination were interestingly explained.

One of the features of the convention was the presence of many students from the neighboring universities and colleges. One party of [illegible] was present from Iowa City, and consisted of a number of instructors and students of the senior and junior classes of electrical, civil and mechanical engineering in this university. Other students were present from the Ames College of Applied Science and from Mt. Vernon. Much interest was shown by them in the display of mechanical goods in the lobby of the hotel.

A number of trips were taken to neighboring power houses and manufacturing establishments, one of the most interesting of which was that to the packing house of the T. M. Sinclair Company. The local entertainment committee had arranged for special cars to leave headquarters at the Montrose hotel for the excursion and officials at the packing house had kindly arranged for a killing in the afternoon so that the delegates had the opportunity of seeing in operation every branch of the establishment.

The social features wound up with a banquet given to the officers, delegates, members and supplymen in the dining room of the hotel. One hundred people were provided for and after being served with a tasty six-course dinner, E. A. Sherman, of Cedar Rapids, acting as toastmaster, introduced Fred W. Raven, who delivered a short address on the objects of the association and organization. A. C. Wilford, of Waterloo, then spoke on the benefits of a license law. Other speakers were: F. M. Williamson, J. T. Carmody, C. O. Bates, C. E. Tibbles and W. A. Converse. The success of the convention was such that upon leaving all visitors felt that they had added many names to their list of friends in Iowa.

It is with the deepest regret we have to record that early Monday morning, May 24, following the convention, Mayor Carmody, who so warmly welcomed the convention to Cedar Rapids, was shot in the abdomen in an encounter with a burglar at his residence, the bullet inflicting a serious flesh wound. Latest advices are to the effect that Mr. Carmody's condition is as satisfactory as can be expected under the circumstances, and although the bullet had not been found at this writing, he will recover.

Ohio Society of Mechanical, Electrical and Steam Engineers

The nineteenth meeting of the Ohio Society of Mechanical, Electrical and Steam Engineers was held at Canton, May 21 and 22, with headquarters at the Hotel Courtland.

The meeting was called to order by President F. W. Ballard, who introduced Charles A. Dougherty, president of the Canton Board of Trade, who welcomed the society to the city. Mr. Dougherty made it evident that Canton in his estimation at least, is the fairest city in the country, and from the applause he received, it would appear that others were of the same opinion. Among other things he said that more than 6000 special articles are manufactured in the city and county.

President Ballard brought out and dwelt upon the thought that the engineering profession is one of utmost importance, and that mankind owes more to it than to medicine, law, or other professions.

A departure was made in the manner of presenting the various papers to the society. Instead of the authors reading their papers, as printed in the journal, a condensed presentation of the salient points in each paper was given by the author. The members, who were supposed to have familiarized themselves with the text matter of each paper, were then given an opportunity to discuss the original paper. This plan gave very pleasing results, and with the exception of such as did not refer particularly to steam or electrical matters, the papers were fairly well discussed.

The first paper treated upon "Hot, Soft Water for Steam Boilers," by G. H. Gibson. He described the manner in which scale forming particles get into feed water in the first place, and gave the chemical action that occurs when various chemicals are introduced into the feed water. The point was made that some engineers are under the impression that some feed waters are chemically pure; pure water, however, can only be obtained by distillation.

The method of testing water for solids was discussed, also the effect of scale in a boiler, but the predominating thought in this connection was that, although scale undoubtedly makes an increase in coal consumption, and has a great bearing as to the matter of economy, these factors are of less importance than that of safety in operation, and the cost of repairs, due to a reduction of labor expenses. The matter of safety being the leading feature in boiler practice, scale should be eliminated for that reason if for no other.

In discussing the treatment of scale with soda ash, it was brought out that care should be exercised, as it tends to pass into the steam lines and dissolve the rubber gaskets in the flange joints, and that as a remedy a steam separator would in most instances eliminate this trouble. The separator, however, should be provided with a drip pipe of sufficient dimensions to take care of all water the separator would be apt to handle. Another factor in dealing with the use of soda ash was relative to the injurious effect it has on brass seats and disks of blowoff valves, and copper seats and disks were recommended.

The second paper read dealt with "The Interpole Motor," by Prof. H. B. Dates. He stated that it was not a new idea, probably about 25 years old, and undoubtedly originated abroad. The motor is found extremely useful in cases where the machine is to work with high-speed tools which require special speeds. A brief description of the motor was entered into in which was incorporated the statement that there are indications that the electrical companies are inclined to work the interpole idea overtime in order to be sure that trouble will not occur from sparking commutators. Another advantage of this type of motor is that it is available for [illegible] service, as it will produce the same power, although occupying less space than the ordinary type. Another thing, the idea is not limited to motors, but can be applied to generators where trouble has been encountered with sparking at the commutator.

A paper on "Heat Treatment" was well received. Mr. [illegible], the author, was not pres... and an abstract of the paper was given by W. L. Brown, who said, among other things, that the subject of thoroughly insulating steam pipes has become of great importance, especially since the introduction of superheated steam, and that the best results are now being obtained by 85 per cent. asbestos covering, the thickness and style of application being governed by the temperature of the steam. There are three kinds of covering; that suitable for low-pressure plants, that adaptable for a steam pressures up to 150 pounds per square inch, and superheated steam. No pipe covering is made that will withstand moisture to any great extent, was the statement made to inquiries relative to this point.

"On the Ethics of Society Membership," a paper presented by David Gaehr, contained much of benefit to the members of the society. It pointed out how each member could, and should promote the interest of the society by meeting every obligation as it came to him, by attending the meetings, by obtaining new members, by preparing a paper to be read at some meeting of the society on a subject thoroughly understood by the author, and to take an active part in the discussion of papers presented to the meeting.

"Lubrication of Steam Cylinders by Grease" was a paper prepared by B. F. Fisher. The matter of cylinder lubrication was taken up to some extent, as well as the composition of various oils used for that purpose, the main portion of the paper being devoted to the method of lubricating cylinders with grease of a special mixture and with a special feeding device. This paper aroused about as much interest as any that was presented. In the discussion that followed the reading of the paper it was brought out that one plant had operated for 72 hours on one pound of grease, costing 12½ cents, as compared with five gallons of cylinder oil, costing 58 cents a gallon. It was claimed that the grease softened up old packing and made it pliable, thus adding to its life.

At 2:30 p.m., the members of the society were taken on an inspection trip in a special car about the beautiful city of Canton, a visit being made to the works of the Canton Steam Pump Company and the Canton boiler works. On Saturday afternoon the members were taken by trolley to the power station of the Northern Ohio Traction Company, where the opportunity of viewing the dissected parts of a Curtis turbine was afforded. Next a visit was made to the city pumping station and from there to the McKinley Memorial.

The most important business transacted by the society was the nomination of the following committees: Research Committee, to carry on the work of getting together important data from any available source relating to the work of the society regarding steam, electrical and mechanical engineering; Membership Committee; Publicity Committee and Advertising Committee, the three latter to attend to such matters as their names signify.

Thirty-three active members and one associate member were received into the society. The next meeting will be held at Lima, O., Friday and Saturday, November 19 and 20, 1909.

Annual Convention of the A. I. E. E.

The next annual convention of the American Institute of Electrical Engineers will be held at Hotel Frontenac, Thousand Islands, Frontenac, N. Y., beginning Monday, June 28, 1909. A tentative list of the papers to be presented is as follows:

"Some Consideration in Designing Heavy Capacity Fuses," by L. W. Downes.

"A Sketch of the Theory of the Adjustable Speed Single-phase Shunt Induction Motor," by F. Creedy.

"Calculation of the High Tension," by Percy H. Thomas.

Transmission Paper, by W. S. Moody.

"Effect of Frequency upon the Cost of Alternators," by C. J. Fechheimer.

Two papers on high-tension transmission subjects, by R. D. Mershon.

"The Reduction in Capacity of Induction Motors due to Unbalancing in Voltage," by S. B. Charters and W. A. Hillebrand.

"The Heating of Induction Motors," by Alexander M. Gray.

Telephone paper, by J. J. Carty.

Three Industrial Power papers, by D. B. Rushmore.

"The Resistance and Reactance of Armored Cables," by J. B. Whitehead.

Two Educational papers, by A. S. Langsdorf and H. J. Ryan.

"Generation for 100,000 Cycles," by E. F. Alexanderson.

"Repulsion Motors with Variable-Speed Shunt Characteristics," by E. F. Alexanderson.

"Auxiliary Poles for Direct-current Machines," by John N. Dodd.

"The Thermal Convection from Thin Copper Wire Supported in Air," by A. E. Kennelly, C. A. Wright and J. S. Bylevelt.

Two papers, by Comfort A. Adams.

"Harmonics, Even and Odd," by J. B. Taylor.

"Electric Measuring Devices," by L. T. Robinson.

"The Purification of Boiler Feed Water" is the subject of two tables published by the Harrison Safety Boiler Works, of Philadelphia. The larger of these gives the characteristics and reactions accompanying purification of water according to Stingl, as given in "Analysis and Softening of Boiler Feed Water," by Wehrenfennig. The paper first enumerates seven classes of material occurring in water. Under each class is indicated the scale formation due to its presence. The third section gives the degree of solubility in natural water; the fourth, the means of causing precipitation and transposition; the fifth section indicates the procedure and the reactions occurring thereunder; the sixth and seventh sections give, respectively, the substances remaining in solution and in the precipitates after the precipitation or transposition occurs. The chart is 9x22 inches and contains in this condensed form a fund of information which will be valuable to the engineer. The smaller table is reprinted from a paper read by Messrs. Hunt and Clapp before the American Society of Mechanical Engineers, and accredited by them to Prof. S. M. Norton, giving the cures recommended for such troubles as incrustation, corrosion and priming. These charts, we understand, will be sent gratuitously to any applying for them, the interest of the Harrison Safety Boiler Works in the matter being due to the fact that the charts show that the purification of water for boiler-feeding purposes can be accomplished in a commercially successful manner by the proper application of heat and soda ash, as is done in their open heater system; that is, that these two remedies will protect the boilers from corrosion, since they completely neutralize any acid which may be in the water, and from the formation of hard scale, since heating water by spraying through the steam takes the place of the caustic lime or caustic soda used in other processes for taking up carbon dioxide.

Personal

Charles K. Thomas, formerly sales agent of the D. T. Williams Valve Company, of Cincinnati, has been elected vice-president of the company, to succeed the late Francis X. Pund.

Obituary

The late Francis X. Pund, whose death, on May 8, was announced in the June 1 number, was born in Cincinnati and at an early age secured a position with Post & Co., and after faithfully serving this firm for eight years, he and one of his fellow employees, George Puchta, bought out Post & Co., and continued business under the name of Puchta, Pund & Co., and later as the Queen City Supply Company, which became one of the best known mill and factory supply houses in the country. In 1904 he entered the manufacturing business and with David T. Williams, formerly general manager of the Lunkenheimer Company, founded the well-known D. T. Williams Valve Company.

Book Reviews

FREEHAND AND PERSPECTIVE DRAWING. By Herbert E. Everett and William H. Lawrence. Published by the American School of Correspondence, Chicago, 1909. Cloth; 126 pages, 6½x9½ inches; 83 illustrations. Price, $1.

This book, which is one of a series of handbooks on a great variety of subjects, published by the American School, is divided into two parts, the first containing 62 pages on freehand drawing and Part II 64 pages on perspective drawing, the author of each part being given in respective order. As usual with these volumes, the book has been prepared for home study in a style easily within range of common understanding. Part I contains the fundamental principles of freehand drawing, a number of elementary exercises and some plates of the common types of ornament of Egyptian, Assyrian, Greek and Italian design. Part II is devoted to definitions, the general theory of perspective drawing briefly treated, methods employed and a number of problems in perspective.

WATER POWER ENGINEERING. By Daniel W. Mead. Published by McGraw Publishing Company, New York, 1908. Cloth; 787 pages, 6x9 inches; 413 illustrations; 89 tables. Price, $6.

In the compilation of this book the author has recognized that a knowledge of design and construction is by no means all that is required in the development of a water-power project. Other factors, such as the adequacy of supply, the head and power available and the probable variations, the plan for development, cost of construction and operation, and the advisability of the investment are quite as important and each factor must be carefully considered to assure ultimate success. The author has drawn freely from his 25 years of professional practice and his lectures to the senior class of the University of Wisconsin, and an extended acquaintance with the literature on the subject is shown by the number of references given at the end of the various chapters. The book is specific and thorough in its treatment of the various phases of water-power engineering, and to the student or the hydraulic engineer should prove to be a valued edition.

Beginning with a short introduction on the history of water-power development, a second chapter on power and a third giving the basic principles of hydraulics, a series of five chapters is devoted to the method of studying stream flow by actual or comparative hydrographs. The determination of available head for all conditions of flow and all conditions of use is given considerable space and a method outlined for the consideration of possible variations in flow during periods for which no measurements are available based on the rainfall records, the effect of variations in head and that of pondage on the amount of power developed being duly noted. In this portion of the book rainfall and its disposal, run-off, stream flow and its measurement are given due attention. Following in natural sequence are chapters on the water wheel, turbine details, hydraulics of the turbine and a chapter of some length on turbine testing. A method of turbine analysis and selection based on actual tests is presented, and a careful study of these chapters should enable the engineer to intelligently select a turbine for any particular condition of service and closely approximate the results which would be obtained during all conditions of flow and variations in head.

Load factors, speed regulation and water-wheel governors, arrangement of the reaction wheel, selection of machinery and design of plant, examples of water-power plants, construction of dams, pondage and storage, cost and sale of power, and the investigation of water-power projects are all subjects treated in the concluding chapters of the book, and these are followed by appendices on water hammer, speed regulation, the standpipe, test data of turbine water wheels, effect of an umbrella upon formation of vortices, evaporation tables, two new water-wheel governors, and miscellaneous tables.

Supplemental to the text are charts of stream flow, rainfall, evaporation and run-off, horsepower curves, load curves and curves characteristic of various turbines, in addition to other information in chart and curve form. The illustrations are numerous and well chosen, and in all, the book is a highly commendable treatise on the subject.

HYDRO-ELECTRIC PRACTICE. By H. A. E. C. von Schon. Published by J. B. Lippincott Company, Philadelphia and London, 1908. Cloth; 382 pages, 7¼x9½ inches; 256 illustrations; 33 tables. Price, $6.

This book is a treatment of hydro-electric practice worthy of the highest comment. It is divided into two parts. The first division, containing 80 pages, presents the commercial side of the subject, and as it is devoid of technical treatment no special engineering training nor experience is required to clearly understand and appreciate the contents. Chapter I treats briefly of the market of electric current; Chapter II discusses the power opportunity, with articles on flow, drainage, precipitation, evaporation, available fall, power output, etc.; Chapter III relates to the practicability of the development; Chapter IV gives a synopsis of the cost of development, including cost of dam, diversion work, power house, reservoir embankments, power equipment and transmission lines. Chapter V concludes the first part with a review of the value of the project and suggests its proper presentation. Although the various subjects enumerated are presented briefly, enough is given to acquaint the reader with the requirements of the work, the probable cost and the feasibility of any particular installation.

Part II is devoted to the designing and equipping of the plant and was written for the student and engineer in practical work. To appreciate fully this section a knowledge of the principles of surveying and the rudiments of hydrology, hydrostatics and dynamics is required. The technic in this part is elementary and methods or deductions are presented for the most part without complexity. Useful constants are reduced to diagrammatic form and features of importance are illustrated by sketches or views from existing plants.

Beginning with the surveys, flow measurements by different methods, and development programs covering the many possibilities presented by various conditions, the second part continues with a chapter of 136 pages on structural types, including the theory and constants of concrete-steel construction, methods of cofferring preparatory to dam and power-house construction, with tables of quantities for dikes, sheet pile and wall curtains, and the various types of spill structures. The subject of dams and spillways is introduced by an extended consideration of the theories of pressure and resistance and the underlying principles, with determinations of practical constants for a variety of designs. The concrete-steel gravity dam is fully detailed and some space devoted to diversion works embracing open channels, flumes and pipe lines, with data on flow, slope and velocities. Power-station construction is treated in detail of foundation, pits, penstocks and the operating floor, and special attention is given to the submerged power station.

Following is a chapter on power equipment, including the various types of turbine, their designs and efficiencies, hydraulic governors, the electrical generator and minor apparatus, and the transmission line. Part of the space devoted to electrical equipment is taken by an elementary consideration of magneto-dynamic theories, alternating current, purpose and design of the various parts of a dynamo, etc., all of which would appear a little out of place in a book of this character. A brief generalization on constructing the plant, incorporating the preparation of plans, estimates and specifications, closes the book.

Part II is a little brief in places, touching features on the surface only, but in a book on such a diversity of subjects and using 12-point type, although a little wider than usual, this is to be expected. Points most pertinent to the subject in hand are given a reasonable amount of space, and the book in its entirety should be a most desirable and useful contribution.

Business Items

A very neat and handy telephone index is being sent out by R. F. Morse, 74 Weybosset street, Providence, R. I. Send and get one—it is free.

The American Steam Gauge and Valve Manufacturing Company made more than seventy thousand safety and relief valves during a single year.

The Builders' Iron Foundry, Providence, R. I., is the licensee and builder of the new transmission dynamometer described by William H. Kenerson in a paper read at the recent A.S.M.E. meeting at Washington, D. C.

The Gatesville Electric Light Company, Gatesville, Tex., has awarded a contract to the Minneapolis Steel and Machinery Company for a 75-horsepower Muenzel gas engine and lignite producer which is to be installed in a new plant now being built.

The Lincoln Motor Works Company, of Cleveland, has changed its corporate name to the Reliance Electric and Engineering Company. The management remains the same. They will continue to build the Lincoln variable-speed motor, and will also add a complete line of constant speed motors.

The Sight Feed Oil Company, of Milwaukee, Wis., is building a new plant for the manufacture of the Richardson oil pump, and it is expected to be ready for occupancy August 1. The business of this company has increased so during the past eight years that it has had to enlarge its works several times.

The Murphy Iron Works announces that its New York office has been removed to room 1671, Hudson Terminal building, 50 Church street. H. W. Cunning, formerly representing this company in Birmingham, will be in charge as district manager, and will be pleased to give prompt attention to any request for information with regard to Murphy automatic smokeless furnaces.

Adam Happel, 408 East Ninety-third street, New York, is having a 12x30 Corliss girder-frame engine built by the Hewes & Phillips Iron Works for operating one of his plahts. This is the second engine order Hewes & Phillips have from Mr. Happel. The Hewes & Phillips Iron Works also reports an increasing demand for its high-grade castings. All pig iron, coke and other materials entering into the work is first subjected to chemical analysis and the company can satisfy the most critical buyers.

The Museum of Safety and Sanitation announces the election of Arthur Williams to the board of trustees. Mr. Williams is the general inspector of the New York Edison Company and a member of the American Institute of Electrical Engineers. In 1907 he was decorated by the French government. He is a member of the American section of the Internationl Housing Congress and was a member of the Eighth International Congress of Social Insurance at Rome, 1908. Mr. Williams will serve on the lecture committee of the Museum of Safety and Sanitation.

Circular 1502 issued by the Westinghouse Electric and Manufacturing Company contains much valuable information on alternating-current distribution, covering transformers, lightning arresters, insulators, cross arms, etc. Considerable space is devoted to underground and overhead construction applicable to congested and scattered districts. There is also given information on potential regulating systems. The circular contains 52 pages of information of value to any central-station man or any other connected in any way with the distribution of power by alternating-current lines.

The purification of boiler feed water is the subject of two charts reprinted from well-known authorities upon this subject by the Harrison Safety Boiler Works, Seventeenth and Clearfield streets, Philadelphia. The charts show that the purification of water for boiler feeding purposes can be accomplished in a commercially successful manner by the proper application of heat and soda ash; that is, that these two remedies will entirely protect the boilers from corrosion and from the formation of hard scale, since boiler feed water should be heated in any case and since heating water by spraying through steam takes the place of the caustic lime or caustic soda used in other processes for taking up carbon dioxide.

The Wisconsin Engine Company, of Corliss, Wis., has just shipped to the Allegheny Valley Street Railway Company, of Pittsburg, two horizontal cross-compound heavy-duty Corliss engines of its "higher speed" type. Each engine will develop 750 horsepower and is direct-connected to a 500-kilowatt generator operating at 150 revolutions per minute, a speed usually thought to be beyond the limit of the Corliss engine. The Wisconsin Engine Company, however, has made a specialty of what it calls its "higher speed" Corliss engines and has built a large number of them, all of which are operating very successfully. One of the engines afore mentioned drives a direct-current generator the other an alternating-current generator.

Keystone grease, manufactured by the Keystone Lubricating Company, Philadelphia, is used as a lubricant for pumping-station machinery at a number of large private water companies in the vicinity of New York City. One of these is the Hackensack Water Company, operating two triple-expansion vertical Allis pumping engines at 170 pounds steam pressure, with a duty of 20,000,000 gallons per 24 hours against a head of 180 pounds. This plant supplies a large section from Spring Valley, N. Y., to Weehawken, N. J. The pressure on the engine journals is 290 pounds per square inch. No. 4 density Keystone grease is used on these engines, at a reported saving of 52.5 per cent. in cost of lubricant over the lubricating oil formerly used, and with no increase in the friction load. There is also a decided saving of labor, and of mess under the pumps. This water company is now putting in a new 12,000,000 gallon unit of the same type, which will also be lubricatd with Keystone grease.

"The Proper Care of Belts" is the title of a new booklet of 24 pages, recently prepared by the Joseph Dixon Crucible Company, Jersey City, N. J. It is divided into three sections, headed respectively: Belts; Belt Dressings; and Hints, Kinks, Tables. The first section deals with the running condition of belts; the second takes up treatment with various preparations; and the third, as the title indicates, has some general points upon belting and its use. This last section contains some interesting matter collected from several sources. It tells what results were secured in a plant where records were kept over a period of years; gives the economical speeds at which leather belts should be run; has some matter telling of the different styles of joints, illustrating three methods of leather lacing; contains rules for calculating speed of pulleys; gives horsepower transmitted by various sizes of single and double belts, etc. While it is got out in the interests of the traction and solid belt dressings that the Dixon company place on the market, it contains so much matter of general interest as to be valuable to the practical man.

New Equipment

The Newport (Tenn.) Bottling Works will install ice-making plant.

The I. T. Goodrich Company, Savannah, Ga., will install a 20-ton refrigerating machine.

The F. Mayer Boot and Shoe Company, Milwaukee, Wis., will erect a new power plant.

The Lytle Creek Power Company, San Bernardino, Cal., will increase output of plant.

The city of Crockett, Tex., has issued $25,000 bonds for the construction of new water works.

The Striffler Ice and Coal Company, Springfield, Ill., is erecting a new ice and cold-storage plant.

City of Canyon, Tex., will vote on issuance of $33,000 bonds for water works and sewer system.

The Westfield (Mass.) Power Company has awarded contract for the construction of a new building.

The Middletown (Ohio) Gas and Electric Light Company will erect a new electric light power house.

The city of Bessemer, Mich., is contemplating replacement of boilers, pumps, etc., for water-works system.

The Edison Company, New York, has filed plans for a new power-house on 26th street, near Sixth avenue.

The El Paso (Tex.) Electric Railway Company will erect an addition to power house to cost $14,000.

City of Appalachia, Va., will issue $50,000 bonds for construction of water works. Address the mayor.

City of Newberry, S. C., voted to issue $40,000 bonds ror extension of sewer and water systems. Address the mayor.

The Eastern Wisconsin Traction Company, Fond du Lac, Wis., is planning to abolish line shaft changing to direct-connected generators. Will change from 8000-volt series direct-current to 660 volts, 7 lights in series.

Help Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

WANTED—Steam specialty salesmen on commission. Reiter Boiler Cleaner Co., Elgin, Ill.

SELLING ENGINEER wanted for steam condensers. Schutte & Koerting Co., Philadelphia, Pa.

WANTED—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. Address "M. M. Co.," POWER.

AN ENGINEER in each town to sell the best rocking grate for steam boilers. Write Martin Grate Co., 281 Dearborn St., Chicago.

WANTED—First-class foreman blacksmith, capable of handling shop doing both hand and machine work, and of developing new methods. Box 57, POWER.

DRAFTSMAN WANTED—Steam engine or turbine experience essential. Write, giving age, experience and salary required. The Terry Steam Turbine Company, Hartford, Conn.

Situations Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

SITUATION as Corliss engineer in some mill or plant. Box 58, POWER.

DRAFTSMAN—Three years' experience in engineering and steam turbine power station design, and three years in steel plant. Box 56, POWER.

CORNELL GRADUATE, age 32, desires position. Practical experience includes power plant and shop superintendence; electric and pneumatic power distribution; applications of electricity in manufacturing plants, particularly individual motor drive; specification work and correspondence. Broad knowledge of general machinery. Executive and business ability. Highest endorsements. Box 59, POWER.

Miscellaneous

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

WANTED—From 500 to 1500 horsepower of B. & W. water tube boilers in units of 250 horsepower each. Must be in A-1 condition. Inquire of J. F. Cargill, Room 1630, Frick Building, Pittsburg, Pa.

PATENTS secured promptly in the United States and foreign countries. Pamphlet of

The New Keystone Watch Case Co. Plant

How an Old Plant Was Remodeled and Made Uptodate During a Busy Period, without Interrupting the Service; the Units Installed

BY F. L. JOHNSON

When an engineer sees a new uptodate power plant operating in an industry where he knows for a certainty that only a short time before the same ground was occupied by old boilers, old engines and apparatus generally, and when he learns that the change from return tubular boilers to water-tube boilers, from slow-speed belted engines to higher-speed engines with electric generators on the shafts, from wide and long main driving belts to small wires, carrying power to widely distributed motors, and, in fact, from everything that was old in the methods of power transmission to all that is new, without a moment's interruption in the service, the story of the manifold steps in the transformation excites as much interest as, if not more than, the perfect working of the plant.

Early in 1907, as a basis for other improvements, the management of the Keystone Watch Case Company decided to remodel the power plant of the factory, changing it from a belt- to a motor-driven system which would embody all of the later and better improvements in individual and group machine driving. Some idea of the problems to be solved in the change may be had when it is understood that from the engine, boiler and pump rooms there were taken four horizontal return-tubular boilers, two pumps, three engines, one feed-water heater, four electric generators and two motors, with all accompanying smoke flues, steam and exhaust piping, switchboard, etc., and there were installed in these same rooms three water-tube boilers, three engines with direct-connected generators, six pumps, two air compressors, one elevator, switchboards, gage boards, oil filters for machine and cylinder oils with the necessary storage tanks and everything that goes into the makeup of a modern manufacturing power plant.

After the change was decided upon but before any work was started the chief engineer under whose direct supervision the project was to be carried out prepared a schedule or a sort of scorecard on which all the steps of the proposed renovation were set down in the probable order in which they would take place, it being his intention to mark all completed steps by drawing a pencil mark through each paragraph as the work indicated in it was completed. One copy was furnished to Treasurer and Secretary Charles M. Fogg, by which he was enabled to see at a glance just how much progress was being made from day to day.

After several consultations between the manager and the chief engineer, it was decided to proceed with the work, even though the demands on the capacity of the factory had never been greater than at that time. Contracts for the new equipment were given out and operations following the lines of a well-digested plan were begun. It being summer, when little power was needed for lights, one of

FINISHED WALL OF ENGINE AND BOILER HOUSE

the four 72-inch by 18-foot boilers could be spared. It was disconnected from the system and taken out, and in its place was installed the first of the three Maxim water-tube boilers, of 300 horsepower each which were contracted for. This boiler was connected to a temporary stack and to the engines by a temporary steam main. By means of forced draft and increase in coal used it was made to develop more than 300 boiler horsepower. In a shed just outside the engine room there was an Erie City Iron Works 12x12 high-speed engine, with a 70-kilowatt Diehl generator on the shaft, and wired to motors which were installed in different parts of the factory to drive the shafting that had been belted to one of the engines. The belted engine was taken out and in its place on a new foundation one of the two new Murray Iron Works Corliss engines which had been purchased was installed. Each of the new engines was what is commonly called direct-connected to Diehl compound-wound electric generators.

During the time that the engines were furnished with steam from the single Maxim boiler connected to its temporary stack, the permanent stack, which had been in use for 20 years and was in need of repairs, was relined with brick.

When the first Murray-Corliss engine was erected it was connected, like the high-speed engine in the shed, to the boiler by a temporary steam pipe and put into service. This, in connection with the small engine in the yard, furnished the electric current which through motors drove the entire factory, and another engine was taken out and in its place the second Murray-Corliss was erected.

As the work in the engine room progressed the boiler room was not neglected. In the place formerly occupied by the three horizontal tubular boilers which had furnished steam for the engines and pumps while the first Maxim boiler was being installed, there were two more Maxim boilers erected and equipped with temporary stacks. While the engines were being erected the permanent steam main was constructed.

Crane "Ferrosteel" extra-heavy nonreturn stop valves for a working pressure of 250 pounds were provided for the boiler nozzles, and to these the 10-inch extra-heavy steam main, with Van Stone joints and Crane "Ferrosteel" valves, was finally connected. This main after leaving the boilers runs first backward and then down by long-turn bends and passes under the engine-room floor, branching on the way to several directions leading to other points where steam is needed, either for heat or motive power. Individual pipes to each engine leave the main by long bends upward, passing considerably above the cylinders, and by return bends of long radius turned downward to the throttle valves. Notwithstanding several is used throughout and in the engine room this is covered by a jacket of planished russia iron with half-oval bands of brass at the joints.

In the pump room, which is on the boiler-room floor level, are six steam

CHIEF ENGINEER'S OFFICE

pumps of various sizes, four of which are so connected by the water piping that they may be independently or collectively used for boiler feeding or for fire pumps in addition to the regular Underwriters' fire pump, which stands alone in the fire-pump room at the right-hand end of the boiler room. All drips from the engines and pumps are led to a large settling and separating tank set below the floor of the pump room which, while it allows the water to flow away to the sewer, collects and retains all of the oil, which is automatically returned to the lubricating-oil filter tank. Settling and separating tanks are quite an important feature in this establishment, as all the waste water from the laundry and wash sinks is carefully treated for the purpose of recovering the gold and silver that are washed from the hands, faces and clothing of the operatives, something like $18,000 worth of the precious metals being recovered by this process each year.

Large quantities of hot water are used in all parts of the factory and in the laundry, where all of the outer clothing of the operatives is washed. This water is supplied from the boiler feed-water pipe leading from a 1000-horsepower Ferguson feed-water heater conveniently located under the engine room, a pressure regulating valve maintaining a constant pressure of 40 pounds on the factory system. The exhaust-steam and water piping are so arranged that the heater can be bypassed any time it is necessary to examine or repair the heater.

Although a delivery and erection of all of the steam and electrical apparatus necessitated in the new installation was required within 60 days of the date of the

FRONT WALL OF ENGINE AND BOILER ROOMS WHILE WORK WAS GOING ON

signing of the contracts, nothing that was not of the highest grade in design, workmanship and efficiency was considered; guarantees for efficiency and satisfactory operation under normal and overload conditions were exacted and exhaustive tests were conducted, substantiating by their results all claims made. Not until the new plant had been in operation several months and everything was going on in the regular routine was any attempt made to conduct tests. The boilers, three in number, are Maxim water-tube boilers, with the lower drum separated from the combustion space by firebrick arches and connected to the upper drum by six rows of specially bent tubes, the grates extending the entire length of the boiler, as described and illustrated in POWER of August 11, 1908.

Tests for the purpose of determining the capacity and efficiency of the boiler were conducted on April 1 and May 12, 1908, the results of which appear in the tabulated report on the opposite page.

The electrical apparatus for the plant was furnished by the Diehl Manufacturing Company, of Elizabethport, N. J., and consists of one 200-kilowatt and one 170-kilowatt engine-type generators, running at 125 revolutions per minute, and one 75-kilowatt generator operated at 250 revolutions per minute, for night and holiday service. During the changes from belt drive to motor equipment, two engines and generators did severe service, running night and day, with, very frequently, long 50 per cent. overload periods.

The motor equipment consists of about 60 motors, ranging from 2 to 30 horsepower, all except five being of slow speed, ranging from 350 to 600 revolutions per minute, mostly of the ceiling suspension type, and in many of the rooms the motors have been so placed that they are scarcely

REPORT OF TESTS AT THE PLANT OF THE KEYSTONE WATCH CASE COMPANY ON MAXIM WATER-TUBE BOILERS.

Date of test	April 1, 1908	May 12, 1908.
Duration of test	10 hours	10 hours
Number of boilers	2	3
Heating surface of each boiler	2,500 sq.ft	2,500 sq.ft.
Area of grate of each boiler	70 sq.ft	70 sq.ft
Ratio of heating to grate surface	35.7	35.7
Kind of draft used	steam blower	natural draft 0.44"
Average temperature of feed water	62.5° F	67° F.
Average temperature of steam	387° F	3[illegible]° F
Highest temperature of escaping gases	370° F.	667° F
Lowest temperature of escaping gases	300° F	310° F
Average temperature of escaping gases	312° F	381° F
Kind of fuel used	Buckwheat No. 2 or rice	
Total fuel used	13,800 lb.	22,400 lb
Moisture in fuel	1,104 lb.	1,344 lb.
Percentage of moisture in fuel	8%	6%
Weight of refuse	3,725 lb	4,946 lb.
Percentage of refuse	26.9%	23.16%
Total combustible (dry weight of fuel less refuse)	8,973 lb.	16,110 lb.
Quality of steam	99.5	99.16
Percentage of moisture in steam	0.5%	0.84%
Total water fed to boiler, actual	91,367 lb	181,458 lb
Water actually evaporated corrected for moisture in steam	90,911 lb.	180,186 lb
Equivalent water actually evaporated from and at 212° per pound of combustible	12.177 lb	11.145 lb

noticeable. The motors driving the polishing lathes are of the floor type, 4 to 20 horsepower, direct-connected to the shaft and running at an average speed of 320 revolutions per minute. The electroplating department and engine-turning rooms are equipped with motor-generator sets. The blower and air-compressor motors are of the variable-speed type, with a 2 to 1 variation.

Practically everything around the factory is motor-equipped, fans, elevators, pumps, exhaust wheels, blowers, mills, etc., motors being selected of types and speeds to suit the various conditions to be met. All the starting and controlling apparatus are of the Cutler-Hammer type.

The new boilers, engines and generators are located in the rooms occupied by the old apparatus. Every detail of this plant was worked out with such precision that no changes or alterations have been made since starting, and on the whole the plant will compare favorably with any in the country.

16X30 MURRAY-CORLISS ENGINE WITH 170-KILOWATT SOFT GENERATOR

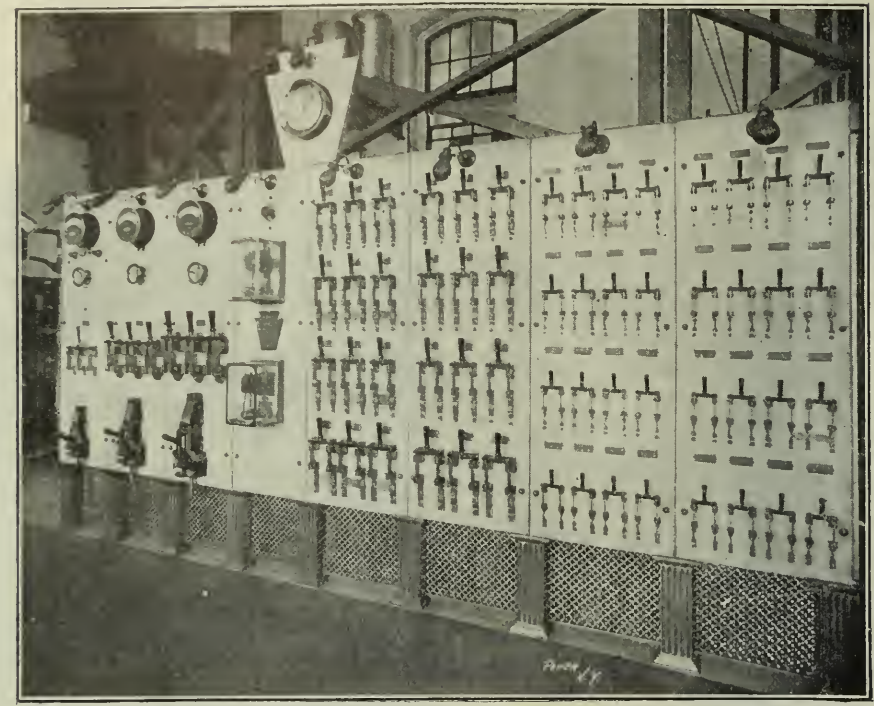
16X30 MURRAY-CORLISS AND 12X15 ERIE CITY IRON WORKS ENGINES, WITH 2[illegible]0 AND 70-KILOWATT SOFT GENERATORS

It was demonstrated by the acceptance tests of the installment that the guaranteed efficiency was far higher for all machinery than was provided for in the specifications. All the generators and motors have been run many times longer than three hours with an overload of more than 50 per cent., without sparking or heating above the limit specified.

The contract for the Murray Iron Works Corliss engines allowed an extremely short time, about 60 days, for delivery and installation, but each engine was delivered considerably ahead of time. The contract provided that the engines should operate noncondensing under a steam pressure of 150 pounds at 125 revolutions per minute, with a water consumption not exceeding 24½ pounds per indicated horsepower per hour. After the installation of the engines a 10-hour test, at which both parties to the contract were duly represented, was run on March 31, 1908, the water consumed by the engines being weighed to the boilers, and all the precautions taken to insure exact results. During this test, indicator diagrams were taken every 10 minutes, a nearly constant load being maintained, the results showing a water consumption of 22.36 pounds per indicated horsepower-hour. Succeeding this, a test was run for overloads, and upon the engine rated at 254 indicated horsepower a load of 400 indicated horsepower was maintained for several hours, an equivalent to 57 per cent. overload. The cutoff of the engine at this load shown by the diagrams, was 43 per cent. of the stroke and as the engine is of the long-range cutoff type, guaranteed to maintain control from lead to 5/8 of the stroke, it is evident that a considerably heavier overload could have been carried. The speed of the engine on the rated load tests was 127 revolutions per minute, steam pressure 140 pounds. On the overloads, the steam pressure was the same, and the speed fell to 126 revolutions per minute, showing a change in regulation maintained with an overload of 83 per cent. of less than 3/4 of 1 per cent. variation.

Both Corliss engines are equipped with Murray high-speed governor which operate at about twice the speed of the engine, while the economical features were the result of extremely close cylinder clearances, adjustable bearings and the special double-ported Murray steam and exhaust valves, with the valve gearing operated by double eccentrics and dashpots, so perfected as to produce instantaneous release at the desired moment.

The frames are of one-piece castings, designed by Frederick W. Salmon. An interesting feature is the introduction of a large wedge, controlled by a screw, placed immediately under the bottom bearing box, on each bearing, whereby the engine shaft can be kept in constant alinement, by the simple use of a wrench, as the babbitt wears.



SWITCHBOARD CONTROLLING ALL MOTORS AND LAMPS IN THE FACTORY

The engines have been in operation for about a year and a half and, notwithstanding the high speed under which they have been operated, show no signs of wear on any of the parts and have given no trouble, but have operated smoothly and easily during this time, although frequent overloads of 50 per cent. have been carried at various times. Fifty-six single-throw switches on the marble switchboard in front of the engines, with ample floor space both front and rear, give the engineer control of each group of motors and the lights in every department of the entire factory. This board was designed by the chief engineer and built to the specifications furnished by him, and, with its circuit-breakers, ammeters, voltmeters and automatic controlling instruments, provides for any demand or emergency

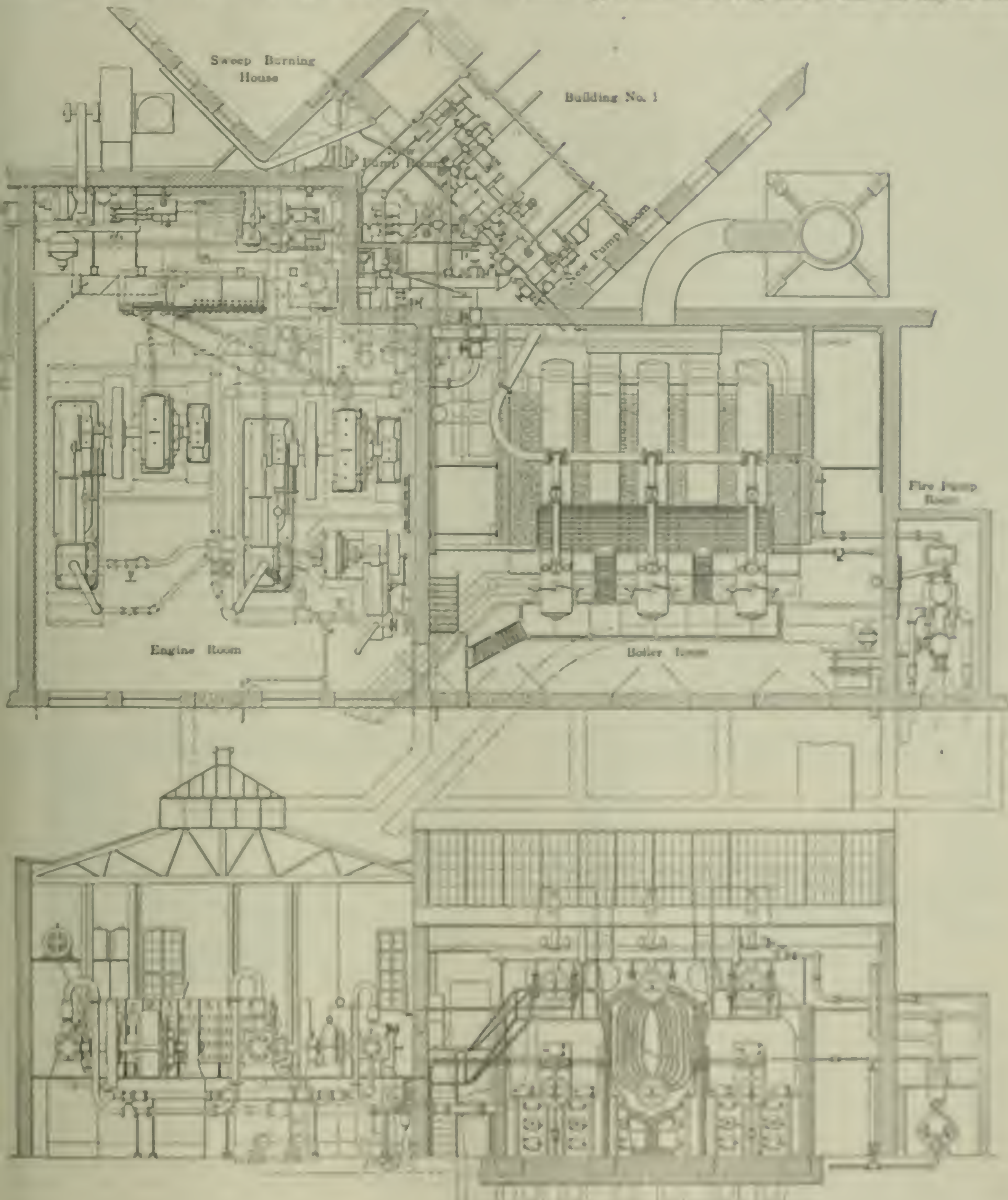
BOILER FRONTS DURING CHANGE

BOILER FRONTS AFTER CHANGE

that could possibly arise in the distribution of power.

From the extreme end of the boiler room where the 1000-gallon Wheeler Underwriters' fire pump stands ready for instant service, through the boiler, pump and engine rooms, through the machine, blacksmith and carpenter shops, to the chief engineer's office on the third floor, everything is at all times in first-class working order. Every detail gives evidence of thought given by a master mind. Chief Engineer F. Mink is a thorough organizer and from the daily reports in each department he makes up the complete report for the motive power department.

He can tell to the fraction of a cent the cost of power for each day of the year and his monthly statements show every item of expense. If it should appear that the motive power for December of one year cost more than for December of any other year, the statement shows whether this extra cost was due to labor, inferior or higher-priced coal, a few extra jobs for repairs, a new boiler tube, or what not. For more than 20 years these records have been kept and at a glance the cost of motive power for any month of that time and every item of that cost may be seen.



ELEVATION AND PLAN OF BOILER AND ENGINE ROOMS

Care and Management of the Horizontal Tubular Boiler

By William Kavanagh

The horizontal tubular boiler is very reliable and economical when properly handled and cared for. It is capable of storing large quantities of heat; its longevity is equal if not superior to any other type of boiler; it is cheap to install and repair; simple to handle and not at all difficult to clean, although one of the stock arguments against this type of boiler is that it is difficult to clean; when, however, the correct method of cleaning this boiler is properly understood there will be no difficulty found in keeping it clean and free from scale, making it one of the most economical boilers to operate.

Assuming that the boiler is under steam pressure and it has been decided to shut it down for cleaning, the correct way to clean it is as follows: Having shut the main stop valve, clean the furnace of ashes and whatever fire remains after the run, and close every door and damper on the boiler. Let the water remain in the boiler and allow the brickwork, boiler and water to cool together. When the process of cooling is over, open the safety valve and blow-down cock and let the water run off. After the water is out of the boiler, take off the manhole and handhole plates and put a wooden or other plug in the blow-down connection. Take a hose and enter the boiler on top, and having secured a light in a convenient position, play a strong stream of water between the tubes and around the shell, especially near the head flanges. It will be found that the most scale and mud will accumulate around the head

FIG. 3

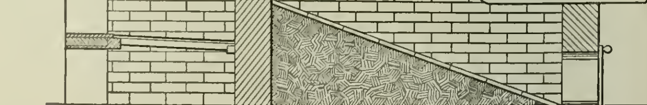


FIG. 4.

flanges and particular attention must be given to these parts.

Having given the boiler a thorough washing down, come out and, after playing a strong stream of water between the tubes either through the handhole or lower manhole, take a long-handled light hoe and collect all of the scale and mud at the nearest and most convenient opening. With a short, light hoe haul out all sediment and dirt. This part of the cleaning process being over, once more enter the boiler through the upper manhole and, having secured a light in a handy place, take a flat bar of sufficient length to reach from the top row of tubes down to and below the lowest row of tubes, as shown in Fig. 1, and swing this bar lengthwise of the boiler and between each row of tubes, being sure not to miss any of the rows, which will effectively clean out all scale.

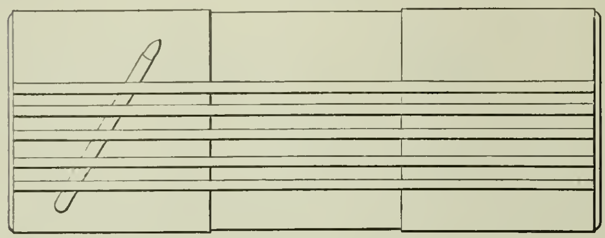


FIG. 1

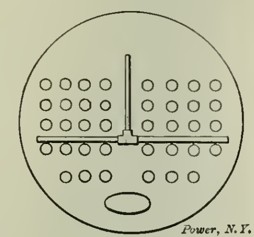


FIG. 2

When the use of the flat bar is finished, take a tee-bar, as shown in Fig. 2, and by placing it across and between each row of tubes and drawing the bar from head to head, all or nearly all of the scale lying between the tubes in the crosswise direction will be knocked down on the crown sheet. The scraping of the tubes being over, now inspect them to see how well it has been done.

While in the boiler have a boiler-room employee fix an incandescent lamp on a long, light, wooden or iron rod or pipe, and then by having the light placed beneath the tubes and shifted from row to row, and along the rows, you can look downward between the tubes and see how clean they are.

After this mode of cleaning the tubes is finished, play a fresh stream of water once more around the tubes and shell and then have all of the scale removed. Before leaving the inside of the boiler, inspect it for loose braces. By striking the braces with a light hammer you can easily discover if any is loose, and all braces found loose must be tightened.

When a loose brace is struck with a hammer the vibrations set up in the brace are long and slow, and the tone or "ring" is low. If the brace is taut, the "ring" or tone will be sharp and the vibrations short and rapid. A loose brace can also be detected by placing the thumb and forefinger on the rivet, when the looseness can be felt as the brace is struck. Again, a loose brace can be detected by comparing the ring of two or more braces having the same length and diameter. The ear can detect the difference in sound, the brace under the least tension having the lowest tone. Usually long braces are fitted with turnbuckles for the purpose of keeping them taut, while the short flat braces are riveted to the head and shell and are not provided with means for keeping them taut. The short braces seldom get loose.

Being satisfied that the braces are in good order, inspect the shell along the water line for corrosion, sometimes called "pitting" and "grooving." Pitting can be detected by dull, red spots, and grooving by seams, small channels or grooves. The corrosion runs along the line coincident with the hight the water is carried and will be heaviest where the hight of the water varies most.

When pitting and grooving occur sufficiently to cause a suspicion of the weakening of the shell or tubes, it will be necessary to follow up these signs and learn how deep the corrosive action has eaten into the metal. If of a depth to weaken the plate seriously, a hole should be drilled at each end of the groove or weakened spot and a patch riveted on. Corrosion attacks the tubes mostly near a point where they enter the boiler heads. By striking the tubes with a small peen hammer, the weakened tubes will become dented or bent inward. Good strong tubes are not easily bent or dented with a blow of a light peen hammer. All weakened tubes should be taken out and replaced with good ones.

After inspecting the tubes for flat spots, weakened or corrosive parts, inspect for leaky riveted seams. If a seam leaks, take a calking tool and close up the leak, and if a loose rivet is found it may be made steam-tight with the calking tool; if not, the rivet should be cut out and a fuller rivet inserted. The inside of the boiler having been properly inspected, pass out all tools, lights, etc., and enter the furnace and inspect the crown sheet for blisters, etc. That part of the crown sheet directly over the bridgewall should receive particular attention. By using a light ball peen hammer and tapping the sheet carefully one is apt to locate any weak spots or injured parts. If a blister is found the skin of the blister should be cut off and trimmed all round, as by doing this you will be enabled to tell the depth or thickness of the metal cut away and the thickness of the remaining sheet. If the sheet has been weakened too much a patch must be riveted over the weakened spot.

The back-connection sheet should receive a similar test to the fire sheet. The tubes in the back head must be inspected, as the portion of the tube extending beyond the head becomes eaten away by the action of the heat. If the handhole has been leaking for some time the head sheet will become corroded and weakened around the handhole. This is often a source of great danger, because when the boiler is under steam it is difficult to see if the handhole plate is tight or leaking. A good plan is to take an incandescent lamp and run its wires through a piece of pipe. Then by cutting a hole in the wall opposite the handhole the lamp can be pushed in near the boiler head, thus affording an excellent opportunity for inspection of the rear tube sheet.

Having thoroughly inspected the outside of the boiler, take out the plug in the blow-down connection, put on the handhole and manhole plates and make them tight. Take a stiff broom and attach it to a handle and rub off the dust from the fire sheet and tube sheets. Mix some fireclay to the consistency of stiff putty and plaster it around the rear handhole nut and stem. This will protect the nut and stem from the heat action. There are asbestos guards made for this purpose and their use will be found superior to fireclay.

In Fig. 3 is shown how the lamp is inserted through the hole at *A*. After using the lamp, the hole can be closed by dropping the door *B* over it. In this way cold air is excluded and the draft is unimpaired.

Fig. 4 shows an improved method of feeding a horizontal tubular boiler, and it will be noticed the feed water can be discharged either into the front or rear water arches, as indicated by the arrows. This method of boiler feeding does away with repairs to or falling rear arches, besides adding considerable heat to the feed water.

It is almost needless to add that in raising steam it should be done as slowly as possible, the slower the better; the steam gage and safety valve should be reliable and in good working condition; the gage cocks and water column connections should be clean and all passages free from scale.

Close Regulation of Ridgway Engines

The accompanying diagrams were taken from Ridgway engines and generators being installed in the Edgmere clubhouse, Edgmere, L. I., by C. F. Piehl, chief engineer, during two days' tests.

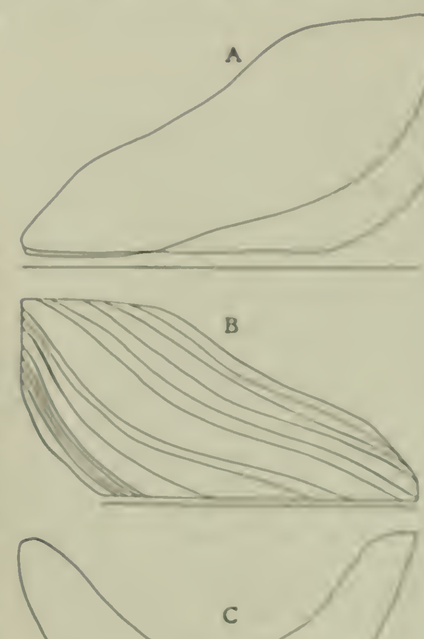
There are two units, one of 30 kilowatts, 125 volts and 325 revolutions per minute, and one of 50 kilowatts, 125 volts, 300 revolutions per minute. The 30-kilowatt set is for carrying the day load from 1 a.m. to 4 p.m., during which time the lighting load is from 80 to 100 amperes, and an additional elevator load, which consists of one Sprague 4000-pound-capacity passenger elevator.

The 50-kilowatt set is for the night service, from 4 p.m. to 1 a.m., when the lighting load is about 300 to 350 amperes, in addition to the elevator service. These conditions require very close regulation of engines and generators.

The governors are of the Ridgway type, applied to side-crank construction, and operate without dashpots. The very quick action of this governor is evidenced by card *A*, which shows that the governor made the complete change from full to no load in less than two revolutions, when the circuit-breaker was thrown out. The card *B* shows the change with a load quickly applied, which illustrates changes in the form of the card for different loads. Representative indicator cards are shown by *C*, *D* and *E*.

The full elevator load of about 140 amperes thrown on or off either of these units instantaneously produces a change of less than one volt in the circuit. With this amount of load thrown on or off instantaneously, and the two units in parallel, the instantaneous change of voltage is less than one-half a volt. These governors were tested with adjustment for a rise of speed of 5 revolutions when the load was applied and operated entirely satisfactorily. This was done to test their stability without dashpots. They were also adjusted to run at exactly the same speed, when fully loaded as when light, under which condition they operated without fluctuation, apparently as satisfactorily as when set for a falling off in speed of 1 or 2 revolutions.

The generators are of the Ridgway type, with compensating winding. With full load on the 50-kilowatt generator for 5 hours, the compensating winding rise was only 56 degrees Fahrenheit above the atmosphere, and on the 30-kilowatt machine, for the same length of time, 65 degrees Fahrenheit. The field-coil rise for the 30-kilowatt generator was 56 de-



INDICATOR DIAGRAMS FROM RIDGWAY ENGINES

grees Fahrenheit, and for the 50-kilowatt, 60 degrees Fahrenheit. The armature rise was 60 degrees Fahrenheit for the 30-kilowatt and 58 degrees Fahrenheit for the 50-kilowatt machine. The commutator rise was 65 degrees for the 30-kilowatt machine and [illegible] degrees for the 50-kilowatt generator.

According to a consular report, 1230 foreign students are enrolled at the nine leading German engineering schools.

"Phasing" Alternating Current Generators

Curves Explaining Principles Involved in Phasing Out, and the Result of Throwing in Parallel Machines Not Properly Phased Out

BY F. J. FOOTE

Phasing is not the same as synchronizing, although the two operations are very closely related. Briefly stated, phasing consists in determining whether the phases of alternating-current generators are connected in the proper relation to the switchboard or other apparatus.

The principles involved in phasing out and the consequences of throwing the machines together in parallel that are not properly phased out are best illustrated and explained by means of curves representing the names of electromotive forces generated by the machines.

In Fig. 1 is shown the armature connections for two machines connected through switches to busbars. These machines may be generators, synchronous motors, rotary converters, or a combination of any of these, as the problem is the same in any case. I have chosen two-phase machines for the explanation because two-phase curves are simpler than three-phase curves, and practically the same measuring applies to both two-phase and three-phase machines.

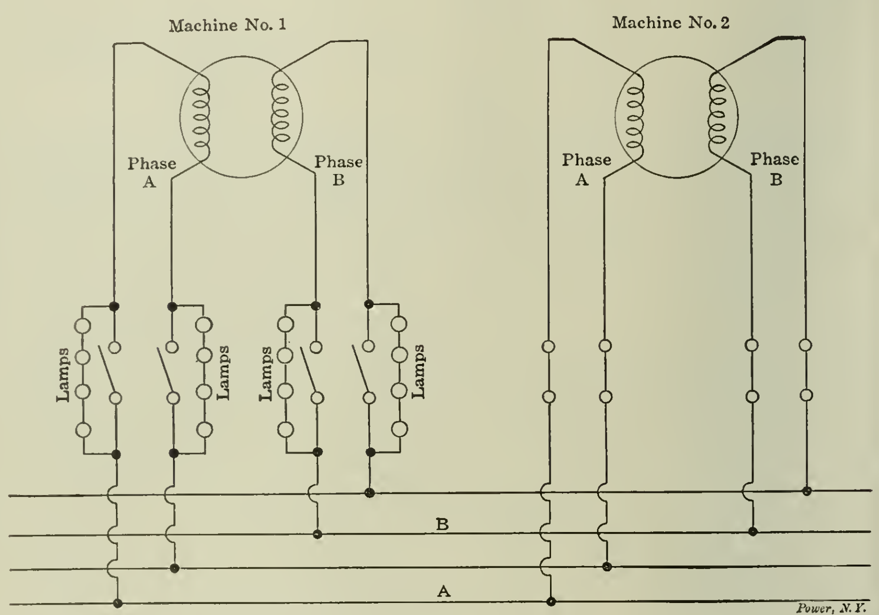


FIG. 1

In practice the machine to be put in service is phased simply with the busbars of the switchboard on the lines running to the machine, without considering the other machines that are already in operation. In the diagrams, however, I have shown the second machine in the hope of making the explanation clearer.

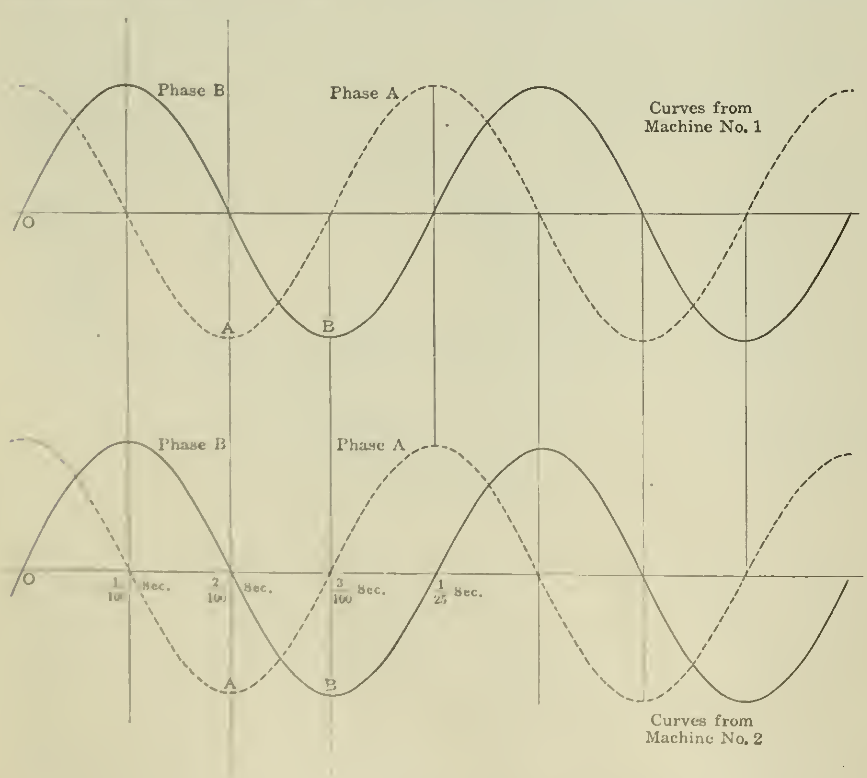


FIG. 2

How to Use the Curves

In Fig. 1 the switches of machine No. 2 are shown closed, while those of machine No. 1 are open. In this case machine No. 1 is to be put into commission. In Fig. 2 are shown the voltage curves for machines No. 1 and No. 2 of Fig. 1. The frequency chosen is 25 cycles per second, so that a complete cycle will occur in 1/25 second, as shown. In all these curves the distance horizontally is a measure of time in fractions of a second, and the distance vertically is a measure of the voltage at any instant of time. In all cases the curve generated by phase *A* is shown by dotted lines, and the curve generated by phase *B* is shown by solid lines.

Considering Fig. 2, the dotted curve *A* represents the instantaneous voltage generated in the armature coils of phase *A*. The straight horizontal line through the center of these curves is called the axis of the curves and at the instant a curve crosses this line it indicates that the voltage in the corresponding phase is zero. It is evident that phases *A* in both machine No. 1 and machine No. 2 reach their maximum at the same instant, so that if the *A* phases of the machines were connected together while they are running in this way there would be no tendency for current to flow from one machine to the other. The *B* phases of both machines also reach their positive and negative maximum values at the same

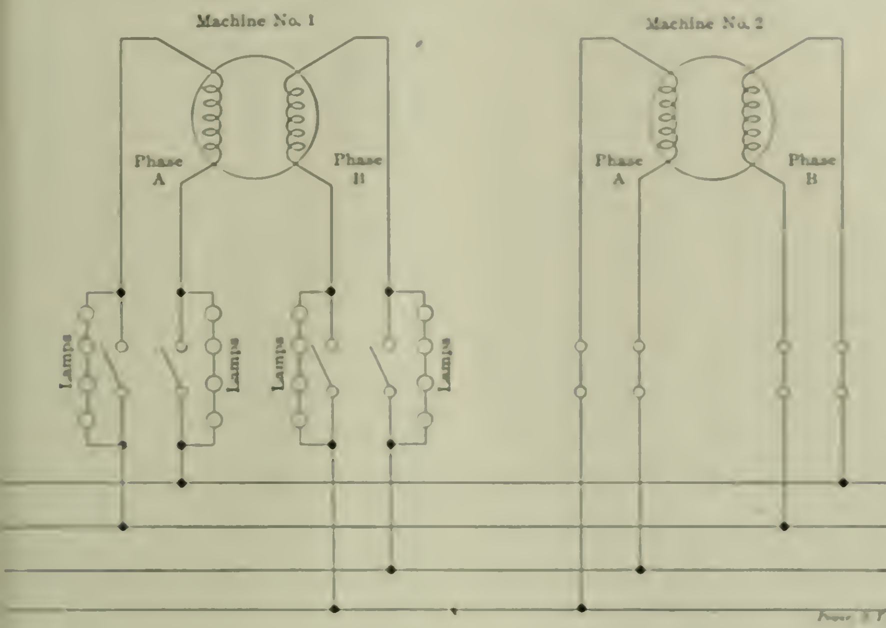


FIG. 3

instant, so that the *B* phases could also be connected together without tendency for current to flow between them. In other words Fig. 2 shows the correct conditions for throwing the machines in parallel, that is, they "phase out" correctly.

Suppose for simplicity that the machines represented diagrammatically in Fig. 1 have a normal voltage of about 400 volts, so that a bank of four 100-volt lamps in series would come up to full brightness if connected across one phase. If two such sets of series lamps are connected around the two open switches of phase *A* of machine No. 1, with both machines running at normal voltage, the lamps will alternately come up to full brightness, then become entirely dark, the rapidity of this action depending on the *difference* in speed of the two machines (assuming the machines to have same number of poles).

We can explain this action by means of the curves in Fig. 2, in this way: As long as the machines run at exactly the same speed, and the curves of the two machines have the relation they have in Fig. 2, the lamps will remain dark. As soon, however, as one of the machines, say No. 2, begins to lag behind the other, its voltage will reach the maximum at a later instant than that of machine No. 1, and there will be a tendency for current to flow from one machine to the other through the lamps. The more machine No. 2 lags behind No. 1, the greater will be this tendency, so that when machine No. 2 has lagged one-half cycle behind No. 1, phase *A* of machine No. 2 will be a maximum negative voltage, while phase *A* of machine No. 1 is at maximum positive voltage; consequently, the lamps on phase *A* will burn at full brightness.

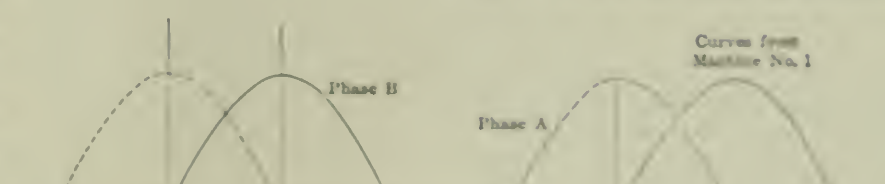


FIG. 4

How to Get a Clear Idea of the Action

A clearer idea of the exact action taking place may be obtained by placing a strip of transparent celluloid or very thin tracing cloth over the curves, say of machine No. 1, making a tracing of them, and then moving this tracing along, keeping the axis of the curves on the tracing cloth directly over the axis beneath. The vertical distances between the *A* curve of the original and that of the tracing at any point will be a measure of the voltage tending to cause current to flow through the lamps. Move the tracing along one-half a cycle, or a distance equal to that between 0 and 180. The maximum distance between the curves will then be twice the maximum hight of one curve, and since one machine gives 400 volts, the two machines connected as per Fig. 1 will give 800 volts, which will bring the eight 100-volt lamps to full brightness.

With the connections of Fig. 1, what was said about phase *A* will also apply to phase *B* in each case. Consequently, the lamps on both phases will glow and grow dark together. This is the test that shows that the machines are properly phased out.

Suppose that we have a case like that shown in Fig. 3, where by accident the phases are "crossed," that is, phase *B* of machine No. 1 is connected to phase *A* of machine No. 2, and phase *A* of machine No. 1 is connected to phase *B* of machine No. 2. In this case when the machines are running at normal voltage, the sets of lamps on the two phases will alternate in lighting up, the lamps on phase *A* being bright while those on phase *B* are dark, and vice versa.

By examining Fig. 4, the reader can

see just why this is. Fig. 4 represents the curves generated by the machines when the lamps on phase *B* of machine No. 1 (see Fig. 3) are dark. This is seen to be true since phase *B* of machine No. 1 is connected to phase *A* of machine No. 2, and curve *B* of machine No. 1 and curve *A* of machine No. 2 both reach their positive maximum values at the same instant, so that there will be no tendency for the current to flow through the lamps.

The switches on phase *B* of machine No. 1 could be closed under these conditions without injury to the apparatus, but this is not true of the switches on phase *A* of this machine. Again referring to Fig. 4 and remembering that the phases of each machine are one-quarter of a cycle apart, it is evident that phase *A* of machine No. 1 will reach its maximum one quarter of a cycle *ahead* of phase *B* of machine No. 1, and that phase *B* of machine No. 2 will reach its maximum one quarter cycle *behind* phase *A* of machine No. 2. In other words, phase *A* of machine No. 1 is one-half cycle ahead of phase *B* of machine No. 2. These phases being connected by means of the lamps, these lamps will be bright while the other lamps are dark, and the result of throwing the machines together at this time and with this connection would be to cause a heavy current to pass between these last named phases and might cause great damage.

How to Correct a Wrong Connection

Having discovered by means of the lamps that there is a wrong connection, the next thing is to decide how to correct it.

If it is desired simply to put the machines into operating condition without regard to the appearance of the connections, all that is required is to reverse the leads on either phase of one of the machines. It will then be found that the lamps will light up together, and the switches on both phases can be closed with safety.

A third case may occur from crossing the leads of one phase, as represented in Fig. 5, where the *B* phases are correctly connected, but the leads of phase *A*, machine No. 1, are "crossed" or reversed. In this case, just as in the previous case, the lamps will alternate in brightness.

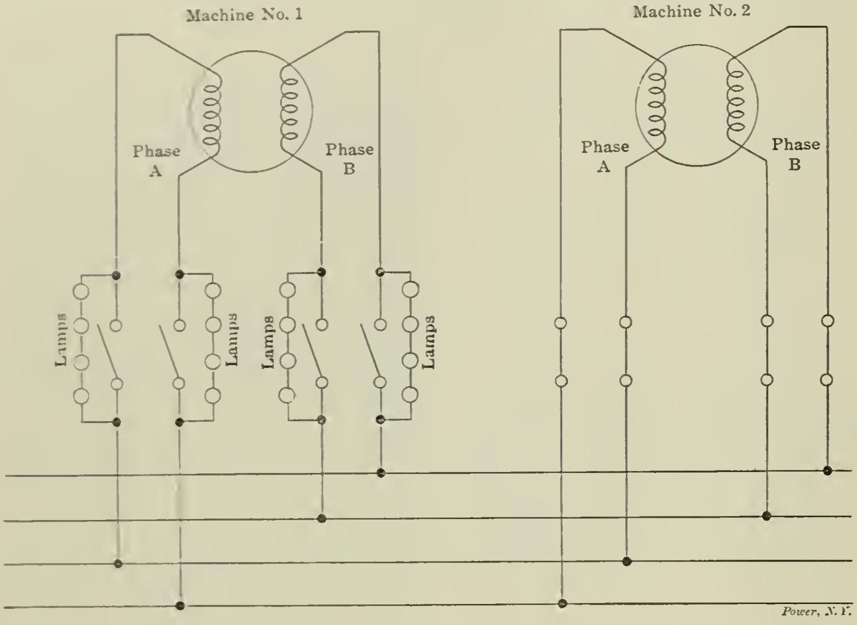


FIG. 5

The corresponding generator curves are drawn in Fig. 6. These curves show that when the *B* phases are in step, that is, they come to a positive maximum at the same instant, the *A* phases are in direct opposition, the *A* phase in machine No. 1 being at positive maximum and the *A* phase of machine No. 2 being at negative maximum simultaneously. The results of throwing the machines together with this connection will be just as disastrous as in the previous case. The correct thing to do, of course, is to reverse the leads of phase *A*, machine No. 1, although as far as operation is concerned the leads of phase *B*, machine No. 1, could be reversed instead, as may be proved from the curves in Fig. 6.

Where the operating voltage is below 400 or 500 volts, the method described of putting sets of lamps around the open switches will be found the simplest and most satisfactory.

Where the operating voltage is above 500 volts the direct method requires so many lamps that it becomes inconvenient and in such cases small transformers are used to "step down" the generator voltage to suit the lamps. The results with transformers are the same as with the direct method, but especial care must be exercised to make sure the connections are correct, because there are errors possible in using transformers that are impossible with the direct method.

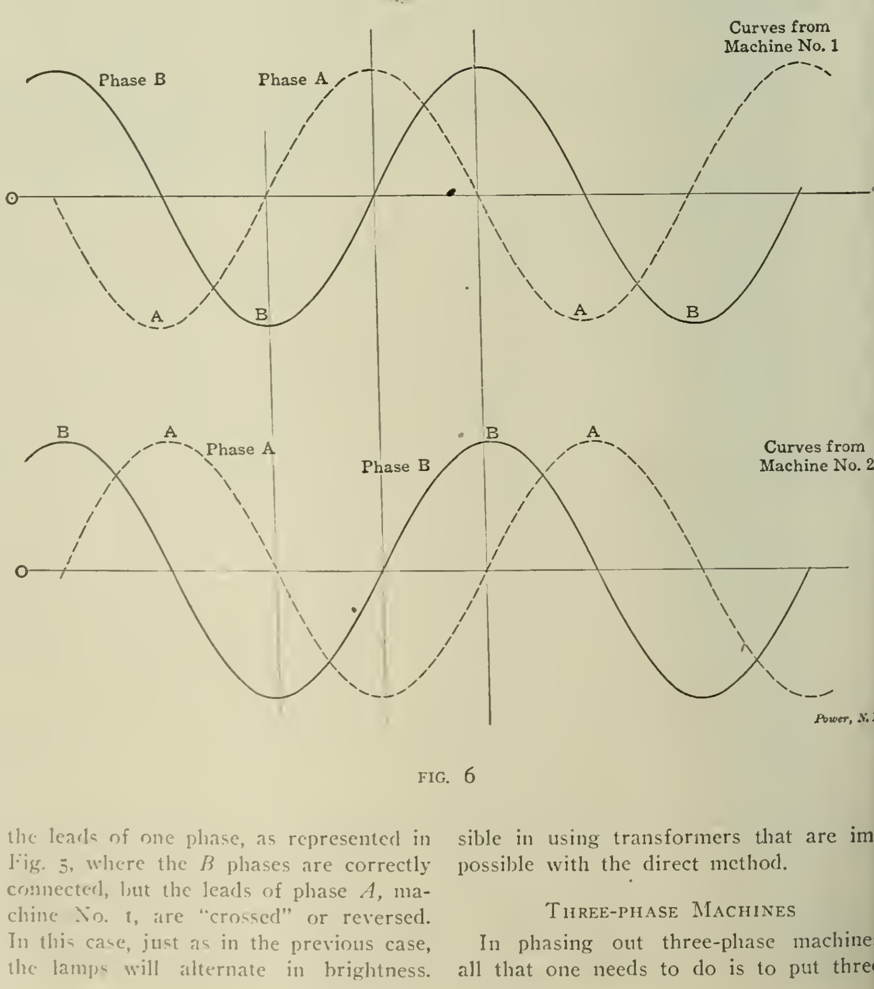


FIG. 6

Three-phase Machines

In phasing out three-phase machines all that one needs to do is to put three sets of lamps around the three open switches, or poles, of a three-pole switch, assuming, of course, that the direct method can be used. If the machine is properly phased out, all three sets of lamps will become bright at the same time. If not properly phased, the lamps will become bright at different moments, one set following another at regular intervals; in this case, if any two leads are reversed the machine will be properly phased.

Leather Belts for the Transmission of Power *

By Harrington Emerson

Leather is tough, elastic, strong, flexible and durable. Nothing has superseded it for the soles of shoes, nothing has superseded it for the uppers where real, not fancy, service is wanted. Rubber, although soft and tough, cannot compete. A good leather sole will outlast two sets of the best rubber heels, a good leather sole will outlast the hob nails with which it is studded. Canvas is not even thought of for soles. For durability in the rough service of a man's shoe, subjected to sopping wetness, to burning dryness, to cutting sharpness and to abrading grit, leather has held undisputed superiority over any other substance.

It is because of these inherent qualities that leather belting has been used for the transmission of power, and just as leather soles are more lasting than soles of either canvas or rubber or rawhide, so good leather belts are better than transmission belts of canvas or rubber or of rawhide.

Belts often have to run in damp or wet places. Before waterproofed leather belting was developed, leather belts deteriorated very rapidly under these conditions. Rubber belts by their very name gave promise of lasting longer, and they did last longer, but not as long as waterproofed leather belts last today.

The chief excuse for other substitutes for leather is that they are cheaper. If a leather belt which ought to last for twenty years is subjected to such wear and tear as to give out in a few weeks, it would be better to use a cheaper substitute, but in such a case it is preferable to improve conditions so that leather again becomes the cheaper. Hide from which leather is made even before tanning is one of the toughest substances in nature. The object of tanning is not to change the originally good qualities but to make them better. Both rubber and cotton are treated to give them qualities which they do not possess in their natural states. It is easy to test leather belting, for stretch and permanent set under load, for breaking strain, and ability to stand sharp bending. A knowledge of these will enable a belt repairer soon to become fairly expert as to quality. Similar tests cannot be applied to either cotton or rubber.

Leather belting is made from steer hides. Rubber comes from wholly different sources and its quality varies greatly; some contains as little as 1 per cent., other samples as much as 20 per cent. resin. The best grades of rubber come from Para, but there is no practical way of telling whether a sample of rubber is Para or not. Rubber is useless in its native state as it absorbs water and oxidizes. When mixed with sulphur at a temperature above 250 degrees Fahrenheit and below 300 degrees Fahrenheit a combination takes place which preserves the rubber and also increases its strength. After it has been vulcanized, as this process is called, 60 per cent. to 70 per cent. adulterant can be added. If natural rubber is overworked, if it is not properly vulcanized (each kind of rubber requiring different treatment), if it is adulterated with mineral oils, or if it is exposed to light, it deteriorates rapidly. Everyone knows that even the best Para rubber bands rot in a few years.

Recently, conveyer belting made of different materials was submitted to a sandblast test for 45 minutes and the loss of weight compared.

Considering best rubber belting as the unit:

Rubber	1
Balata	5
Woven cotton, 1st quality	5
Stitched cotton	8
Woven cotton, ordinary quality	12

The cotton belting wore out 5 to 12 times as rapidly as rubber belting, which in turn deteriorates much faster than leather belting.

Grease or oil will soon ruin any rubber belt, but a good oil enlivens a leather belt. Cotton belts are usually filled with oil, paraffin or other substances, the outside being coated with a waterproof pigment. When new they are fairly flexible but soon become as stiff as not to run true or straight. They are sensitive to atmospheric changes and require constant adjustment of the takeup to keep them at proper driving tension. The main claim for cotton belts is low first cost, but they should not be used for permanent installation.

Rubber belts are waterproof only when the cover is intact. If water reaches the duck through cuts or punctures in the cover, the duck absorbs water, causing the rubber to lose its hold, forming a blister which grows every time it passes over the pulley. The splicing of either rubber or cotton belts is always difficult.

Canvas is not as durable, is much less elastic, much harder to splice than leather belting. It is cheaper per foot, and if belting is to be neglected so that it is to be ruined in a few weeks or months, canvas belting would not cost as much, but if leather belting is properly cared for and maintained it will cost in the long run far less than canvas belting, which is peculiarly hard on shafting and bearings, owing to the variations of tension due to change of weather.

Rubber, if good, is much more expensive and deteriorates rapidly even if not used. There are modern waterproofing treatments which render leather belts capable of running continuously under water, so that even for installations of this kind leather belting can now be used.

The most highly efficient, reliable and cheapest power installations and transmissions with which the writer is acquainted are natural-gas engines with a leather-belt drive to main shafts, to countershafts and to machines. If in special cases there are serious practical operating objections to leather belting, other forms of transmission will have to be considered.

Because it did not require any high-class skill to install belting so that it would work somehow, most belting installations have been badly planned and badly installed. The makers of the earliest types of machine tools were also partly responsible for this. Not only was it cheaper to build a machine tool with light and narrow pulleys, but this feature was also a good talking point, as the very lightness of the pulleys and cones seemed to indicate that the machine tool would require very little power. If wide pulleys were made part of the machine, competitors at once claimed that this was because the machine was a power eater, and the argument had its effect. The consequence was that the pulleys were undersized and the belts were overloaded.

The sellers of highly accurate, carefully designed and carefully installed chain, rope and individual motor drives have not allowed the opportunity to escape to compare these modern transmissions with very inferior and out-of-date belting equipment. Because electric trolleys have replaced horse traction, because elevators moved by wire ropes have taken the place of stairs, because the modern automobile uses a chain drive, because high-speed steel has replaced carbon steel, conclusions have been fostered that all modern installations must be superior in the same degree to older methods. It is, however, not to be overlooked that recent years have brought about very great improvements in matters that were very old. Wheeled vehicles are very, very old, but both the bicycle and the automobile are wheeled vehicles. It is overlooked that the great efficiency engineer, F. W. Taylor, who discovered high-speed steels, then revolutionizing all modern shop methods and

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*Abstract of paper presented to the Leather Belting Manufacturers' Association, February 1, 1909.

practices, also, after nine years of observation and study, laid down rules for proper installation, operation and maintenance of belting. ("Notes on Belting." F. W. Taylor, part of Vol. 15 of the *Transactions* of the A. S. M. E.

If any industrial plant does not recognize the importance of high-grade installations of all kinds, a constant care over them and best maintenance, if it is to be a slipshod, happy-go-lucky plant (many plants are of this character), then it is better to install belting and stick to it, as it will stand more ignorance, abuse and neglect than any other installation.

One of the fundamental peculiarities of leather belting is elasticity. If belting were not elastic, could not stretch, it would lose most of its value as a transmitter of power. It fills the same purpose between shaft and tool that a pneumatic tire does between road and automobile or bicycle. It absorbs shock that otherwise would cause smashing and breaking, but it does more than this. If the strain becomes too great, the belt either slips or in the worst case breaks. In either case repairs are promptly made with minimum expense.

The inclination to change length under load or when the weather changes is the cause of all the legitimate wear on belts; it is the main difficulty in the way of correct operation and maintenance. A great majority of belt installations do not admit of adjustable pulleys, adjustable shafts, nor tightener pulleys by which the belt tension can be regulated. In the shops of the Santa Fe Railroad a method has been evolved which permits tightening belts, which could not be made endless, with very little trouble and delay. When first put on the belt was cut 6 inches short, and a 6-inch piece was used to fill the gap. This insert was connected at both ends to the belt by rawhide lacing or spiral wire hinge. At the end of a few hours the 6-inch piece was taken out, returned to the belt room and a 5-inch piece inserted. This change required a very short time. At the end of a day a 4-inch piece replaced the 5 inch piece, and as the belt gradually lengthened, shorter and shorter insert pieces were put in, thus at all times adjusting the tension to climatic and service conditions.

The whole of correct belting operation can be summed up in a very few principles. There should be allowed 1080 feet per minute of double belt, 1 inch wide, per horsepower. The lowest initial tension should be used under which the belt will pull without slip.*

A tension of 35 pounds per inch of double belt exclusive of load is sufficient. The result will be that the creep of the belt should be a minimum and extend through a very small angle on the face of the pulley.

A belt runs to the driving pulley under tension and it runs off the driving pulley slack or under less tension. When under tension the belt stretches. When the tension is lessened it shortens. This shortening must take place on the face of the driving pulley. The stretch must take place on the face of the driven pulley. As a consequence the belt creeps against the direction of its running on the driving pulley and creeps in the direction of the running on the driven pulley.

If the load is heavy, the stretch is great and the creep is great. If the load is light the creep is small. If the hug of the belt to the pulley is close, the creep, whether great or little, is through a small angle. If the hug of belt to pulley is poor, the creep whether great or little is through a large angle.

To insure, therefore, a minimum creep through a small angle the load should be light and the hug close.

Oak-tanned and fulled belts last longer, cause fewer interruptions to manufacture, stretch more evenly, cost less per year of service, require tightening less often and give less trouble when first started than others.

The belt itself must unroll straight, and be of even quality and thickness throughout.

The less the normal load the more elastic the belt can be.

The number of lineal feet of double belt, 1 inch wide, passing around a pulley per minute, to transmit 1 horsepower is about 450 feet.

The belt speed for maximum economy is between 4000 to 4500 feet per minute, but for main-drive belts it can be considerably higher.

Leather belts are more durable and work more satisfactorily when made narrow and thick rather than wide and thin. The best plan is to use single leather belts on pulleys less than 12 inches in diameter, double belts on pulleys less than 20 inches in diameter and triple belts on pulleys less than 30 inches in diameter.

The ends of belts should be either spliced or cemented or be joined by removable insert pieces, which may be either laced with rawhide or united by spiral wire hinge with removable rawhide pin.

Belts which will not run by the hug of their own sag, as long driving belts, should be put on or retightened under a stretch of ½ to 1 inch per 10 feet of belt.

Belts should be kept clean, soft and pliable.

Belts should be continually inspected so as to repair weaknesses and prevent breakdowns.

Pulleys should be 25 per cent. wider than the belts running on them.

They should be very smooth, very slightly crowned, if at all, it being essential that the crowning be absolutely central; the pulleys must be perfectly round, run true and be in perfect alinement.

Belts of any width can be successfully shifted backward and forward on tight and loose pulleys. Belts running 6000 feet a minute and driving 300 horsepower, are daily shifted on tight and loose pulleys to throw lines of shafting in and out of use.

Shifting pulleys are preferable to cut-off couplings or friction clutch pulleys for throwing heavy lines of shafting in and out of use.

Old-time belt installations and many present ones suffer from two main faults —lack of convenient means of shortening or lengthening the belt, and too high a working load. As a consequence belts stretched rapidly were subjected to excessive creep, wore out rapidly and broke often.

To provide some means of taking up the recurring slack, all the poor methods of belt fastening came into use, the English overlap, brass studs, riveted hinges, claws, unnecessarily large holes for rawhide lacing. To prevent the excessive creep and slip, all sorts of belt dopes came into use, from powdered resin up, and the maintenance and care of the belts were generally intrusted to the mechanic in charge of the machine.

A perfectly clean, soft hand will not slip easily even on smooth glass or polished wood. Leather was once skin, and soft clean leather will not slip easily on a smooth, bright pulley surface.

A belt ought to slip if the strain is too great. Keep the load down by making the belt large enough, let the hug be close, and there will be very little creep, or slip or wear.

In most mill and machine-shop installations, leather belting will prove least expensive to install, least expensive to operate and least expensive to maintain.

For distant transmissions, half a mile and upward, where it is impossible to subdivide the prime mover, as from a waterfall, electric transmission is the cheapest, although, per horsepower to be transmitted, first cost is very high.

For medium distance, where the power can be subdivided or closely located as from one mill to another, or from a water power several hundred feet away to a mill, the choice will lie between rope, either wire or fiber and shaft drive.

For immediate transmission, whether from steam engines, gas or oil engine, or electric motor to mill and shop machinery, the combination of shafting and leather belts is the best.

*This rule is not applicable to heavy main-drive belts. "Kent's Pocket Book," page 882 gives the reason for this rule. The question is not how narrow a belt can be to transmit a given horsepower but how wide it must be to transmit the given horsepower with the minimum cost in time and worry and power for reliable operation. A single belt 1 inch wide running 550 feet per minute may transmit a horsepower without immediately breaking, but it will not do it as reliably nor economically as a double belt running 1000 feet per minute.

Reclaiming Coal from the Culm Pile

Description of the Operation of Washeries in the Anthracite Region, by Means of Which Immense Quantities of Fuel Are Recovered

BY WARREN O. ROGERS

FIG. 1. A ONE-HUNDRED-MILLION-TON CULM BANK

As early as ten years ago the question was asked: "Cannot some use be made of the large banks of culm and waste found at all the collieries through the anthracite regions of Pennsylvania?" Up to this time the question had been actively discussed by anthracite men and something had been done toward reclaiming the smaller sizes of coal that had been thrown away years before. At several places coal-washing and screening plants had been established to wash out the small coal, consisting largely of chestnut, pea, buckwheat and rice, to be used for steam purposes. This industry has grown until the original huge culm banks are fast disappearing and in a few years will be worked out.

Culm Piles and Washeries

There are two different types of culm pile. The original culm pile consists of slate, bone and waste coal which was thrown away during the period when there was no demand for the smaller sizes of coal for steam purposes. As the accumulation had been going on for about twenty years, it is not surprising that the culm piles reached enormous proportions and that thousands and thousands of tons of good, marketable coal was mixed in with the refuse and only awaited the ingenuity of man to place it in a marketable condition. The first separator or washery for this purpose was erected about 1890, and the work has so progressed that at present practically every anthracite mine is reclaiming its culm piles at a cost which nets a very good return for the time and money invested.

The second type of culm pile which is being made today consists of very fine particles of dust and dirt suitable only for the manufacture of briquets or for pulverizing, to be burnt in suitable furnaces for this kind of fuel.

It is claimed by those who know that during the early operation of coal mining less than 50 per cent. of the coal mined was marketed, this inefficiency being largely due to the crude methods used in mining and preparing the coal for shipment. In those days a different idea was held as to the coal areas than is held

FIG. 3. CONVEYERS AT THE TOP OF THE WASHERY

FIG. 2. CULM ELEVATOR TO WASHERY

today, some thinking that the mountains in the coal-bearing district were one huge mass of coal. With a supposedly unlimited amount of coal in sight, it is not strange that considerable careless waste took place, and those who have traveled through the anthracite region have had their attention attracted to huge culm piles, in the vicinity of the mine shafts, which are directly traceable to the early wasteful methods of mining.

The smallest coal marketable prior to 1866 was the nut size which would pass through a $1\frac{3}{8}$-inch mesh and over a screen with meshes 1 inch square. A year later pea coal was first prepared for the market and, it is said, was a means of saving 15 per cent. of the total amount of coal mined. Buckwheat coal was introduced in 1877 for steaming purposes, and rice, barley and culm were first shipped to market during that year.

One reason why the character of the culm pile is different today than formerly is because the small sizes of coal, which then went to the culm bank, are now sent to market; the percentages running about 10 per cent. for chestnut, 20 per cent. for pea, 30 per cent. for buckwheat, 25 per cent. for rice and 15 per cent. for barley. It is estimated that during the past eighteen or twenty years more than 4,000,000 tons of coal for use under boilers has been saved from culm piles, and it is estimated that there still remains in the culm piles 286,000,000 tons of small-sized coal.

A washery capable of treating 500 tons of coal per day will cost about $30,000, depending largely, of course, upon the kind of machinery installed. In many instances old collieries have used old breakers by transforming them into washeries, in which case the cost of remodeling them amounted to an insignificant sum.

FIG. 4. THE TWO-DECK SHAKING SCREEN

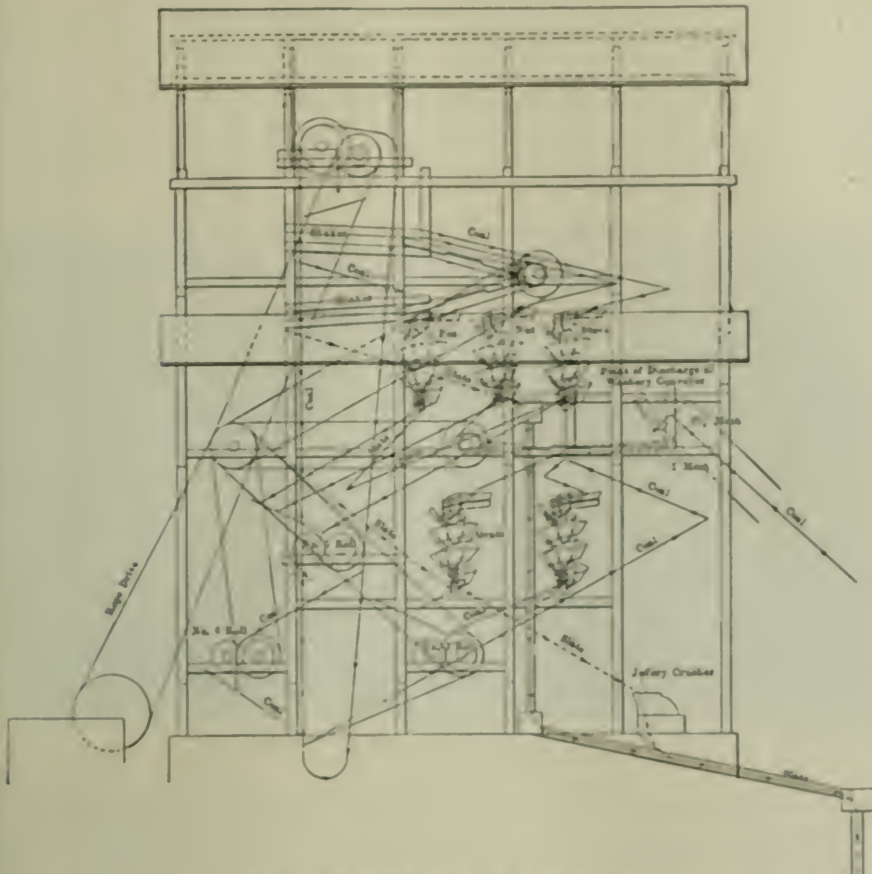


FIG. 5. ELEVATION OF NO. 2 WASHERY

Power, N.Y.

In washing the coal from the dirt, slate and bone of the culm pile the whole is usually elevated to the highest part of the building by a bucket elevator and discharged into a hopper placed over two screens, through which the material is separated into various sizes. The upper screen usually has 1½ inch openings for a part of its length and then the spaces become larger, while the lower screen contains ⅜-inch holes. In some of the older and larger washeries the material in passing over the first screen is dropped into a chute, where the usual method of hand picking of slate, by boys, is still observed. The largest sizes of coal, such as egg, stove and nut, are separated by means of screens. The chief machinery found in such a structure consists of screens, a picker roll, a crusher and the separators. In separating the culm from the coal, water is used in large quantities, it being estimated that approximately 500 gallons of water is required per ton of washed coal. After washing the silt from the coal, the water is usually conveyed through an iron pipe into abandoned mine workings, where it fills up the worked-out chambers.

Several methods are used in conveying culm to the washeries. In most instances the culm is flushed into a series of conveyers by water, the conveyers being from 100 to 300 feet long and placed in series, where more than two are used, one forming a permanent line to the washer and the other designed to allow for swinging or extending as the supply of culm in the pile recedes. A set of conveyers is usually operated by a separate engine. The general arrangement of a conveyer includes a wooden framework on which the conveyer runs, the conveyer consisting of an endless chain on which are suspended travelers which convey the culm from one end of the trough to the other, where it is delivered to the next conveyer, and so on, until it reaches the washery. The conveyers are fed with culm by means of water which flushes the material from the pile into the temporary trough. The water is supplied through a hose and nozzle and two men are sufficient to keep in continuous operation one of the conveyer systems, it being estimated that about 175 gallons of water per ton is necessary to do this work.

The Kingston Washery

It was the writer's privilege recently to visit the No. 2 washery of the Kingston Coal Company's mine, at Kingston, Penn., and following is a description of the method employed in washing the coal from the culm bank at this washery.

Fig. 1 is a sectional view of a tremendous culm pile in which it is estimated there are about one hundred million tons of material. It will be seen that there are two men engaged in washing the culm

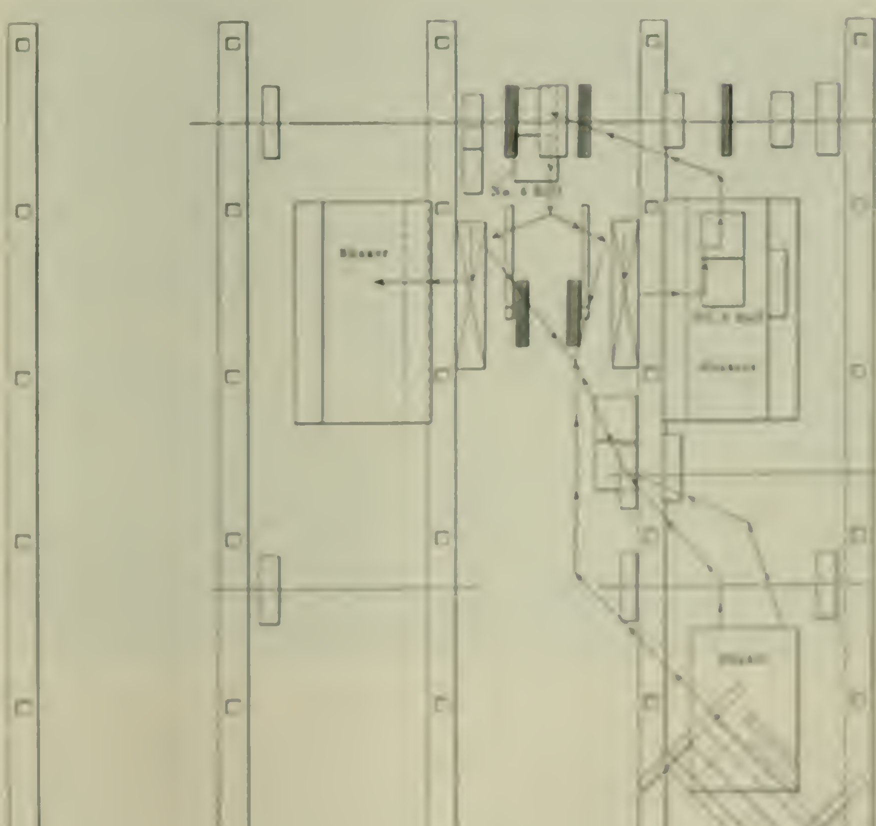


FIG. 6. PLAN VIEW OF NO. 2 WASHERY

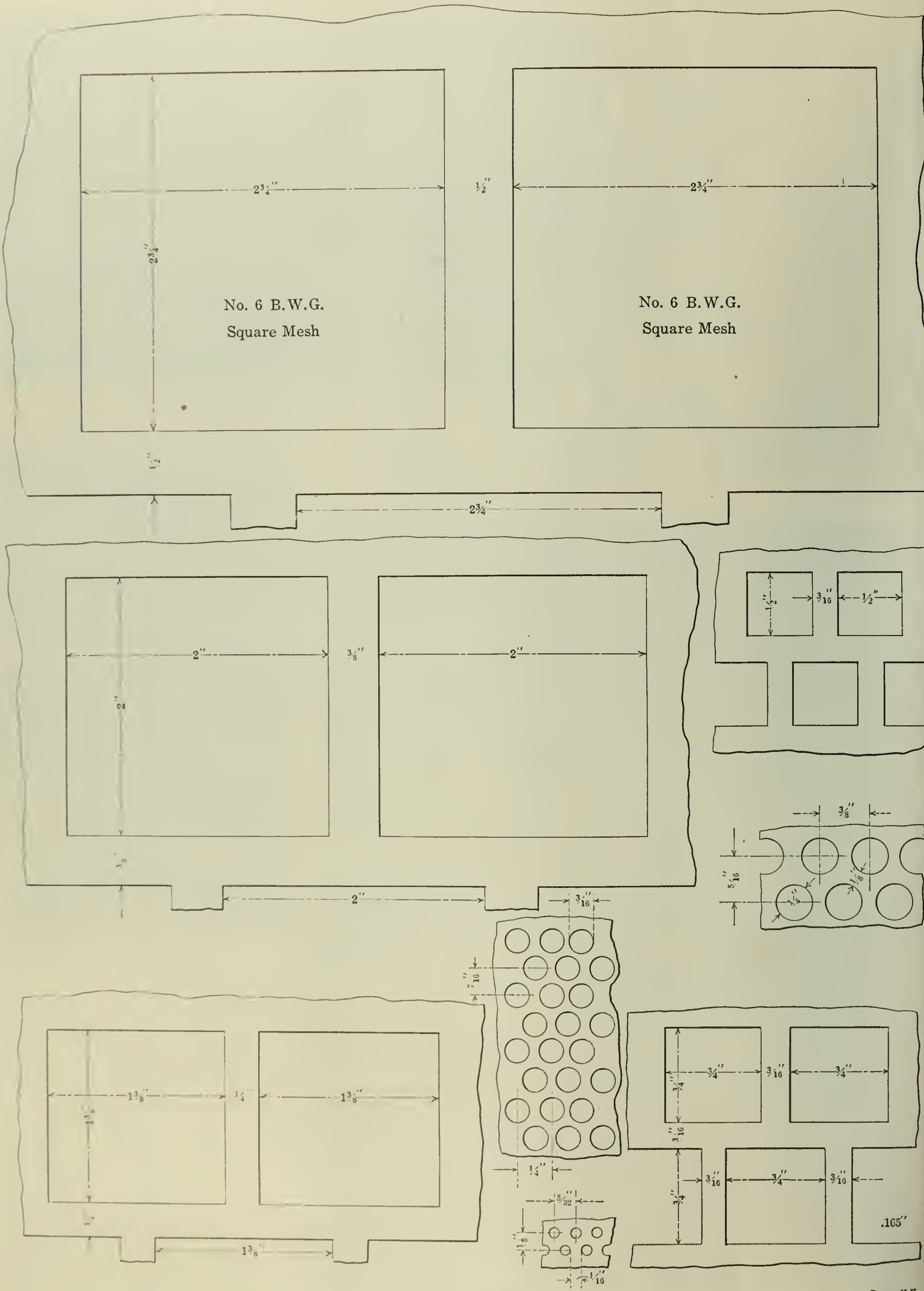


FIG. 7. ACTUAL SIZE OF SCREENS

down into the conveyer, one man reaching the highest portion of the pile, while the other directs the stream lower down, in order to maintain a constant supply to the conveyer system. The conveyers are kept as close to the foot of the bank as safety of the men will allow, as the bank frequently changes and slides out

FIG. 8. CRUSHING ROLLS

some distance at the bottom. Although there have been a number of men killed at different times and places, none has been injured at the Kingston company's works by being caught under the caving culm bank. It requires good judgment and care to keep the conveyers close enough to handle the culm economically and at the same time make it safe for the men who are handling the hose.

In this installation the conveyers carry the culm about half way to the top of the washery, as shown in Fig. 2, where it is discharged on a set of two-deck shaking screens, the top deck being jacketed with a 2½-inch square-mesh perforation. This carries over all pieces larger than egg-coal size. The bottom deck is jacketed with a 2-inch square mesh, which carries over the egg-coal size and drops through everything smaller, which goes to the main elevator, which in turn carries it to the top of the building by means of an elevator, Fig. 3, for further separation. The material which passes over the top deck is "grate" size, and larger, and is carried to a mechanical separator which takes out what coal there is in it, usually about 5 per cent. The balance, which is slate, goes to a Jeffrey swing-hammer crusher which pulverizes it, when it is carried away with the other refuse and silt to a bore hole and flushed into the old workings in the mine. The egg size is treated in the same manner. Fig. 4 shows a portion of the two-deck shaking screen, also the water used in washing the coal.

All of the large-sized coal taken out goes to No. 3 crushing rolls, Fig. 8, which grind it to stove size and smaller, whence it goes to the main elevator with the material which passes through the first set of shakers. The elevators each discharge on a bank of six decks of 6x15 foot shaking screens which size the coal into stove or 1¾-inch square mesh, chestnut or ¾ inch square mesh, pea or ½ inch square mesh, buckwheat or ¼-inch round mesh, rice or 1/8 inch round mesh and barley or 3/32 inch round mesh. A study of the plan and elevation of this washery, Figs. 5 and 6, will show clearly the paths

FIG. 9. SHAKING SCREEN FOR SMALLER SIZED COAL

of the culm and coal to their respective destinations, the path of the coal being shown by the direction of the arrows and that of the culm by the broken line. Fig. 7 shows the exact size of the various coal.

Stove and chestnut coal are handled in the same manner as the "grate" and egg, with the exception that the stove coal goes to a pair of crusher rolls similar to those shown in Fig. 8, which grind it to chestnut sizes, when it, with the chestnut from the separators, goes into another pair of rolls, No. 5, which grind it to pea and smaller sizes. The coal then goes to the elevator and is again taken to the top to be properly sized through the shaker shown in Fig. 9. All pea and buckwheat are put over mechanical separators which take out the slate and then go to the pocket ready to be loaded into railroad cars.

THE MECHANICAL PICKER AND THE SEPARATOR

In passing, it may be well to state that the mechanical pickers are fast displacing the breaker boys in the colliery breaker and many of the culm washeries. Although the breaker boy is a healthy-looking individual, as is apparent in Fig. 10, the indications are that he will soon be unnecessary for the economical operation of coal-mine breakers. The principal features of the mechanical picker are that no power is required to operate the machine; it requires but a small area of space, is lightweight and can be used on washed or dry material, giving three separate separations, that is, coal, bone and slate, or only two, coal and slate, as desired. It is also economical in first cost and in repair. The Farrel separator used by the Kingston Coal Company takes out the worst of the slate and rock of the larger sizes, and saves the good coal and bone to be ground into smaller sizes. On rice, pea and buckwheat coal the spiral separates the slate from the coal so as to make the coal clean enough for market.

Its operation is simple. The slate,

weighing more than the coal, has a greater friction, and therefore moves at a lesser speed than the coal. For this reason the coal works down through the separator at a higher velocity than the slate and, gaining sufficient momentum, flies off the outside edge of the runway, while the slate falls on the inside. The pea and buckwheat sizes are put over a mechanical separator which takes out the

FIG. 10. BREAKER BOY

slate in the same manner, and the coal then goes to the pocket ready to be loaded into railroad cars. The rice and barley coal goes direct from the shaker to the pocket, no preparation other than sizing being required. As the culm coal is thoroughly saturated with water during this process of separation while passing through the shakers, it comes out at the end ready for shipment in a thoroughly clean condition.

The washery foreman's troubles are not always ended when the coal is loaded in cars, because each car is subjected to a rigid inspection and, if not prepared to a fixed standard, must be dumped into elevators and taken back to the washery to be prepared over again. It must contain only a certain percentage of slate and bone; and it is also condemned if over or under size, or if not thoroughly washed.

Nothing of the culm pile is wasted and besides the benefit derived in reclaiming the coal by the washing industry, the surfaces are cleared of the unsightly culm piles and made available for other uses; and the flushing of the pulverized rock and silt into the old workings sustain their roofs, and also make it possible to remove more of the solid coal than could otherwise be done.

Throttles

By F. Webster

Wiley, the chief, went up into the switchboard gallery to do some stunts, and left Burns, the second engineer, at the throttle. It was not uncommon for them to have some entertainment when throwing in a 25-cycle three-phase unit to parallel the one that was getting overloaded. But the fun they had always experienced with the old engines was not a circumstance as compared with the "didoes" of the new cross-compound engine recently installed at the end of the power line farthest from the boiler room. Aside from the trouble of getting it right on the dot for synchronizing, it was often a case of either plunging or bucking after the start in parallel was made.

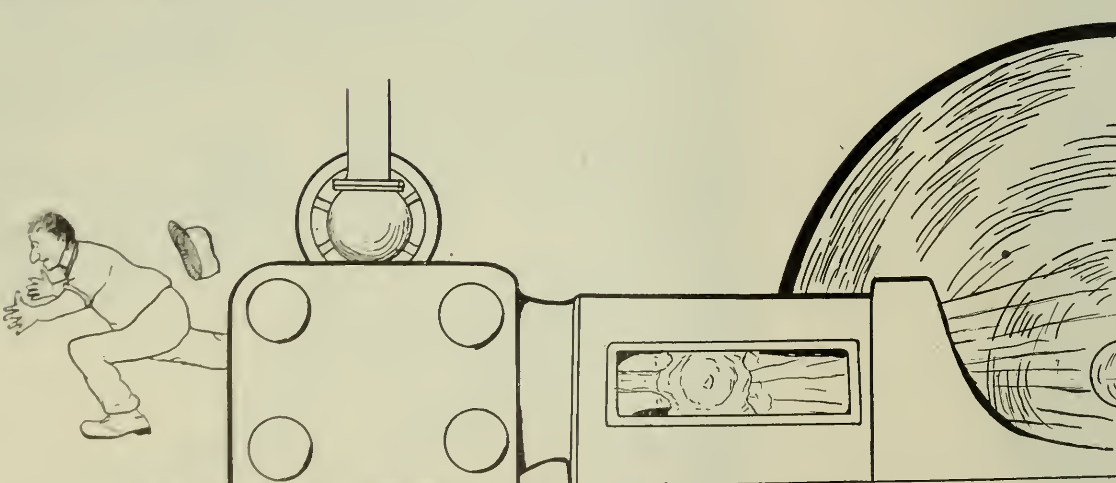
The engine acted very independent when it came to regulation, and neither coaxing nor argument had any effect in getting it to work in harmony with the other engines. Some of the station habitués said that the wild wail of the new generator-field cores made the engine daft. Those probably more capable of diagnosing engine diseases, however, believed that the eccentric straps and other reciprocating parts were so massive that the shaft governor was unable to drive the team at a steady gait. Sometimes the engine would plunge ahead and carry the whole station load, and then just as suddenly, maybe, take a notion to lie down and get pushed along as the generator motored.

In the meantime, before changes in the design of the eccentric straps and governor springs could be worked out and the new parts fitted, the big engine had to be operated a few hours each day; and our story opens on an occasion when all was in readiness for the testing out of the chief's new idea in engine regulation in connection with the synchronizing of three-phase 25-cycle generators.

Everything was running normally when some combination was made at the switchboard that caused the new engine to groan for a moment, and then it made a dash ahead at a record-breaking pace. No matter about the electrical connections that formed the combination for the shake-up, as the diagram will not be used again. There was a hair-raising clatter in the governor pulley as the parts concentric, eccentric and hyperbolic began to hit the stops, both a-coming and a-going. Burns let go of the throttle wheel and dropped into the condenser pit without touching the ladder. You see, the throttle wheel was located right in line with all the reciprocating and revolving combinations.

"Get back to your post!" yelled the chief.

"Stop chucking the engine, or else put the throttle where I won't get killed," piped Burns, as he stood on the ladder and peered over the edge of the floor.



"WHEN THE ENGINEER 'HIKES' FOR THE TALL TIMBER"

"All right, I'll stop," came from the switchboard; and as the engine seemed pacified, Burns went back to the throttle, but as cautiously as a rat making its first trip into the pantry.

Wiley came down from the gallery humming a Mother Goose melody with power-station variations.

"Oh, where should the throttle be,
The throttle be, the throttle be,

Oh, where should the throttle be-er
To save the life of the engin-e-er?"

Most any operating engineer can tell you of one or more of his experiences in the engine room—cases where he has been scared limp, and when he wished the throttle was located in a bomb-proof subway or over in some other voting precinct; anything in the world but to be compelled to stand up before belts or rope drives and that clacking aggregation on the engine shaft.

Illustrations have appeared frequently in POWER showing engine-room smashups in which flywheels and engineers were conspicuous by their absence.

SAFER IN THE BOILER ROOM THAN IN THE ENGINE ROOM

To most people, the statement may seem paradoxical that it is safer in the boiler room than in the engine room. Yet it is a fact that there is a greater loss ratio in the insurance of flywheels than there is on steam-boiler insurance. The applicant works out the boiler-seam problems with a flourish and gets a license to operate an engine. But how about the problem of the flywheel on his engine—its factor of safety against bursting or to prevent the arms from being ripped off the rim by a short-circuit?

This does not mean to imply that engineers are ignorant of flywheel theory, for they are not. For example, one enterprising engineer applied himself to the perfection of an engine safety stop that would be operated by the bulging effect of the flywheel rim between the arms when operating at a high speed. Surely this man knew what would happen, but he did not figure on furnishing a range finder and a field glass for observing the effectiveness of his invention.

The ancestors of steam-engine designers and of operating engineers came out of the same woods, yet the layout of some installations indicates a gap of several missing links between the two occupations. The designer becomes so absorbed in the weighty problems of first cost and of economy in operation that he fails to notice the spectacular gymnastics of the engineer as he leaps the loop on the flywheel to start the engine, or when he "takes" for the tall timber or the cave lands to escape a shower of power-house debris. It would be a joke were not the ending like that of a circus acrobat who dares perform without a net—six weeks in the hospital and two months on crutches.

A comparison of different makes of engine in the same service shows the throttle wheels located at all the cardinal points of the compass, with an occasional tendency on so-wester to spare. The location selected is often treated as a trivial matter worthy of only a few moments consideration, but for the engineer it is a lifetime.

There are branches of power-engineering service other than the power station where the convenience and safety of the operating engineer is not always considered, notwithstanding the fact that human life is more valuable than any kind of a power station. Recently a large order of switching locomotives was completed by a prominent builder. An examination of these locomotives showed that the engineer could neither stand nor sit except in positions of discomfort or danger, and more fatigue would be caused by his trying to get next to the work than in actually performing the running operations. If the history of these engines could be correctly written, no doubt it would be found that others besides the engineers were made to suffer on account of the poor work of the designer.

Cooling Gas Engine Jacket Water

By JOHN S. LEESE

As one of the chief reasons for installing gas engines instead of steam engines is often poor water supply at the desired locality, the repeated use of the circulating water is quite a live question. This applies especially to engines of small power, say up to 80 or 100 horsepower, since these are usually installed in out-of-the-way places.

The volume of the cooling water necessary for a 100-horsepower engine is considerable, and if it were simply run through to the sewer the water bill would be a large item in the running expenses. The usual provision for cooling the water so that it can be used again consists of tanks connected up so that thermo-siphon circulation can take place. These tanks take up considerable space and are often an eyesore to the neighborhood, and again they are often inadequate to cool the water sufficiently. The accompanying sketches illustrate a method of cooling jacket water, which is cheaper to install and gives less trouble in operation than any other method the writer knows of.

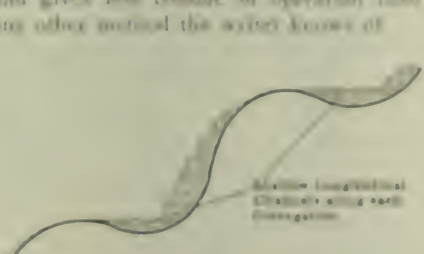


FIG. 2

In a corner of the yard, against a wall as near the engine room as possible (and, if possible, in a place where the sun never shines directly) put up a piece of ordinary corrugated iron, with not too shallow corrugations, as shown in Fig. 1. The slope should be determined by having it so that there is a longitudinal channel along each corrugation just sufficient to hold a shallow layer of water; this idea is indicated in Fig. 2. The object of these channels is further to cool the water as it flows down the sheet, by letting it flow into a channel full of cooler water at each corrugation.

The corrugated iron sheet must be kept as flat as possible to avoid the water flowing together toward a depression, thus lessening the cooling surface and reducing the efficiency. A good method of supporting it is to spike it to three stout timbers, as shown at A in Fig. 1. These timbers should stop about 9 inches from the bottom end of the sheet, which should be about 9 inches from the ground or floor level. The sides of the sheet should be bent up enough to prevent the water running off there, and the bottom corrugation should end with a downward curve or wave (Fig. 3), because if it ends with a level or upward part of the corrugation, the water will tend to creep round under the sheet, due to capillary action, and will not drop off in a square, clean sheet.

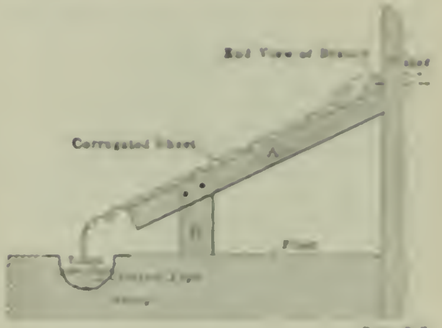


FIG. 1

A trough to receive the water at the floor or ground can be made in concrete or out of the old drain pipes. The trough should slope toward one end (that being more convenient to apply the outside pipe than the middle) and the water should drain into a sump where the pump suction intake is situated about 4 inches from the bottom. A strainer, made of brass-wire gauze wrapped around a perforated cylinder, should be used to keep extraneous matter out of the jackets. This completes the cooling plant.

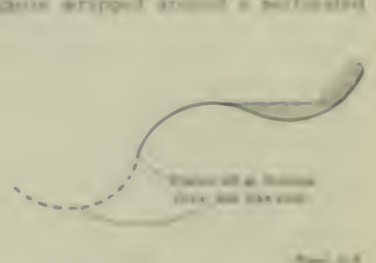


FIG. 3

If desired, the water can also be passed through a small storage tank, although if the cooler is designed properly for the engine horsepower and the jacket-water flow properly regulated, it is sufficient. I find that in a strong wind a piece of canvas suspended about 12 inches above the corrugated iron to shade it, and "doused" occasionally with a bucket of water, keeps the system in efficient condition.

As regards the feeding of the water onto the cooling surface, the outlet pipe is brought to a tee with the arms extending right and left along the top of the sheet

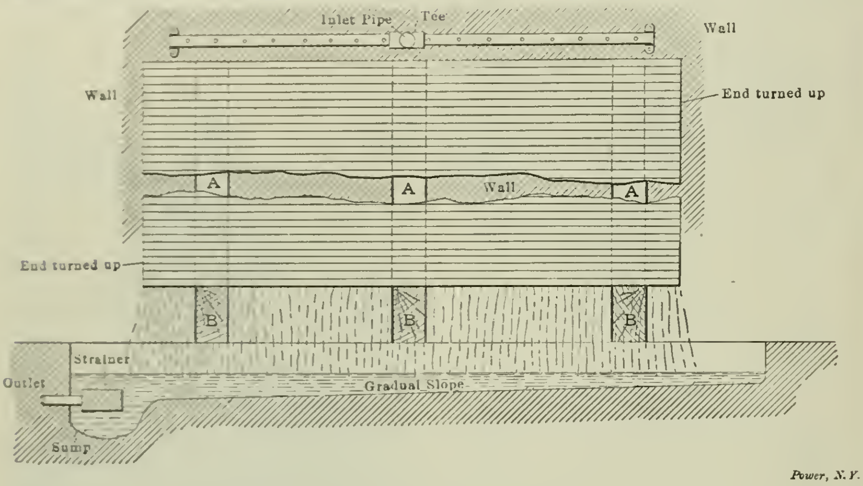


FIG. 4

an inch above the top. These arms are plugged at the ends and holes drilled in them with a total area equal to the area of the outlet pipe. This is shown in Fig. 4.

Catechism of Electricity

1066. *Illustrate and describe in detail the construction of the magnet poles.*

From Fig. 297, which shows one of the magnet poles before it is cast into the frame, it may be seen that the pole is built up of sheets (these are annealed steel) of two different widths *c* and *e*, assembled so as to form the size and shape of the pole pieces. The minute spaces between these laminations and the slight oxidization on the surface of each sheet tend to reduce eddy currents in the pole faces so as to decrease the iron loss and increase the efficiency of the machine.

The poles are slotted parallel with the shaft as shown at *n*, to prevent as far as possible the distortion of the magnetic field at heavy loads. The shape of the ends at *m* is such that when the molten metal is poured into the mold for the yoke, it grips the bases of the poles firmly and makes a good mechanical and magnetic joint.

1067. *Are direct-current generators ever built with more than two bearings?*

Large direct-current generators designed for belt drive are often built with three bearings. Fig. 298 shows a six-pole generator of this class built to supply current to a street railway system. It differs from the generator shown in Fig. 296 in that the bedplate, bearing pedestals and field magnet yoke are separate castings.

1068. *Illustrate and describe in detail the construction of the armature.*

Fig. 299 shows the armature partly wound; the core *a* is built of mild sheet-steel stampings which are japanned before assembling to reduce the eddy-current losses in the core. The armature-core disks are assembled under heavy pressure and held together by bolts passing through both halves of the armature spider, which are keyed to the shaft. Air ducts, *c*, extend from the inside up through the armature windings, and air is forced through them by the motion of the armature.

The armature coils are made of wire or bar copper, according to the capacity of the machine, the latter being employed when large currents are to be carried. These are form wound as shown at *s* to make all coils of the same shape. All coils are wrapped with linen tape, dipped in insulating varnish and baked. The slots of the armature core are also insulated as shown at *e* to afford additional protection to the coils. The coils are held at the ends of tinned-steel band wires beyond the ends of the core, where the cylindrical ribbed flanges *h* and *l* of the spider support the ends of the coils and secure ventilation around the ends of the coils from the interior of the core. Wooden wedges, in notched grooves in the slots below the surface of the core, hold the coils within the length of the core. The commutator segments *o* are assembled on a drum mounted on an extension of the armature hub. The segments are securely held on the drum by

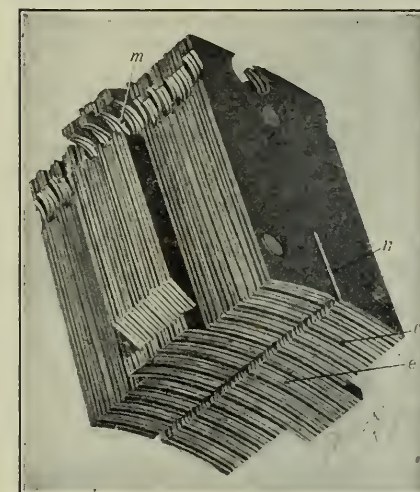


FIG. 297. LAMINATED POLE PIECE BEFORE BEING CAST-WELDED INTO THE FRAME OF THE FORT WAYNE GENERATOR, FIG. 296

end flanges at *b* and *r* which clamp over the beveled ends of the segments and draw them together.

Equalizer rings are placed between the commutator and the armature core and are connected to the armature winding at equipotential points as explained in a previous description.

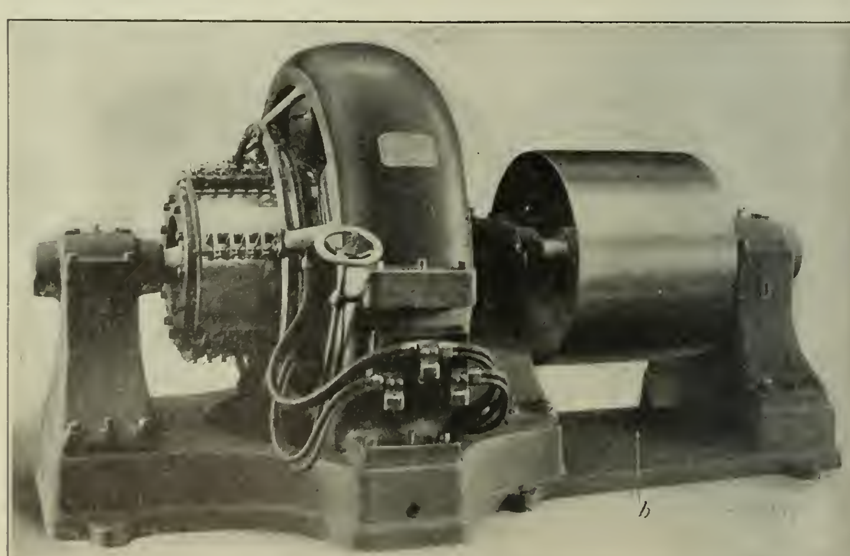


FIG. 298. FORT WAYNE THREE-BEARING MULTIPOLAR GENERATOR

1069. *Are solid field-magnet poles ever cast into the yoke?*

Yes; Fig. 300 shows the parts of a four-pole shunt-wound direct-current generator embodying this construction. The assembled machine is shown in Fig. 301.

1070. *Describe the construction of the generator shown in Figs. 300 and 301.*

The frame is of cast iron and the poles are of steel-circular in cross-section, and cast-welded into the frame. The armature core is built up of sheet-steel disks mounted directly on the shaft in the smaller sizes and on a cast-iron spider in the larger sizes. In both cases they are clamped together so that the pressure is applied near the slots. The coils are form-wound, taped and dipped in an insulating varnish; finally they are put in an oven to bake the varnish. There are longitudinal ventilating holes in both armature core and commutator, and through these, as well as between the commutator tails, air passes freely while the machine is in operation and assists in cooling the armature. The field-magnet coils are wound on circular forms, and are heavily insulated and protected by a tough, moisture-proof covering. They are held in place by pole-shoes fastened to the ends of the magnet poles.

The brushes slide in box holders and are pressed against the commutator by adjustable springs. The studs carrying the brush holders are attached to, but insulated from, a rocker arm by means of which all of the brushes may be shifted simultaneously around the commutator. The armature shaft is made of machinery steel, ground to size. It is made larger in the journals than in the projecting end, so that if worn or damaged from any cause the journal may be turned down without reducing its diameter below that of the projection. The leads from the field coils and brush holders are connected to the inner ends of brass studs which pass through the magnet at each side and are insulated therefrom by porcelain bushings. Although the dynamo selected for illustration is shunt-wound, this type of machine is also built either series or compound wound.

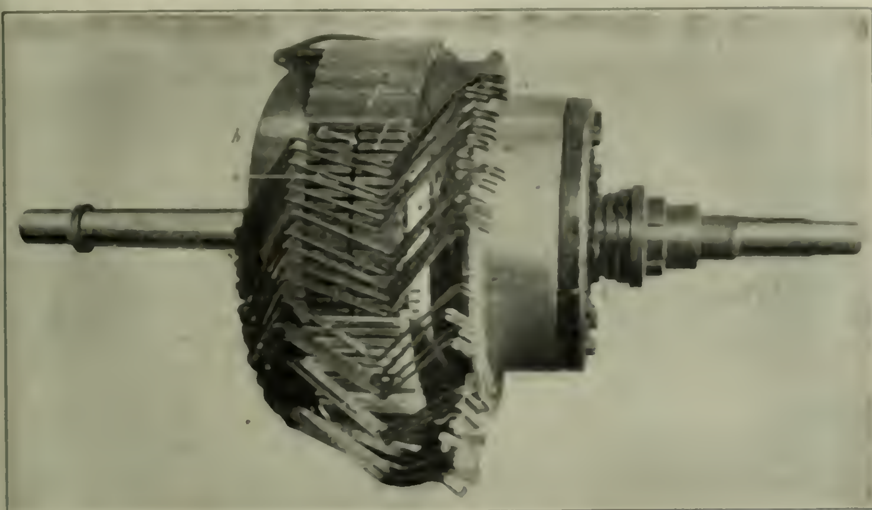


FIG. 299. PARTLY WOUND ARMATURE OF THE FORT WAYNE GENERATOR SHOWN IN FIG. 298

FIG. 301. CROCKER-WHEELER FOUR-POLE SHUNT-WOUND GENERATOR

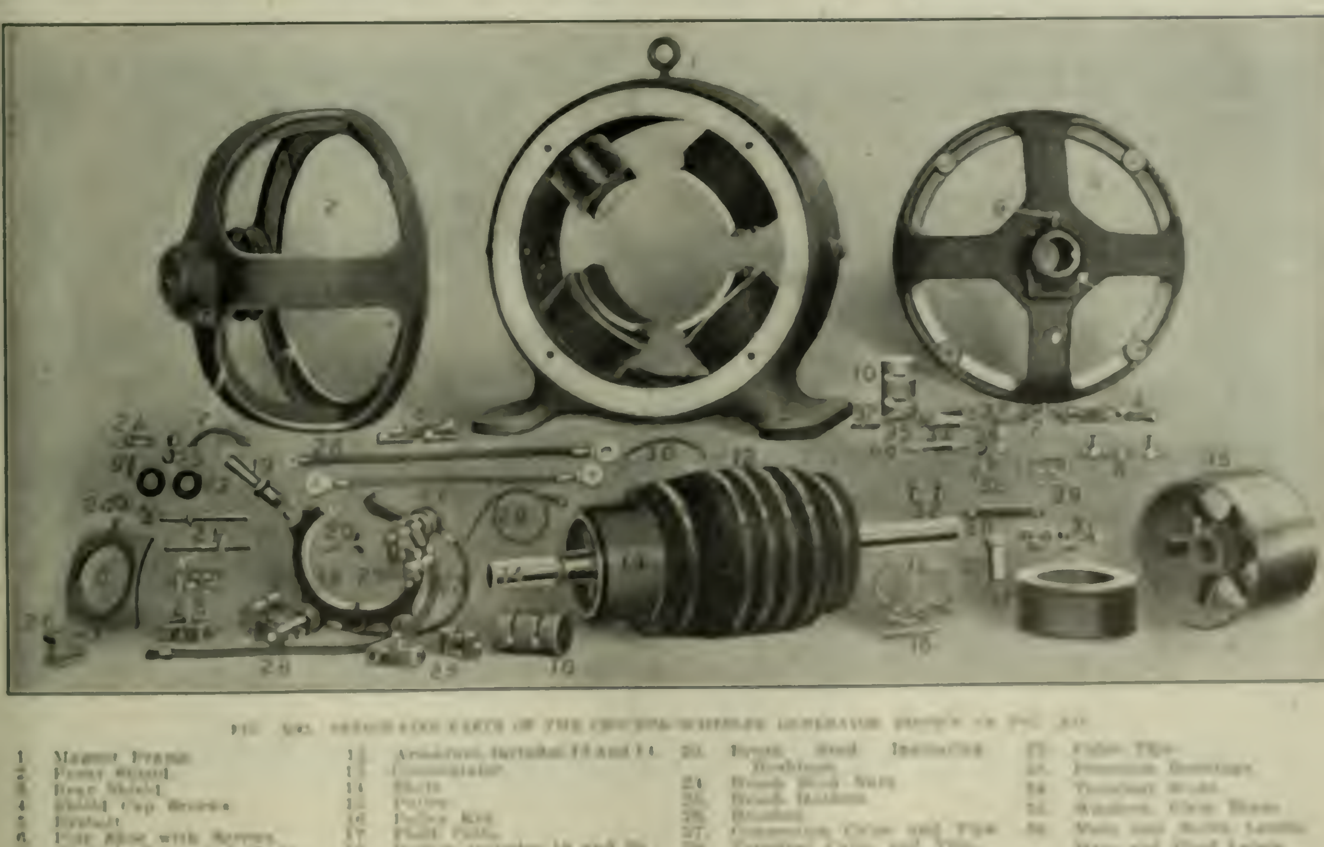


FIG. 302. SEPARATED PARTS OF THE CROCKER-WHEELER GENERATOR SHOWN IN FIG. 301

1	Magnet Frame	12	Armature, Includes 13 and 14	23	Brush Stud Insulating Bushings	32	Cable Tips
2	Front Shield	13	Commutator	24	Brush Stud Nuts	33	Porcelain Bushings
3	Rear Shield	14	Shaft	25	Brush Holders	34	Terminal Studs
4	Shield Cap Screws	15	Pulley	26	Brushes	35	[illegible]
5	Eyebolt	16	Pulley Key	27	Connection Cable and Tips	36	[illegible]
6	Pole Shoe with Screws	17	Field Coils	28	Terminal Cable and Tips	37	Terminal Stud Nuts
7	Oil Hole Cover and Chain	18	Rocker, Includes 19 and 20	29	Shunt Cable and Tips	38	[illegible]
8	Oil Gages	19	Rocker Handle	30	Shunt Field Connector	39	[illegible]
9	Journal Screws	20	Wing Screw	31	[illegible]		
10	Journal Boxes	21	Brush Studs				
11	Oil Rings	22	Insulating Washers				

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Pneumatic Oiling System

Herewith are an explanation and illustrations of an oiling system which is not advanced as anything new or original, except that the oil is all practically handled by compressed air, instead of by gravity feed or direct pump pressure.

Such a system has the advantage that the new oil in being drawn from barrels does not enter the power station at all, the barrels remaining outside of the building, as shown in Fig. 1. The vacuum in the oil tank is induced by the pipe running to a Conover independent condenser. There is no oil wasted nor spilled by this method. All filters, oil tanks, pumps, etc., are below the engine-room floor, where they can all be attended to by one attendant. There are no unsightly tanks on the wall of the engine room.

This system consists of five tanks, Fig. 2, arranged in a row; the first four receive the waste-oil drips from all the engines, which filter down through waste, and up through water in the bottom of the tank, flowing from the top of the water out into a header pipe common to the four filters, and discharging into a receptacle at the top of the tank *A*. This tank has five ½-inch pipes, with valves attached, arranged around the circumference of the receptacle at the bottom, and discharging through these into five wire-screen cylinders, closed at the bottom, and wrapped with toweling, through which all the oil filters.

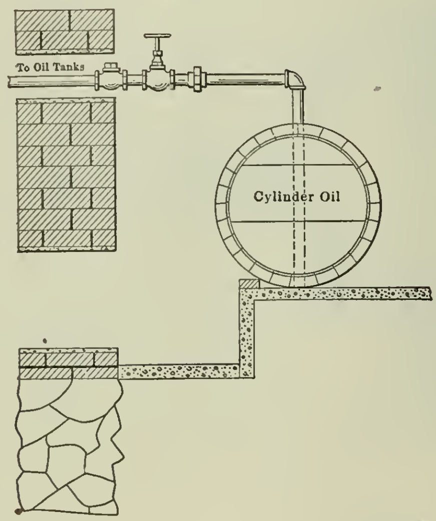


FIG. 1. METHOD OF GETTING OIL INTO STORAGE TANK

These cylinders are set on a perforated plate into which space the oil drips from the cylinders, through the toweling, and then runs through the suction pipe of the oil pump, which enters the bottom of the tank, and it is then pumped to the filtered oil-storage and feed tanks by the electrically driven pump.

These tanks have an air pressure of 15 pounds applied to the top of the oil. Enough oil is kept in the system to keep both tanks two-thirds full. An overflow pipe is attached to each tank two-thirds of the distance from the bottom, and these combine and discharge together through a safety valve into the filter tank *A*, as shown.

The pump is kept running continuously and if stopped for any cause, there is enough oil in the tanks to supply the engines for some three hours, the air pres-

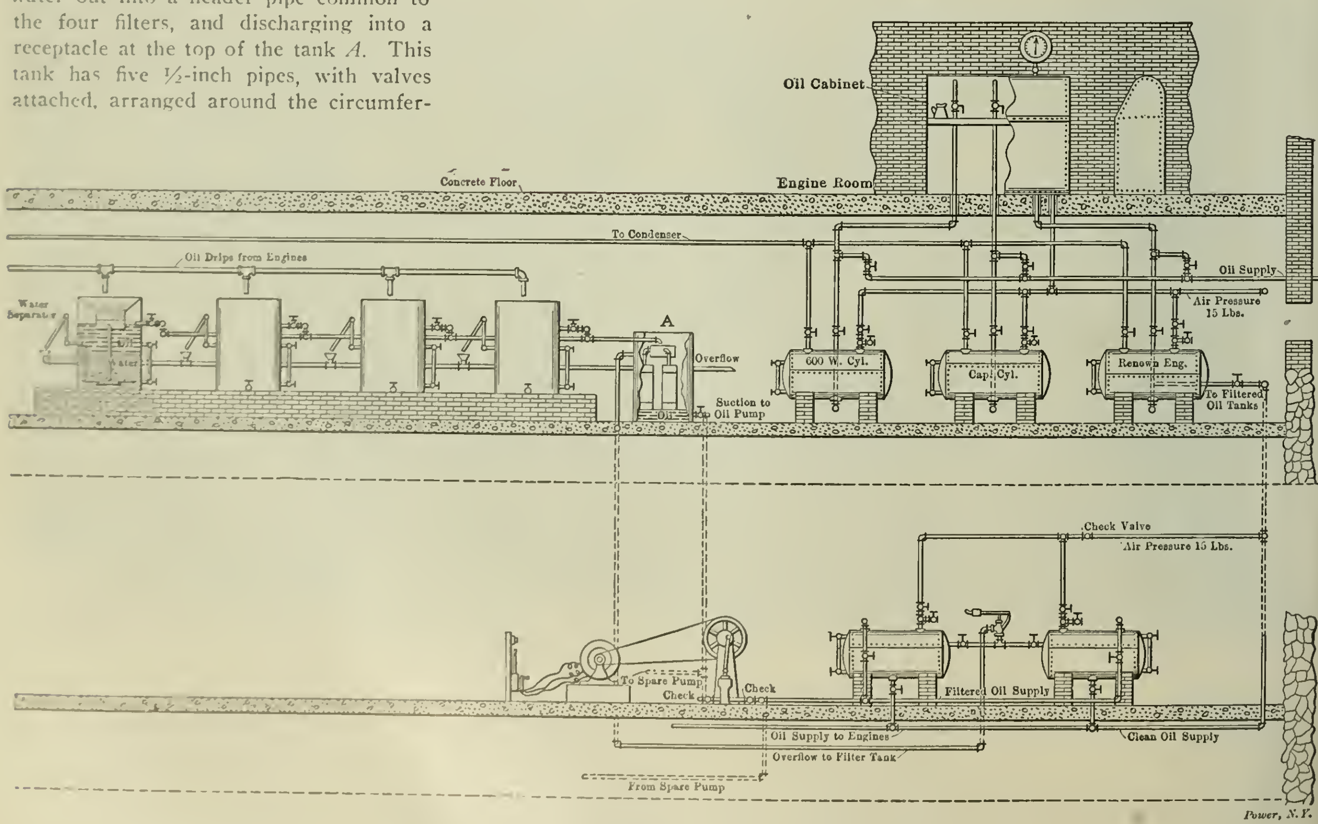


FIG. 2 LAYOUT OF PNEUMATIC OILING SYSTEM

sure supplying the necessary pressure to feed the oil.

When the pump is stopped, either by the circuit-breaker coming out or for any other reason, the handle of the motor-starting rheostat, in going to the off position, throws into circuit a red light which is placed in the engine room, thereby giving notice that the pump is off. The lamp continues to burn until the motor is again started.

We also have a spare pump attached to the end of the main shaft on the Conover condenser, which can be used as a spare pump.

To make up the natural loss of oil, and to keep the system at the required level, there is a pipe branching from the feed line on the new oil tank, through which new oil may be introduced into the filtered oil tanks by simply opening one valve.

New engine oil and two kinds of cylinder oil are drawn into three tanks arranged as shown in Fig. 2. The oil is drawn from barrels, outside of the engine room through a 1¼-inch pipe. The bungs are knocked out of the barrels and the pipe put in, the union made tight and a vacuum turned on. A barrel of engine oil will flow into the tank in about five minutes, cylinder oils take more time, depending on the temperature.

When there is sufficient oil in the tanks, as shown by the gages on the ends, the vacuum is shut off and an air pressure of 15 pounds is applied to the top of the oil and kept on at all times, except when filling the tanks.

Pipes from the bottom of the tanks lead to the oil cabinet in the engine room, and oil is measured out to the oilers from this cabinet and a record kept of it.

New engine oil is used on valve gears and in blowing-engine cylinders, and to make up loss in the filtered-oil systems; all other bearings are lubricated with filtered oil which is all returned to the filters from the drip pans of the engines.

A reducing valve on the high-pressure line reduces the pressure from 120 to 15 pounds. A safety valve is attached to the low-pressure line, in case the reducing valve should stick or leak.

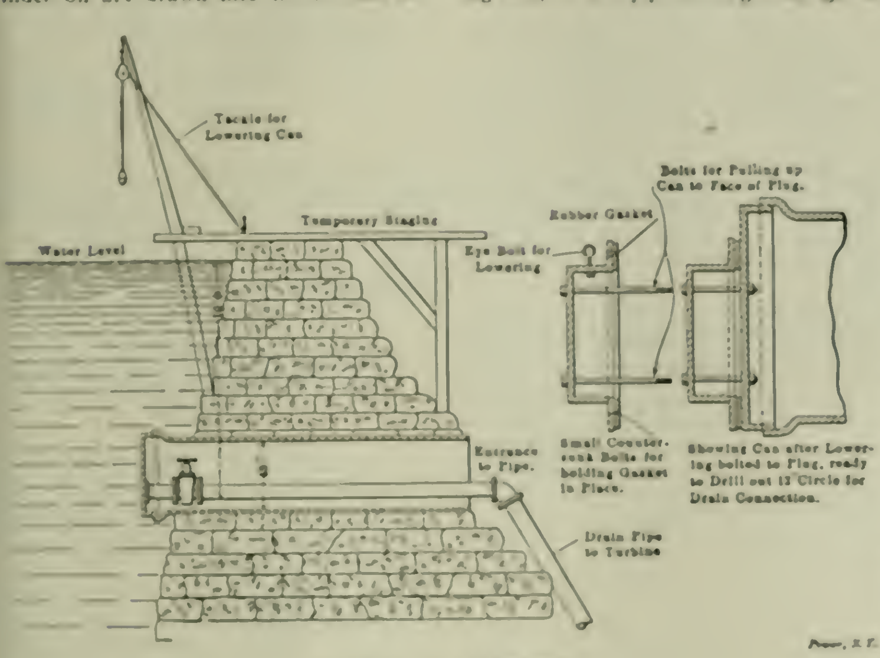
The installation operates very satisfactorily, and is a great saver of time, patience and oil and is reliable.

GEORGE L. FALLS.

Copperhill, Tenn.

Difficult Pipe Connection

The accompanying illustration shows an easy way of cutting a connection through the end of a plugged pipe that is under a head of water, without getting wet, if the pipe is large enough in diameter to permit a man to work inside. The case I refer to was a 48-inch cast-iron pipe.



DIFFICULT PIPE CONNECTION

I first made a water-tight can to conform with the diameter of the plug. I then put two drawbolts through the can to pull it up against the outside face of the plug, and bolted a soft rubber gasket to the flange face of the can with small countersunk bolts. Two holes were drilled through the plug in the end of the pipe, large enough to admit the bolts in the can, the center to be the same as the bolt center on the can. As the holes were drilled a soft wood plug was driven in each.

When both holes were complete a small ⅛" slot was cut along one side of a wood plug and a wire pushed out and fished up to the surface by a man on a platform overhanging the lake.

The can was slung in position for lowering and each wire fastened to its respective bolt.

When the can was near its proper position, the man inside the pipe guided the bolts into the holes with the aid of wire attached, and the can was bolted securely to the face of the plug.

A 12-inch circle was then cut out of the plug and a flange placed on it to which was attached a valve for shutting off at any future time when repairs would be needed on the drive line beyond.

The can was taken off after serving its purpose and the top cut out and a heavy screen put in to keep out fish and foreign matter, and then replaced in usual way.

This proved the simplest and best way after numerous suggestions by clever men. The water level in the lake could not be lowered to permit of work being done on the water side of the dam.

B. NICKERSON.

Montgomery, Ala.

Water Power

On page 686 of the April 13 number, Henry D. Jackson takes up the subject of water power and suggests the careful looking up of Government records for a long time. This must mean the record of rainfall.

This record is important, but there are other things that have a bearing on it that are not often enough taken into account, viz., the general nature of the soil and probable changes.

A country, or section, through which the stream passes that has a scrubby growth of trees that it pays to cut only for wood, and swamps that will not pay to drain, will have a good summer supply and not excessive in winter. This stream will last, as there is no probability of its ever being drained or any woodland destroyed for any length of time, as the roots will sprout and growth begin before erosion will take place.

Such a stream will need storage only for "lean years" and this will not be large. The "run off" on such a stream will be slow.

If we have a section made up of clay, rocks and woods consisting of large trees, with little undergrowth, we have the prospect of the trees being cut and a slow growth.

Clay and rocks do not hold water and a stream running through such a section will have extreme high and low water as the "run off" is rapid, and such a stream would need large storage capacity, as this storage would be called upon nearly every year. During the "lean years" the storage would have to supply the stream for six months.

A section made up chiefly of sand and gravel will be about midway between the foregoing, as, while there may not be many springs in such a section, the "run off" will be moderately slow, the soil having a fair capacity for retaining water. In looking up water powers, these considerations should enter into the account as well as cheap sites for storage. Storage is the important item, if the water proposition is to be a success. If possible, the dam site should be a gorge or narrow place so as to have a short dam.

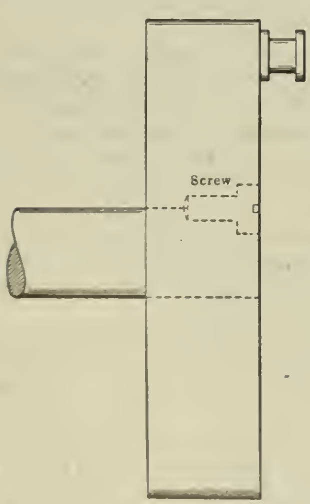
When we go through a drought, we claim that it is the worst that ever happened and the oldest inhabitant never saw anything like it. There will be more just like it, and if one goes into the water-power business he must provide for it.

W. E. Crane.

Broadalbin, N. Y.

Securing a Loose Crank Disk

In a recent issue I saw a method of repairing a loose crank disk by the use of tapered pins. I have a method which I have used in several cases that I think makes a better job. I drill and tap a hole, half in the disk and half in the shaft, the size varying according to the diameter of the shaft. Then I counterbore about ¼ inch deep and make a screw of tool steel with a slight amount of taper, enough to insure a tight fit, allowing the body to go in the counterbored hole so it may be finished nicely without showing.



SECURING A LOOSE CRANK DISK

For a stud I use a piece of stock about 7 or 8 inches long and screw it in with a pipe wrench as tight as it will go; I then saw it off, leaving just enough to rivet up.

I used this method in the case of a disk which worked off the shaft, and the engine is running yet and gives no trouble. The thread will hold the disk from slipping endwise.

C. F. Brandon.

Mittineague, Mass.

Diagrams Explained

On page 686, of the April 13 number, C. K. Desai shows indicator diagrams and wants them explained. Diagrams like these can be obtained by tightening the drum spring and using a twisted cord that stretches. There are also braided cords that stretch too much for this purpose. The paper drum starts slowly and lags until some of the stretch is out, and its movement is never coincident with that of the piston.

W. E. Crane.

Air Receivers

Referring to the article on air receivers, by John B. Sperry, in the April 6 number, I note Mr. Sperry advises placing the outlet near the top of the air receiver. This was formerly the universal practice, but it is now being discarded to a considerable extent, as it is found more satisfactory to take the air at a point about one foot above the bottom. The advantage is that with a good sized receiver the air is fairly cool near the bottom, and if it contains much moisture on entering the receiver, it is found in practice that the air will be somewhat drier.

In air-drill work, mining, etc., we have found that there is somewhat less trouble from freezing where this plan is followed, and for the same reason vertical receivers are generally preferred where conditions will admit of their being installed to advantage. But as a general thing the air will be found to be a little cooler near the bottom of a vertical receiver than in a horizontal one.

G. A. Reichard.

Los Angeles, Cal.

In the April 6 number, John B. Sperry states that air compressors should be connected with the inlet at the bottom and the outlet at the top; with which I should like to take issue. I have made several experiments in that line and have convinced myself that the proper way to connect is with the inlet at the top and the outlet near the bottom.

The bottom opening of a receiver is always at least 6 inches from the bottom, so that there is no danger of drawing any water from it, and if the compressor is working at near its full capacity the top of the receiver will be very hot. It is my opinion that when the air is taken from the top it will contain a greater amount of moisture in suspension than at the bottom, while when taken from the bottom the air, being cooler, will have precipitated the greater part of it to the bottom. Even in wet weather and without draining the receiver for a week, I have never seen more than about enough water come out of the drain to cover the bottom of the receiver. Our pipe line always carries considerable dry air.

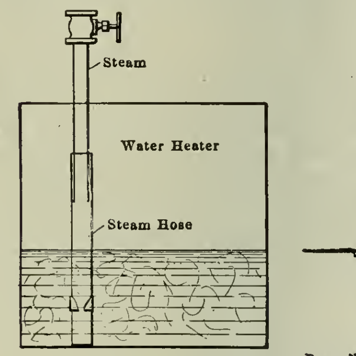
H. Gautschi.

Lusk, Wyo.

A Noiseless Water Heater

I have a noiseless water heater that is a good deal easier and quicker to make than any I have ever seen.

Take a piece of old steam hose 1½ or



A NOISELESS WATER HEATER

2 feet long and cut out about 6 inches from one end, as per the sketch, and stick the other end on the steam pipe.

Frank Gartmann.

Sheboygan, Wis.

Draining High Pressure Steam Lines

I read with much interest a letter by T. J. Bloss, in the February 9 number, and a later one by C. H. Beach, in the April 6 issue, regarding the drainage of high-pressure steam piping.

Mr. Bloss cited a case of a ¾-inch line piped direct from the boiler through 15 feet of horizontal pipe, then rising 96 feet vertically to a temporary bathroom.

As stated by Mr. Bloss, this vertical line stood full of cold water, except when a valve at the upper end of the line was opened, in which case the water backed down again into the boiler; the steam pressure carried was 100 pounds per square inch.

This ¾-inch pipe must have been trapped at some point in the horizontal line, which would account for the vertical line standing full of water when the upper valve is closed.

It would seem quite natural that any water of condensation which forms in a vertical steam pipe, where there is no flow, would tend to drain back to the boilers as fast as it forms, especially where the hight is as great as in the given case, unless the line were trapped. With 96 feet of water standing in a vertical pipe there would be exerted a pressure at its base of

$$0.434 \times 96 = 41.66$$

pounds per square inch. This water of condensation, even if formed into a solid column, should break up sufficiently to run down one side of the pipe while the steam rises on the other side to take its place, where it in turn is condensed.

If it is attempted to drain the water of condensation back against the steam flow, in large steam pipes, water hammer is almost sure to occur, or the water may collect until a "slug" is formed, which greatly reduces the area of the pipe, in which case a heavy flow of steam in the direction of the engines will very likely carry the "slug" of water over with it at high velocity, if not stopped by a separator.

Mr. Beach cites a case of a 75-horsepower Corliss engine connected to 200 feet of pipe with a separator placed just above the engine throttle valve. Still, in several instances, water has passed over in sufficient quantities to stall the engine.

The purpose of a separator is chiefly to prevent water going over in sufficient quantities with the steam flow to cause damage to the engine. If a separator passes a "slug" of water sufficient in quantity to stall an engine and throw it out of alinement it would seem that the so-called separator is not very efficient as a safety device.

There are separators on the market that not only separate or remove large "slugs" of water coming over with the steam flow, but they remove also a large percentage of the moisture held in suspension in the steam, which has a bad effect on the economy of the engine.

I agree with Mr. Beach that tapping a small pipe connection into the bottom of a line of pipe is a poor means of removing the condensation, as the flowing steam will undoubtedly sweep the water along with it past such a small opening. Drip pockets of large cubical capacity should be used, and may be placed in the steam line at the desired drainage points, and the water drained off by a trap or other suitable means.

When a steam header is divided into separate sections any one or more of which may be cut out of service, each section should be dripped, as the steam remaining in the dead section is bound to condense and should be well drained off before opening the dead section again to the live-steam pressure. This will prevent water hammer.

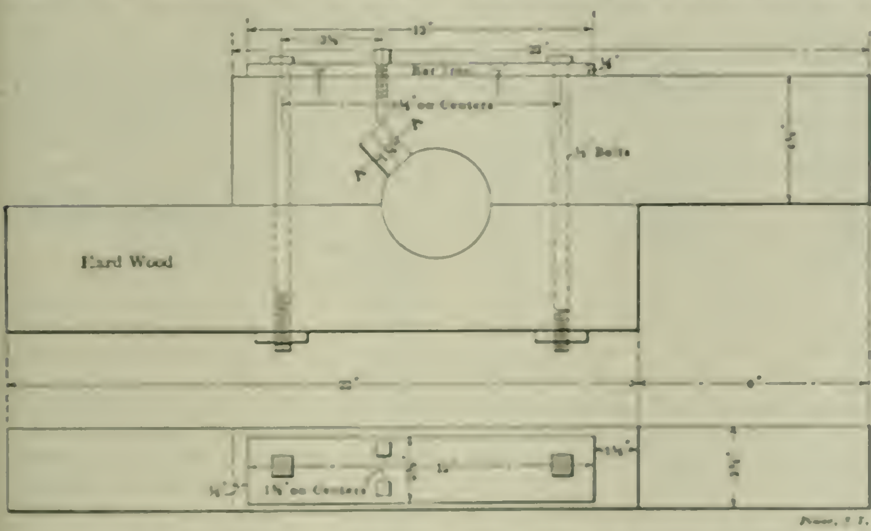
If all high-pressure drip lines are well covered with good-quality nonconductive pipe covering of proper thickness the condensing effect mentioned by Mr. Beach should not prove such a serious drawback.

WILLIAM F. FISCHER.

New York City.

Tool for Turning Pin on Center Crank Engine

The accompanying sketch illustrates a tool used to turn a crank pin on a center-crank engine. The pin was badly out of true, and to get the shaft out, and to the shop, meant a long hard job, so we made the following contrivance do the work.



SIDE ELEVATION AND PLAN VIEW OF APPARATUS FOR TURNING PIN ON CENTER-CRANK ENGINE

Two pieces of oak wood, 4½ inches wide and 3¼ inches thick by 2 feet 10 inches long, made parallel, were fastened together by two ½-inch bolts, a piece of ½-inch flat-iron stock being placed on the top with holes drilled for bolts and countersunk holes for wood screws to hold it. The rig was then taken to the shop and the hole made for the tool, the slot being wide enough to insert a wedge for holding the tool, which was made of common tool steel and flattened on the top to receive the set screw by which it was fed, as illustrated. The rig was first tried on a piece of stock known to be round and proved satisfactory. It was then bolted to the crank pin, and in two hours the pin was round. In making the tool, care must be taken to make a templet of the fillet of the pin to grind the tool by, and also to grind the tool on a very long bevel.

H. L. BECKETT.

West Everett, Mass.

Gas Engine Valve Setting

Undoubtedly when Mr. Hellman wrote his article on the "Method of Setting Gas Engine Valves" he had no intention of creating the discussion that followed. He should be congratulated, however, upon awakening a few of the gas-engine men, for I do not think we hear from them as often as we should.

Gas-engine valve setting and ignition timing are largely matters of experience, but I think we will agree that the timing of ignition depends somewhat upon the size of the engine cylinders, the speed and fuel used. Herein lies the fact upon which I should base my criticism of preceding articles upon this subject (by Mr. Tilden, page 416, March 2, and Messrs. Burchman and Alegg, page 688, April 13), none of which was sufficiently explicit in giving these details.

It is evident that more time is required to burn the gases in a large cylinder than in a small one, and therefore it may be necessary to have the point of ignition earlier in the larger cylinder. In the same way, the speed of the engine will affect the point of ignition, for with the point of ignition the same, relative to crank angle, it is evident that more time is allowed before the crank passes the central position for the ignition of gases in a slow-speed than in a high-speed engine. The kind of fuel used is probably the most important factor, however. Some gases burn much more slowly than others. A mixture of producer gas, for instance, will not ignite as quickly as one of natural gas.

Regarding valve settings: When gas engines were first manufactured, it was the practice to have inlet and exhaust valves open and close when the crank was on the dead centers. Experience, however, taught that better results were obtainable by varying the valve settings considerably. By opening the exhaust valve 30 to 50 degrees earlier, the gases are allowed to expand nearly to atmospheric pressure before the piston commences the exhaust stroke. It is true that this arrangement sacrifices an appreciable area under the expansion curve, but at the same time back pressure on the exhaust stroke is avoided, and this more than compensates for the work lost on the expansion stroke. Another advantage is that less heat will be transferred to the cylinder walls by having this early opening of exhaust valves. The exact time of exhaust closure varies considerably in practice, but an average would probably be between 5 and 10 degrees past the inner center.

The time of opening of inlet valves also varies, some engineers having this event occur before the exhaust valve closes, while others defer it until afterward. The relation of this event to exhaust-valve closure depends upon the fuel burned. In the case of high-speed oil engines, where a comparatively large amount of the heavy hydrocarbons is found in the exhaust gases, the inlet valve is not opened usually until the exhaust valve has closed, in order to prevent back-firing. In cases where other fuels are used I do not think back-firing will be caused, generally, by having both inlet and exhaust valves open at the same time; for if this is a fact, why do not the exhaust gases contained in the clearance space ignite the incoming charge? Also, by having the inlet valve open before the exhaust valve closes, a more complete scavenging of the cylinder is effected.

The foregoing statement is verified by my own experience with three-cylinder single-acting natural-gas engines, which were rated at 360 horsepower, running at 200 revolutions per minute, with cylinders 18 inches in diameter by 22-inch stroke. The best results were obtained with the following timing of events: Ignition, about 24 degrees early; inlet valves opened about 10 degrees before the inner center; inlet valves closed about 30 degrees past the outer center; exhaust valves opened about 45 degrees before the outer center; exhaust valves closed about 10 degrees past the inner center.

The engines carried about three-quarter load and ran on an average fuel consumption of 21 cubic feet of gas per kilowatt-hour for six months, the gas having a heating value of from 950 to 1000 B.t.u. per cubic foot. Back-firing was very rare and never troublesome.

I regret that I have no data relative to other valve settings upon these engines and should like very much to hear from someone who has such data.

J. C. Parmely.

Urbana, Ill.

The communications from Messrs. Buschman and Abegg, set forth some ideas that fit the principles involved and some that, in my estimation, do not.

My letter, in reply to one from Mr. Hollman, reference to which is made, dealt with that type of gas engine used on standard automobiles, with which it is necessary to get right down to "brass tacks" or you don't make the hill on the high gear.

The point I aimed at was the definite necessity of getting a cylinder full of mixture to start with, and it has been my experience that closing the exhaust valve as nearly as possible on the dead center, is a prime requisite to that end.

If the correspondents named have found it necessary to release the expanding charge when the crank lacks some 40 degrees of having reached the end of the stroke, does it indicate that I have advanced a theory that won't hold water, or that the designer of these particular engines (wonder if they are both from the same shop) had peculiar ideas regarding the behavior of gases under pressure?

In considering the engine as a gas pump, the time of opening the exhaust valve has nothing to do with the question, provided the exhaust valve may be closed at the proper time; and Mr. Hollman's letter gave me the impression that the time of closing his exhaust depended on the time of opening it.

Regarding the theory that a column of air and gas will continue in motion after having been put in motion, due to its inertia, it is very easy to confuse the term "inertia" with that property of matter known as momentum.

No one will question that a column of gas and air has inertia, but I do dispute that it has momentum enough when in motion to overcome the resistance of mechanical friction. If the correspondents will spend some time with an indicator on a compound air compressor, where they will have an opportunity to experiment with gas at atmospheric pressure, with a spring to match that sort of work, and check their work by following it through the high-pressure cylinder, I think they will agree with me that while a column of gas at low pressure may be inert it won't "moment" for sour apples.

The last paragraph in Mr. Buschman's letter contains the statement that "the maximum explosion pressure is obtained when the volume of the mixture is the smallest, or in other words, the compression pressure is the highest at the instant the entire mass is ignited."

If the words "explosion" and "compression" were transposed the first proposition would be true, but the last would still lack something of full or exact truth, I believe. The burning of a charge of gas and air in an engine cylinder is not instantaneous as to time, but continues over an easily measurable portion of the crank-pin travel, and the time of the highest explosion pressure depends on the quality of the mixture, the amount of compression, the point of ignition and the speed of the engine. Varying any one of these elements will vary the time or point of the highest explosion pressure.

That part of gas-engine indicator diagram that connects the top of the compression curve with the commencement of the expansion line always has an inward slant, which is an index of the time consumed in burning the charge in the cylinder. If the burning of the charge was an instantaneous explosion, that line would obviously be perpendicular to the atmospheric line.

Mr. Abegg calls attention to two advantages resulting from releasing at 40 degrees ahead of the center, one of which is that the cylinder walls are cooled thereby, which "allows a more complete new charge." That is to say, he throws away part of his charge to facilitate acquiring a bigger charge than is needed for the next power stroke.

If the theory set forth, regarding the inertia of a column of gas in motion, was right, proof of that fact could be found by scrutinizing the exhaust line of an indicator diagram from a gas engine. The burned gases certainly leave the cylinder at a much higher velocity when first released by the opening exhaust valve than is possible when impelled by the comparatively slow-moving piston, and yet whoever heard of the piston being sucked out of the cylinder by the vacuum produced by the "inertia" of the outrushing column of burned gas?

E. G. Tilden.

Downers Grove, Ill.

Cost of Cleaning Boilers

The editorial entitled, "How Much Does It Cost to Clean Boilers?" is a step in the right direction. Power-plant owners and operators should know more than they do about what scale and impure water are costing them. They should keep a record of such costs, including all incidentals, and then at the end of the year they can tell how much they can afford to pay for some system of water treatment.

There is one statement, however, that may give rise to misconception. The editorial says: "How much better off would you be if you had absolutely pure feed water for your boilers, so pure that it would leave absolutely nothing behind it when it boiled away?" This is a commercial impossibility; at least, you cannot get such waters from natural supplies except by distilling, the cost of which would be, in most cases, prohibitive, even as compared with cleaning the boilers.

It is true that a condensing plant under certain conditions might afford to distill its make-up water, but even that is hardly probable. The distinction that is to be drawn is between water which forms scale in the boilers and water which does not, or at the most deposits only sludge, since boilers using the latter can be kept clean by regular blowing down with an occasional washing out with a hose.

Scale is responsible for most of the expense of boiler cleaning and maintenance, necessitating, as it does, the use of mechanical cleaners and causing frequent injuries to tubes, plates and seams through overheating.

By treating sulphates and carbonates you can keep the lime and magnesia out of the water, but a sodium or some similar highly soluble salt will pass on into the boiler and its accumulation there must be prevented by blowing down. At the same time, a certain amount of fine sludge will get through any practical form of filter, and the boilers should be blown down to remove this also.

The foregoing statement applies to every form of treatment, hot or cold, or boiler compound, that I know about, with the exception of barium carbonate, which is not in use in this country on account of its high price.

George H. Gibson.

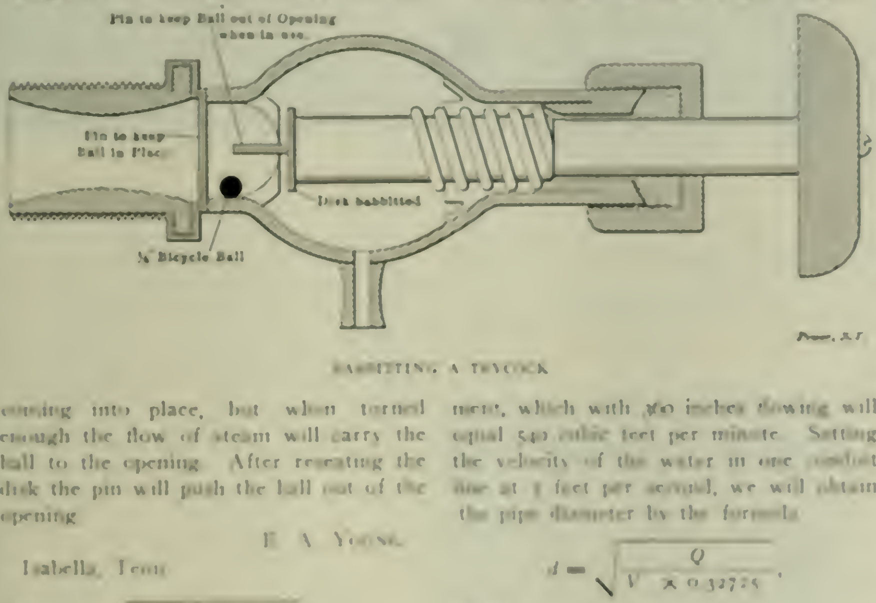
New York City.

Babbitting a Trycock

The accompanying sketch is of a trycock, and shows the way I fixed it so I could take the stem out and put in a new babbitt seat while steam was on the boiler.

I had but one boiler to run five miles of electric railroad and some lighting. We had to run 20 hours a day seven days a week, so we did not have any time to get steam off the boiler for repairs.

It will be noticed that the pin is long enough so that the cock can be opened enough to try the water without the ball coming into place, but when turned enough the flow of steam will carry the ball to the opening. After reseating the disk the pin will push the ball out of the opening.



BABBITTING A TRYCOCK

E. A. Young.

Isabella, Tenn.

Trap Won't Work

On page 600 of the March 30 number, a steam trap is illustrated and explained by H. C. Williamson. In looking at the sketch, it appears that the arrangement shown will not operate. For instance, when the float rises on the rod until it hits the top stopper, then the trap is full of water, but as the float rises, lifting the rod with it, the bell crank will close the outlet valve instead of opening it, as should be the case. On the other hand, the outlet valve is opened by the float falling, which means that if it were possible the outlet valve would open only when the trap was empty and would close only when it was full. The cure would be to attach the bell crank to the inside of the trap on the opposite side from the outlet valve, which would reverse the movement of the outlet valve with relation to the movements of the float and thus render the trap operative.

R. Manly Orr.

Brantford, Ont.

Hydraulic Information

Mr. Piper does not state whether the 360 inches of water delivered is in cubic inches or in miner's inches. There is a great difference in the two terms and calculations made for one would be wholly wrong for the other.

The miner's inch is equal to 1.5 cubic feet of water flowing per minute (approximately), which would make the available power with a head of 140 feet, at 85 per cent. efficiency, about 120 horsepower when 360 inches is flowing. If we take it to mean 360 cubic inches discharge per second, which equals 12.5 cubic feet per minute, we will get with the 140 feet head, at 85 per cent. efficiency, about 2.8 horsepower.

We will take the miner's inch measurement, which with 360 inches flowing will equal 540 cubic feet per minute. Setting the velocity of the water in one conduit line at 3 feet per second, we will obtain the pipe diameter by the formula

$$d = \sqrt{\frac{Q}{V \times 0.32725}},$$

where

d = Diameter of pipe,

Q = Quantity of water discharged per minute,

V = Velocity of water in feet per second.

$$d = \sqrt{\frac{540}{3 \times 0.32725}} = \sqrt{550} = 23.45 +$$

inches. A 24-inch riveted steel pipe should be used, made of 12-gage material, which will weigh about 32 pounds per linear foot. This will give a velocity a trifle less than 3 feet per second, but the writer favors keeping the velocity low, and receiving full benefit of the low pipe friction. The loss by friction in this case is calculated by the formula

$$H = \frac{L}{d} \times \frac{4V^2 + 5V - 2}{1200} = 0.83 +$$

foot head loss, where

H = Head loss,

L = Length of pipe line,

d = Diameter of pipe,

V = Velocity of water flowing in feet per second.

This will give 139.17 feet of effective head.

A water wheel of the pelton impulse type, 6 feet in diameter, taking water with a spouting velocity of about 5600 feet per minute and operating at 150 revolutions per minute, should be installed if the dynamo is to be a belted machine. This would deliver approximately 115 horsepower which, after allowing for necessary losses, both mechanical and electrical, would easily supply one thousand two hundred 16-candlepower lamps of the carbon filament type, or about three thousand two hundred 20-candlepower tungsten lamps.

If the electrical distribution is to be over a large area an alternating-current generator of a suitable phase, cycle and voltage should be installed, but if the load is to be entirely local the low-voltage direct-current system will fill all requirements. The above speed of the wheel could be used only for a belted generator, as the cost of slow-speed electrical machinery is high, which would in this case very likely prohibit its use for direct coupling. If a direct-connected set is desired a higher-speeded wheel can be used, say, 600 revolutions per minute. A good speed regulator should be installed. This point is often overlooked, and results far from pleasing are obtained.

If this hydraulic development was for the smaller power mentioned, using 360 cubic inches of water per second or 12.5 cubic feet per minute, 4-inch iron pipe should be installed and an 18-inch pelton impulse-type wheel used, which will give about 2.5 horsepower, supplying thirty 16-candlepower lamps. If this smaller power was installed there would be no necessity for installing a regulator for the water wheel, the speed being governed by hand as required, or by a small motor connected with a voltage regulator.

Frank A. Byers.

Bennington, N. H.

Standard Pipe Fittings

The recent article regarding architects and "standard pipe fittings" brought to mind the following:

I was employed as a steamfitter in a certain building and an 11-inch pipe was specified. After writing all the leading supply houses, causing a two weeks' delay, we received word they were unable to furnish 11-inch fittings, so the architect was notified, and we were told to install 12-inch pipe, which increased the cost. I afterward figured the piping and was satisfied that a 10-inch pipe would have been amply large.

Samuel T. Moore.

[illegible], Colo.

Vacuum Ash Conveyer at Armour Glue Works

An Installation Serving 4435 Boiler Horsepower Perfected by Experiment to Handle 7 Tons of Ash per Hour at Cost of 7 Cents per Ton

BY GEORGE B. HESS

The vacuum ash-conveying system at this works, which was perfected only after a great deal of experimentation, consists primarily of a positive blower, a storage tank and conveying pipes. The blower exhausts the air from the storage tank into which the ashes are drawn by suction through the pipes leading from the boiler ashpits. The closed storage tank has a capacity of 1640 cubic feet and is elevated about 33 feet above the level of the boiler-room floor. Just above the storage tank is a smaller tank about 7 feet high by 5 feet in diameter, designed to act as a settling chamber. The small tank is connected to the storage tank by a 12-inch pipe leading from the bottom directly into the storage tank and also by two 12-inch bypass pipes that lead from opposite sides and near the top of the chamber down into the storage tank. Leading out of the top of the settling chamber to the inlet side of the blower is a 22-inch galvanized-iron suction pipe and a similar pipe leads from the other side of the blower up into the smoke stack.

As there are two separate boiler rooms, there are also two separate ash-conveying pipes, one for each boiler room. These pipes, which are 10 inches in diameter extend the entire length of the boiler pits and discharge the ashes into the top of the storage tank. The elbow of each pipe, where it leads into the storage tank, is tapped for an ½-inch water pipe for settling the dust and cooling the ashes, and that part of the piping extending along the front of the boiler pits is provided with 6-inch holes on the upper side, the holes being placed at distances to correspond with the doors opening into the ashpit directly beneath the furnaces. When not in use, these holes are covered by caps with handles attached for convenience in handling. When it is desired to pull the ashes from the pit into the conveying pipes, a small portable hopper is used. This has been made with a 6-inch outlet and can readily be placed over any of the openings. The conveyer successfully handles an average of 47 tons of ash every 24 hours, during which time it is in operation only 6 hours and 45 minutes. An outline of the system and some details are shown in Fig. 1 and in Table 1 are given some data on the plant and ash-conveying system, for the perfection of which much credit is due to C. W. Brown, chief engineer of The Armour Glue Works.

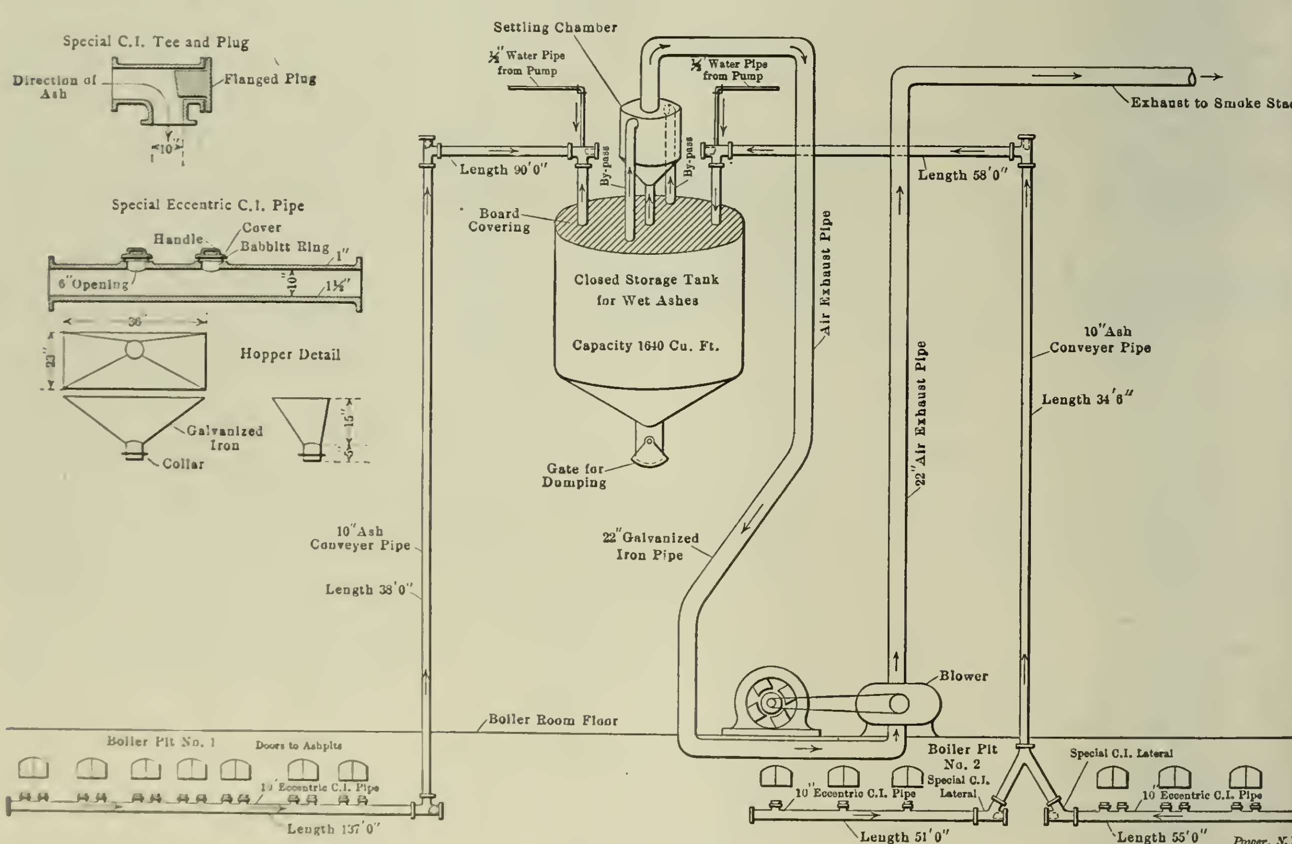


FIG. 1. OUTLINE OF VACUUM ASH-CONVEYING SYSTEM AND DETAIL OF PIPING

As the building of the conveyer was entirely along experimental lines, a successful application was hardly to be expected at the first attempt. The device, however, was installed along lines which it was thought would most nearly meet the requirements, but the result was a failure in almost every respect, and practically the only feature of the original installation which is now made use of is the application of the water in settling the dust and cooling the ashes. It will be necessary to go a little into detail in regard to the original apparatus, the difficulties that were met with and the methods of overcoming them in order to see just why the system has been arranged as it now is.

A Change of Blowers

The exhauster first used was not adapted to this work, and no end of trouble was experienced with this part of the apparatus. It was geared to a 75-horsepower motor, and this in itself was very unsatisfactory. The blower was not only incapable of meeting the demands made upon it, but it was constantly getting out of balance to an extent that might at any time prove serious, and in spite of all the attention that was given to it, the blower finally burst into hundreds of small pieces. The continual tendency to unbalance could be accounted for only in one way, and that was by the wearing away of the fan blades by the small particles of ash which were carried along in the air as it was exhausted from the system. The original blower was then replaced by a 24 [illegible] Root positive blower, Fig. 2, running at [illegible] revolutions per minute and driven by belt from the 75-horsepower 500-volt direct-current motor. This blower has been in service a little over one year and appears to successfully meet all requirements. It steadily maintains a vacuum of 2½ inches of mercury at the inlet side under all working conditions.

FIG. 2. ROOT BLOWER BELTED TO MOTOR

TABLE 1. DATA ON PLANT AND ASH-CONVEYING SYSTEM.

Rated h.p. of boilers (15)	[illegible]
Type of boiler	[illegible]
Type of grate	Chain
Kind of coal	Illinois screenings
Percentage of ash	[illegible]
Character of ash	[illegible]
Tons of ash per 24 hr.	[illegible]
Actual capacity of conveyer per 24 hr., tons	[illegible]
Power required to operate conveyer, kw.	[illegible]
Cost per ton of conveying ashes, cents	[illegible]
Hours of labor required per 24 hr. (1 man)	[illegible]
Vacuum maintained at inlet of blower	[illegible]
Capacity of storage tank, cu. ft.	[illegible]
Size of conveyer pipe (inside), in.	[illegible]
Size of exhaust pipe (inside), in.	[illegible]
Lb. of water required per ton of ash	[illegible]
R.p.m. of blower	[illegible]

The Ash-storage Tank

Originally the large ash-storage tank, Fig. 3, was used only for the purpose of storing the ashes until they could be dumped into cars and was in no way connected with the exhauster. The present tank or settling chamber directly above the storage tank was designed to act as a cyclone produced by causing a violent whirling of the ashes around the inside of the chamber and permitting the heavier particles to drop to the bottom. The exhauster was connected with the top of the chamber and the two ash-conveying pipes led into opposite sides near the top where the two bypasses are now attached. As the ashes settled in this chamber they were allowed to pass out continuously through the 12-inch pipe extending from the cone-shaped bottom of the chamber into the storage tank. This had to be done without letting any air into the chamber, so a rotating valve, operated by a one-horsepower motor, was placed in the ash pipe below the cyclone chamber. This arrangement did serve to act as a seal to the cyclone chamber, yet it was not entirely satisfactory, as the conditions under which the motor had to operate were not such as to secure the best results, and the valve itself had to be repaired very frequently. For these reasons it was thought best to dispense entirely with the cyclone chamber and the rotating valve, if the desired results could possibly be obtained otherwise. A radical [illegible]

FIG. 3. STEEL STORAGE TANK AND SETTLING CHAMBER ABOVE

FIG. 4. CONVEYER PIPE IN FRONT OF [illegible]

TABLE 2. OUNCES OF VACUUM AT DIFFERENT POINTS IN ASH-CONVEYER PIPES.

(All Openings Except Inlet Closed. [illegible])

Boiler Pit No. 1		Boiler Pit No. 2			
Air Inlet at [illegible]		Left Leg, Air Inlet at T		Right Leg, Air Inlet at [illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

parture from the original scheme was now devised. The top of the storage tank was boarded over and the two ash-conveying pipes, which led into the sides of the cyclone chamber, were now led directly into the top of the storage tank and the cyclone chamber was made simply an enlarged section of the exhaust pipe. As the upper side of this chamber was connected to the exhauster by a 22-inch pipe and the lower side to the storage tank by a 12-inch pipe, it was evident that nothing was to be gained from the use of the large exhaust pipe unless the area of the opening in the storage tank was correspondingly as large. To offset this drawback two 12-inch bypass pipes were led from the openings in the chamber where the two conveying pipes previously entered, down into the top of the storage tank. This served to reduce the velocity of the air as it left the storage tank and the tendency of the particles of ash or dust as they passed through the old cyclone chamber, where there was a considerably lower velocity, was to settle and fall back into the storage tank. This is the present arrangement of what is now called the settling chamber.

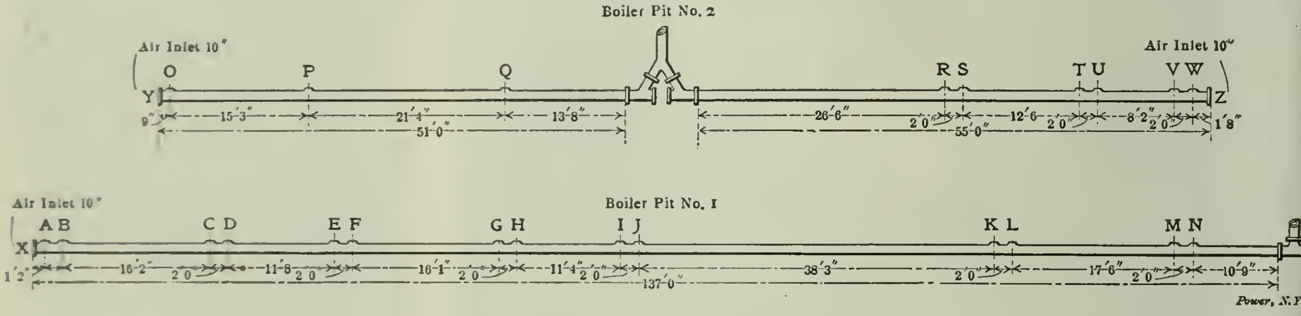


FIG. 5. DETAIL OF ASH-CONVEYING PIPES IN BOILER PITS

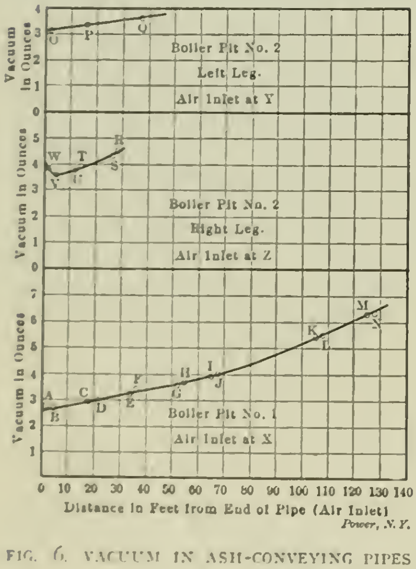


FIG. 6. VACUUM IN ASH-CONVEYING PIPES

Ash-conveyer Piping

The ash-conveying pipes, Figs. 4 and 5, which extend the entire length of the boiler pits and convey the ashes into the storage tank, were made first of 10-inch extra-heavy wrought-iron pipe with 6-inch holes spaced along the top in front of each ashpit. The proper construction of these pipes was a hard matter to decide without experimenting. It was thought that the ash in traveling through the horizontal legs would naturally hug the lower surface of the pipe, but prominent engineers who were consulted in regard to this matter advanced the theory that the air in passing through the pipe with a high velocity would acquire a whirling motion and this same motion would be imparted to the ashes, with the result that a uniform wear of the inner surface of the pipe would take place. Assuming that this theory was correct, the 10-inch extra-heavy wrought-iron pipe with a standard threaded coupling was put in place. It was but a short time before this arrangement showed decided wear. This was first noticeable at the couplings where the thickness of the pipe had been reduced by the cutting of the thread, and shortly after it was apparent that the bottom of the pipe was also affected in the same way. Sections of this pipe as fast as they wore out, were replaced by new pipe, but its life was so short that the wrought-iron pipe was discarded for another and more substantial one of cast iron with flanged joints. For the horizontal lines, where the greatest wear occurred at the bottom, a special eccentric cast-iron pipe was designed, having a thickness of metal of 1 inch on the upper side and 1½ inches on the lower side.

For those sections which were to be placed in front of the ashpits and in which it was necessary to provide openings for the hopper, a boss about 9 inches in diameter was cast at the top of the pipe. This boss, having a 6-inch hole in the center for the hopper, was faced to present a perfectly flat and smooth surface. The caps which were provided to cover these holes when not in use were simply flat circular castings with handles on top. The lower side of the cap was cast with a V-shaped groove about 7½ inches in diameter, which was afterward babbitted and machined, thus making a fairly good air-tight joint when in place on the boss. The areas of the hopper openings in the conveying pipes bear a definite relation to the area of the pipe itself, and this point cannot be overlooked in the construction of a conveyer of this kind. Several attempts to adapt this apparatus to other plants have resulted in failure simply because engineers have not realized the importance of this feature. The ratio of the area of the hopper opening to the area of the pipe, as determined by experiment, is practically 1 to 3. A ratio of 1 to 2.77 has been used in the case of the Armour conveyer with very good results. It is important also that the air inlet at the end of the conveying pipe shall be at the end of the pipe and not on the side. This opening should in no case be less than the full diameter of the pipe, and a bell-shaped opening would seem to be preferable to the flanged end of the pipe as it would permit of a higher velocity of the air at the inlet. That the size and shape of the inlet exert considerable influence over the action of the air at this point has been experimentally shown. For the present installation the vacuum in ounces at the various openings lettered in Fig. 5. are given in the curves of Fig. 6, and the velocity of the air for the various

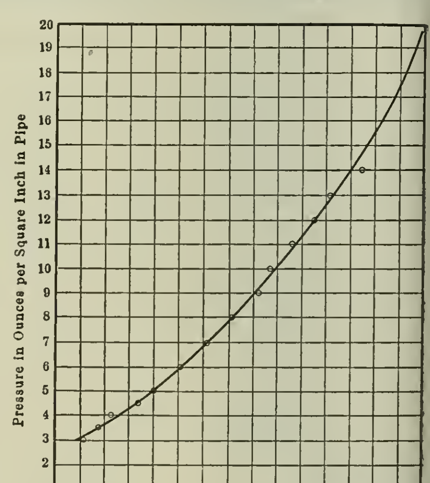


FIG. 7. PRESSURE-VELOCITY CURVE

pressures given may be determined from Fig. 7.

Special Tee Preferred to Elbow

Another difficulty that was overcome only after considerable experimenting was the construction of the elbows for these pipe lines, and as each conveyer pipe had practically three 90-degree elbows, all of which were subject to severe usage, it will be seen that this was a matter requiring early attention. The 10-inch standard wrought iron tee which was first tried was expected to form a sort of pocket, always retaining a certain amount of ash as long as the blower was in operation and thus protecting itself from wear, but no such results were obtained, and an elbow of long sweep was substituted in the hope that it might prove more satisfactory. The elbow did not give any better service and was thrown out to be replaced by a specially designed cast-iron tee and flanged plug. This tee was designed with one side of the run shorter than the other, and it was placed in the position of the old elbow with the longer side of the run attached to the ashpit side of the pipe. To the shorter side of the run of this tee was bolted the flanged plug of cast iron. The plug, which was of solid metal, 7 inches long, was slightly smaller than the inside diameter of the tee, and when placed in position with its flange bolted to the flange of the tee it extended about 1 inch beyond the neck of the outlet. With this arrangement practically all of the wear on the tee, except that which would normally take place in the straight pipe, was now received entirely by the plug inserted in the shorter side of the run.

Besides preventing excessive wear of the pipe, this type of tee also assists in breaking up clinkers. In drawing ashes into the hoppers on the conveying pipe, clinkers almost as large as the 6-inch opening often fall into the pipe. The velocity of the air in the pipe is always sufficient to carry along these large clinkers until they strike the vertical leg, or the point at which the tee and flanged plug are located. By the time these clinkers have reached this point they have acquired considerable momentum and in striking the flanged plug are broken into many small pieces. As the ashes on their way to the storage tank are required to pass through three of these tees, it is evident that by the time they reach the storage tank they will be in a finely divided state. The condition of the ash as drawn from the storage tank is sufficient to prove that this is what actually does happen.

So far as protecting the pipe from wear was concerned this proved to be an ideal arrangement, but whatever effect it produced upon the action of the air due to the increased friction has not yet been determined. The tee undoubtedly offers greater resistance to the air than a long-sweep elbow would, but when the small number of these elbows and the capacity of the apparatus are considered, it appears to be a matter of only minor importance. Frequent inspection of these plugs show that they wear away quite rapidly, while the tee itself shows comparatively little wear. When worn out, it is a simple matter to replace the plugs at slight expense.

For packing the flanged joints of the pipe line, a piece of 1/2-inch asbestos having a diameter slightly less than that of the bolt hole circle was used instead of any of the ordinary packing materials. Small pressure was applied to these joints by the flange bolts, and while the blower was in operation a heavy paint was poured between the flanges. The suction created by the blower drew this paint into any crevices which might have remained after the bolts had been tightened and it soon hardened there, leaving a perfectly air-tight joint at small expense.

Reinforced Concrete for Storage Tank

The original storage tank is still in service, but chemical action caused by the mixture of the ash and water has eaten away the steel until in places nothing but a very thin piece of metal remains. One drawback to a riveted tank of this kind is that the wet ashes are constantly adhering to the joints and rivets, especially to the latter, and they gradually pile up to such an extent that it is necessary to send a man inside to knock them off with a sledge. It will be necessary to replace this tank in the near future, and it is probable that a reinforced-concrete or at least a cement-lined tank, and one having no corners nor projections on the inside, will be substituted in place of steel.

System Cheapens Ash Removal

Application of this conveying system to power plants is dependent upon several factors, of which the first and most important is the coal, with the amount and character of the ash produced. The coal used in connection with the conveyer just described is the ordinary run of Illinois screenings; the ash produced averages practically 20 per cent. of the total coal and the clinkers formed seldom exceed 6 to 8 inches in diameter, and these are of such a nature that they can be easily broken up when pulled into the hopper. With a coal forming a large, hard clinker some means would have to be provided for breaking up the clinker to a size adapted to the openings in the conveying pipe.

The second and next important factor would be the cost of installation, and this should not be considered only from the standpoint of first cost and maintenance, but should take into consideration the yearly saving effected. That the latter is the deciding factor, especially in large plants, has been proved in the case of the conveyer under discussion by actual results, the saving in cost of the yearly disposal of ash amounting to about 55 per cent. of that of the preceding year when the conveyer was not in use.

For each separate power station there will naturally be some obstacles to be overcome, peculiar to that station itself, but there seems to be no reason, however, why this system could not be adapted to fit the conditions, providing that the ash does not form too large a clinker.

If this type of conveyer is so well adapted to the economical handling of ash, the question naturally arises, why should it not be just as well suited to the handling of coal or other materials of a similar nature? A conveyer of this kind has recently been built for the handling of coal, but either because of the nature of the coal or improper design, the device has not produced the excellent results expected of it. This probably can be accounted for by the fact that coal contains a large percentage of moisture which would cause it to stick to the inner surface of the conveying pipe, where it would quickly build up to such an extent as to completely clog the pipe. It would then be necessary to shut down the blower and rod out the pipe before operation could be resumed. It is self-evident that under these conditions no economy can be expected when the whole outfit should require no more than one man to operate it.

International Association for the Prevention of Smoke

The program for the fourth annual convention of the International Association for the Prevention of Smoke, to be held in Syracuse, N. Y., June 23, 24 and 25, is practically complete. The speakers include Dr. Thomas Darlington, health officer, New York City; Prof. H. M. Wilson, chief engineer United States Geological Survey; Paul P. Bird, chief smoke inspector, Chicago; L. M. Booth, D. T. Randall, D. Raymond Cobb, Prof. J. R. Fackler Jr., Syracuse University; O. M. Dean, of New York, and others. The idea has been to make the program short and leave time for the thorough discussion of each paper.

A theater party, an afternoon at the greatest fishing grounds in New York, with a dinner to follow it, are some of the things that are down on the program. The headquarters will be at the Vanderbilt hotel.

At the monthly meeting of the Polytechnic Institute (Brooklyn) student section of the A. S. M. E., held Saturday evening, June 5, James A. Nelson spoke on "Hydraulic Machinery," the lecture being illustrated with stereopticon views.

A New Transmission Dynamometer*

A Compact, Rigid, Coupling-like Instrument That Can Be Used for Either Rotation of the Shaft and Can Be Read at a Distance

BY WM. H. KENERSON

I have received from time to time many requests for a simple transmission dynamometer, and have often felt the need of one which would be more generally applicable than those now in use. These continued requests, together with the requirements of a definite problem whose solution demanded a rigid transmission dynamometer in the form of a coupling, led to the design and construction of the instrument described herewith. The accompanying illustrations show the construction of the dynamometer and its method of application and use. In Figs. 2 and 4 the corresponding parts of the dynamometer are given the same letters and are referred to in the text.

The couplings A and B, each keyed to its respective shaft, are held together loosely by the stud bolts C. The holes in the flange A are larger than the studs C, so that these studs have no part in transmitting power from one shaft to the other. The power is transmitted from A to B through the agency of the latches L, four of which are arranged around the circumference of the flange B. These latches are mounted and are free to turn on the studs E. The two fingers of the latches engage the studs F on the flange A. On the ends of each latch are knife edges parallel to the stud about which the latch turns. For either direction of rotation of the flange A the latches L, which are in effect double bell-crank levers, will exert a pressure on the disk G, tending to force it axially along the hub of the coupling B, and this pressure, it will be seen, is proportional to the torque.

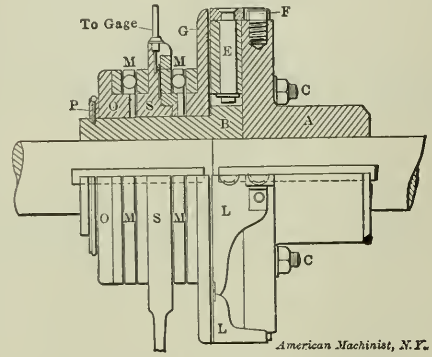


FIG. 2. TRANSMISSION DYNAMOMETER SHOWN IN SECTION

Between the end-thrust ball, or roller, bearings M M is held the stationary ring S, which is the weighing member. O is a thrust collar screwed on the hub of B, and P is its check nut, which is ordinarily pinned to the hub when in position. The stationary member S, in the form of a ring surrounding the shaft, is prevented from rotating by fastening to some fixed object the attached arm shown in the view, Fig. 1, of the assembled instrument. In the ring is an annular cavity covered by a thin, flexible copper diaphragm D, against which the ball race of one of the thrust bearings presses. The edge of this ball race is slightly chamfered to allow some motion to the diaphragm. The cavity is filled with a fluid, such as oil, and connected by means of a tube to a gage. The oil pressure measured by the gage is proportional to the pressure between the thrust bearings, which in turn is proportional to the torque.

The instrument may be calibrated in the torsion-testing machine, or by means of a sensitive friction brake. Fig. 6 is an actual calibration curve for a small instrument, obtained by hanging standard weights at proper distances from the shaft on a horizontal lever attached to the shaft, and reading the pressures indicated by the gage for the various torques shown

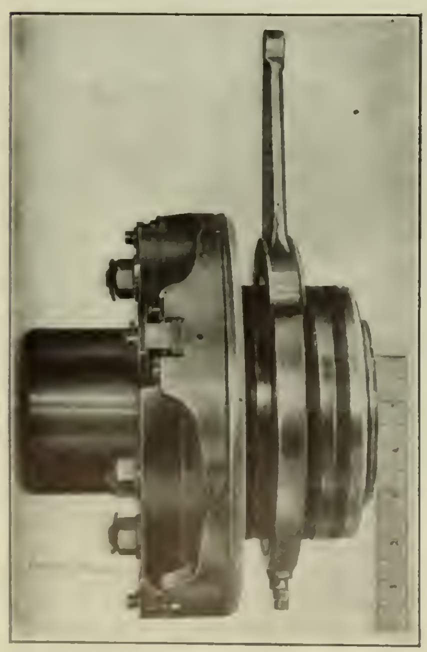


FIG. 1. TRANSMISSION DYNAMOMETER FOR 2-INCH SHAFT—WEIGHT 60 POUNDS

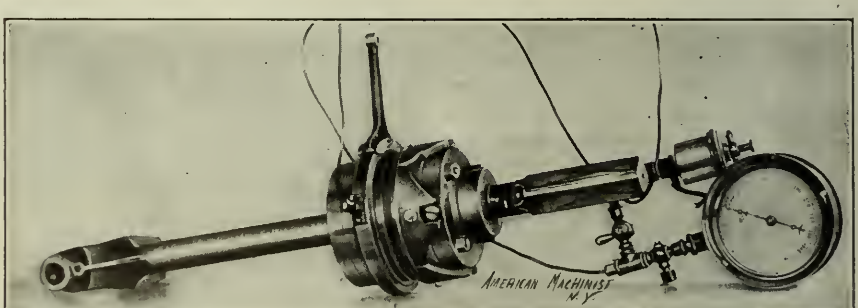


FIG. 3. TRANSMISSION DYNAMOMETER IN AUTOMOBILE PROPELLER SHAFT

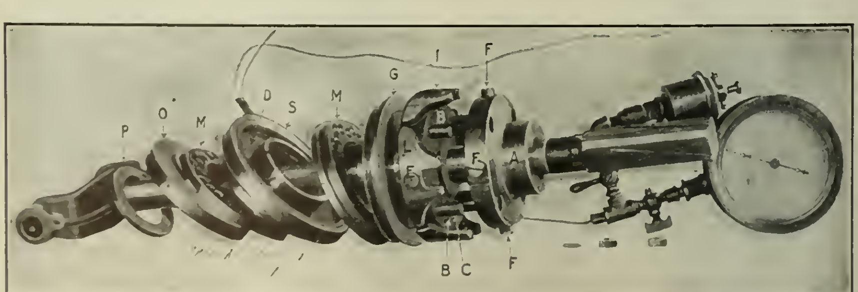


FIG. 4. TRANSMISSION DYNAMOMETER DISASSEMBLED TO SHOW CONSTRUCTION

*Slightly condensed from the *Journal* of the American Society of Mechanical Engineers.

in the diagram. For ordinary purposes, however, it is not necessary to calibrate the instrument by actual trial, since computations of the oil pressures for the various torques from the lengths of the lever arms and diaphragm area check very closely those thus obtained.

It will be seen that the weighing means is similar to that employed in the Emery testing machine, which is recognized as being extremely accurate. It will be possible to employ the Emery flexible steel knife edges on the levers, if desired, but this has been found in practice an unnecessary refinement.

The construction makes the coupling as nearly rigid as materials will permit, the movement of the diaphragm being extremely small. The only flow of oil through the copper connecting pipe is that sufficient to alter the shape of the bourdon tube, if that is the form of gage employed. As soon as the normal position of the gage is reached this flow ceases, hence there can be no fluid friction. It is possible, therefore, to use as long and as small a tube as desired, without introducing error. Where the gage is placed at a distance above or below the coupling, correction should, of course, be made for the static head.

Other means than the gage shown may be employed to measure the fluid pressure. Where extreme accuracy is desired it will be well to employ the weighing device used with the Emery testing machine. The manograph has been used in this connection to measure variations in torque too rapid for indication by the ordinary gage. For example, the variations in torque in a single revolution of the shaft of a three-cylinder gasolene engine have been recorded with its aid.

Where the rate of rotation of the shaft is variable and it is desired to indicate the horsepower direct, the combination of gage and tachometer shown in Fig. 7 is employed. The hydraulic gage is connected to the coupling described, its pointer, therefore, indicating torque. The pointer of the tachometer shows the number of revolutions per minute. Being a function of the revolutions per minute and the torque, the horsepower will be indicated by the intersection of the two pointers and suitable curves on the dial, as shown. Arrangements for recording or integrating the work done may also be attached to the coupling.

A summary of some of the more important characteristics of the instrument follows:

The instrument is compact. The example shown in Figs. 3 and 4, which is designed to transmit 30 horsepower at 500 revolutions per minute, is about 5¼ inches in diameter and weighs about 25 pounds. That shown in Fig. 5 driving a 3-inch shaft is about 11 inches in diameter and weighs about 100 pounds.

It is as rigid as an ordinary flange coupling.

It may be made in the form of a coupling, and will then occupy about the same space as the usual flange coupling, or it may be made in the form of a quill on which a pulley is mounted. This form may be made in halves for application to a continuous shaft.

It will indicate for either direction of rotation of the shaft.

The torque may be read and recorded or the work integrated at a considerable distance from the coupling.

The readings do not require correction for different speeds of rotation. All parts containing oil are stationary, hence are unaffected by variation in speed. Other parts are likewise unaffected by centrifugal action.

It may be made very sensitive and accurate. The construction lends itself very easily to variation of range of application and to varying degrees of sensitiveness, since the oil pressure, and hence the sensitiveness of the instrument, depend upon the area of the diaphragm, the relative lengths of the arms of the latches L, and the diameter of flanges. Its accuracy is dependent mainly on the degree of accuracy of the means employed to measure the fluid pressure, of which a number of forms, other than the usual pressure-gage, are available.

The only power absorbed is the small amount due to the friction of the belt, or pulley bearings, and this can be determined from the pull of the whirling arm. It is unnecessary to make correction for this, however, since the amount is so small as to be negligible.

FIG. 5. DYNAMOMETER IN A LINE SHAFT IN A MACHINE SHOP. SHAFT 3 INCHES IN DIAMETER

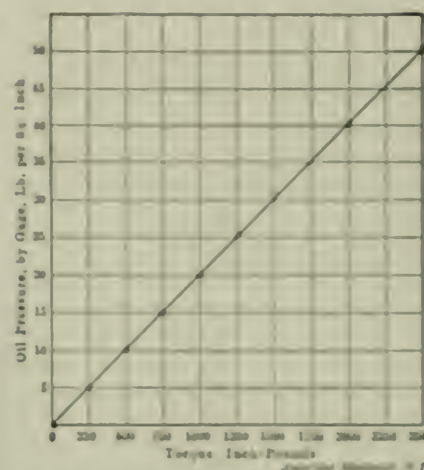


FIG. 6. CALIBRATION CURVE FOR [illegible] DYNAMOMETER

FIG. 7. COMBINATION PRESSURE GAGE AND TACHOMETER INDICATING TORQUE, REVOLUTIONS PER MINUTE AND HORSEPOWER

Since the only wearing parts are the ball, or roller, bearings, which may be lightly loaded, the instrument should not be deranged easily. Because of the very small volume of oil contained in the weighing chamber, ordinary temperature changes do not affect the calibration. All parts containing oil are stationary, hence all joints may be soldered and leakage entirely prevented.

With suitable material and ordinary workmanship, it is believed that there is little likelihood of failure of any part of the instrument. It is conceivable, however, that the balls, or rollers, although lightly loaded might crush; the diaphragm might shear; or the stationary member, although bearing only its own weight and lubricated, might seize to the hub. Remote as are any of these possibilities, should any or all of them occur, the worst that could happen would be the tearing off of the oil pipe and retaining arm, when the whole would revolve as a solid coupling. In no case can the coupling fail to drive the shaft because of its variation from the standard form, since, in addition to the driving latches employed to carry the load normally, the same number of connecting bolts may be employed as in the ordinary coupling, which will still hold the coupling together should the latches fail. Since, however, these latches are farther from the shaft, they should, if properly constructed, be less likely to fail than the connecting bolts usually employed.

Pennsylvania N. A. S. E. Convention

The tenth annual convention of the Pennsylvania State Association of the National Association of Stationary Engineers, was held at Erie, Penn., June 4, 5 and 6, with headquarters at the Liebel house. There were about sixty delegates in attendance. Sessions were held on Friday and Saturday mornings.

The delegates were called to order at 10 a.m. on Friday by John M. Lynch, chairman of the local committee, who assured the visitors that every attention would be given them during their stay in the city. Mr. Lynch then introduced Hon. Michael Liebel, mayor of Erie, who extended to the delegates and guests a warm-hearted welcome; hoped that their stay would be pleasant, and wished they would pay a return visit in the near future. In behalf of the engineers, Charles H. Garlick, past National president of the N. A. S. E., made an earnest response.

The convention was then formally turned over to John G. Lewis, State president, who presented National Treasurer, Samuel B. Forse, who urged that every delegate and guest give the closest attention and inspection to the fine exhibit of the manufacturers. Henry Sims, who followed, emphasized the good resulting to all from a higher appreciation and a closer attention to the display of the supplymen. President Lewis then appointed the several committees, after which the meeting adjourned.

The exhibit hall was then formally opened by Samuel B. Forse.

At the session on Saturday morning, considerable important business was transacted and the following officers were elected: John M. Lynch, president; F. A. Zimmerman, vice-president; D. E. Seeley, secretary; Richard Pope, treasurer; Charles Flint, conductor; John D. Dallas, doorkeeper.

The feature of the entertainment arrangements was a banquet on Friday evening, to which the ladies were invited. After a most appetizing repast, Samuel B. Forse, the genial toastmaster, introduced the following speakers, who made crisp and interesting addresses: G. F. Duemler, John M. Lynch, John A. Kerley, Mayor Liebel, F. R. Low, J. G. Gregory, George Brownhill and Charles Garlick. Jack Armour entertained with song, story and recital.

During the evening, Mrs. George Bowers and her daughter gave several instrumental selections.

Other entertainment features included a sail on Lake Erie, visits to various large plants, a trip to Four-Mile creek and a trolley ride to Waldameer. Great praise was given to the local committee for its very efficient work.

A room for the manufacturers' exhibits was arranged so that the delegates and visitors passed through it on the way to the convention hall. The following exhibited: Garlock Packing Company; Quaker City Rubber Company; Sims Company; Crandall Packing Company; Excelsior Boiler Compound Company; Atlantic Refining Company; Northwestern Pipe and Supply Company; H. W. Johns-Manville Company; Home Rubber Company; United States Asbestos Company; Mechanical Rubber Company; Erie Manufacturing and Supply Company; V. D. Anderson Company; Trill Indicator Company; William Powell Company; Greene, Tweed & Company; Jenkins Brothers; Jarecki Manufacturing Company; Lunkenheimer Company.

Leaky gasolene tanks can be temporarily repaired by the use of common yellow soap. Gasolene will not affect soap and if the latter merely is pressed into a leak the opening will effectually be stopped up. In the absence of shellac, soap is an excellent article to use in making up gasolene-pipe joints.—*Nautical Gazette.*

From March 15 to May 10, inclusive, the Fidelity and Casualty Company reported 38 boiler explosions in the United States, exclusive of railroad locomotive boilers. The loss of life approximated 20 persons.

A Cracked Flywheel Rejected

In looking over and inspecting a large flywheel for installation in your plant would you reject a wheel containing numerous, although not serious, blowholes and a small crack in the lug joining the two halves of the rim together? Would you accept a wheel from the manufacturer and take the responsibility for the destruction to property and the loss of life that might ensue if the defect should prove serious and the flywheel explode during some period of its operation? A conservative engineer who wished to take no chances would undoubtedly reject a wheel of this character and turn it back to the manufacturer. This is what actually happened in a case tried before the supreme court in New York City. A certain works in Massachusetts required 1000 horsepower to drive its new mill, which was to be supplied by a twin gas engine designed for producer gas. The wheel, which was to be mounted between the two engines of this unit, was to be a combination flywheel and rope drive. Flywheels of this special type were not made by the gas-engine company, and the contract for the wheel was let to a prominent builder in this line. The wheel was to be 17 feet in diameter on the pitch circle and have a maximum diameter of 17 feet 3 inches. Its weight was to be about 50,000 pounds and it was to deliver 1000 horsepower at 100 revolutions per minute. In reality it was a double wheel with one of the wheels split horizontally, and the other vertically, so that it contained four sections. On its 5-foot face were 24 grooves for 1¾-inch rope. The two wheels were bolted together at the rim and also bolted at the joints of the rim and hub, and in addition tie rods joined the hub and rim at the joints. The general construction and the section of the rim at the joints will be apparent from Fig. 1, which is only approximate and was sketched from models used in court. For convenience the maker of the flywheel will be called the plaintiff and the gas-engine company the defendant.

In due course of time the wheel was ready for inspection and the defendant sent its representative to examine the wheel, which was completely erected on the pit lathe of the plaintiff. After a careful inspection three of the castings were pronounced good, but the fourth casting contained as many as 19 scab spots in various parts of the rim and hub, the maximum depth being ¾ inch. These spots were not considered serious enough for the rejection of the wheel, and upon provision that these spots should be filled, the wheel was virtually accepted and was shipped for its destination in Massachusetts.

It was not until the wheel was being unloaded that the engineer of the Massachusetts company detected the crack in the lug at the rim joint. This was clearly evident upon the machined surface of the lug, but on the exterior could hardly be detected on account of the paint and dirt covering the casting. As shown in the sketch, Fig. 2, the crack ran through the lug parallel with the bolt holes and apparently continued for 4 inches from the edge of the lug on the machined side and about 2 inches on the exterior. These dimensions for the visible crack are probably correct, as they were determined by the use of a magnifying glass, but there was much discussion on this point, and it was claimed by the plaintiff that the crack extended only 2 inches on the machined side and about 1 inch on the exterior. The crack was at once reported, and as the two manufacturing companies were not able to reach an amicable settlement the lawsuit followed in an attempt by the plaintiff to collect the money for the wheel.

tensile strength of 20,000 pounds per square inch was taken for the iron in the wheel, and no internal stress was assumed, and by the use of these formulas, which were all based on Hooke's law, numerous factors of safety for different parts of the wheel were determined.

The results obtained and given in the evidence are reproduced in the following table

Weight of whole rim, lb	28,400
Weight of rim, lugs, lb	1,900
Complete weight of rim, lb	30,300
Centrifugal force of ½ of rim or half of one section, lb	219,640
Rim speed in feet per minute	5,341
R.p.m. of wheel	100
Area of 12 parting bolts, sq in	42
Breaking load of bolts at 40,000 lb. per sq in., lb	1,680,000
Factor of safety	7.6
Area of five arms at rim, sq in	102
Breaking load of arms at rim at 20,000 lb. per sq in., lb	2,040,000
Factor of safety	9
Complete weight of arms, lb	12,000
Centrifugal force of five arms, lb	41,180

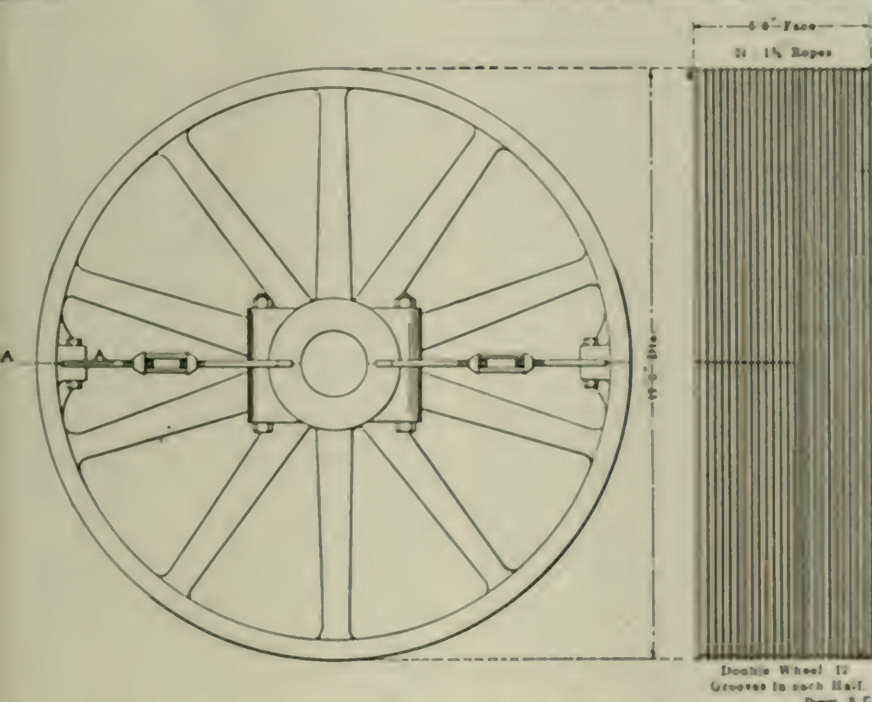


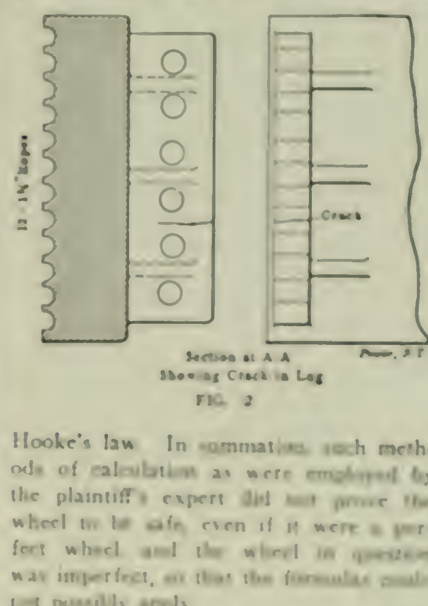
FIG. 1 GENERAL CONSTRUCTION AND SECTION OF RIM

After the wheel had been placed on the flat cars ready for shipment, it was claimed by the plaintiff that its responsibility ended, and this, of course, would have been the case if the crack had been visible during the inspection of the defendant. The crack was not visible, however, as during this inspection the wheel was assembled, and according to law the plaintiff was still responsible for any defect that was hidden or concealed.

Secondly, the plaintiff claimed that it did not make any difference, anyway, for the crack was not dangerous and was not at all a serious defect, and an attempt was made to show that the wheel was perfectly safe, by the usual formulas for centrifugal stress applied to a free rim, then to a spoke, and to the hub, or, in general, to different parts of the wheel considered free of the other parts. A

Centrifugal force of ½ of rim or ½ of one section, including centrifugal force of arms, lb	[illegible]
Area of section of web, reduced by scab hollows in wheels, sq in	[illegible]
Area of reduced sections of arms at hub due to scab hollows, sq in	[illegible]
Present factor of safety at reduced web to take centrifugal force of arms and rim with iron at 20,000 lb per sq in	[illegible]
Present factor of safety of arms at reduced web to take centrifugal force of arms and rim with iron at 20,000 lb per sq in	15
Weight of cantilever formed by overhang of rim at parting line from first arm one side, one section, lb	[illegible]
Centrifugal force of above section, lb	[illegible]
Breaking load of section of above portion of rim at arm, assuming hub and tension rod, in lb	[illegible]
Bending moment, in lb	[illegible]
Factor of safety	[illegible]
Deflection, in	[illegible]
Considering the portion of rim between arms at parting for one section only with improved tension rod. Centrifugal force between arms at parting, lb	[illegible]
Area of tension bolts, sq in	[illegible]
Breaking load of tension bolts at 40,000 lb. per sq in., lb	152,400
Factor of safety, neglecting bending moment of rim at arms and the bolts	3
Factor of safety to hold rim between arms at parting, neglecting the bolts	6

In reply the defendant stated that there must have been internal stress, as the wheel evidently had a shrinkage crack, and if this was the case 20,000 pounds tensile strength was much too high for exterior loading in addition to the internal stresses. It was also contended that the formulas used did not show anything, as they did not apply to a complete wheel with the restraints of one part figured over the others. The rim instead of being a free rim was a continuous girder, undergoing tension in addition to its bending, and it was a special girder because it was wider than its support, the spoke, and had two chances of bending; that is, when the wheel was in motion the metal near the two edges of the rim would tend to bend outward. There was no formula to take account of this unusual bending, and for that matter any of the formulas used in the case were true only to the elastic limit, and not to the breaking point, because all were derived from



Section at A A
Showing Crack in Lug
FIG. 2

Hooke's law. In summation, such methods of calculation as were employed by the plaintiff's expert did not prove the wheel to be safe, even if it were a perfect wheel, and the wheel in question was imperfect, so that the formulas could not possibly apply.

It was practically admitted that the defect was a shrinkage crack, and it was the claim of the defendant that there was no way of telling how deep it was, how far it would go, or in what direction. The plaintiff offered to cut out the crack, but the same objection still remained. If the crack should go through the flange and across part of the rim, the wheel would surely break, as the velocity of the rim was 89 feet per second. The defendant did not know whether the wheel would explode or not, but it had a crack, and as this crack was in cast iron, the chances were good that it would break, and any conservative engineer, in spite of any calculations to the contrary, must reject the wheel. These views of the case were upheld by the jury.

The Principles of Steam Condensers*

Some of the Essential Features Which Make for Efficiency and Economy, Both as Regards Design and Operation of the Apparatus

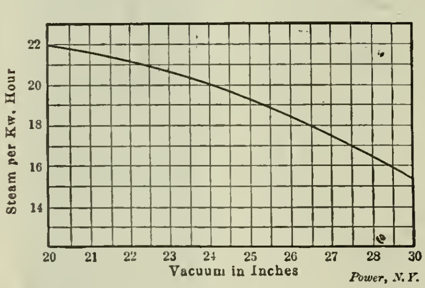
BY M. R. BUMP

The fundamental principle of design and operation of steam condensers is to secure a maximum transfer of heat from steam to water at a minimum of expense for fixed charges; that is, minimum first cost plus operating expenses. The choice of this apparatus depends in greatest measure upon the vacuum obtainable under different atmospheric and weather conditions, and when cooling towers are to be used in the design of apparatus allowance must be made for these conditions and apparatus selected which averages best under all conditions.

The cost of pumping the circulating water depends directly upon the amount of heat imparted to each pound of water in the condenser. Therefore, for a minimum of pumping cost, the water should leave the condenser exactly at the temperature of the steam entering the condenser, for in this case each pound of water carries from the condenser the maximum possible amount of heat and the amount of water required is therefore reduced to a minimum. In practical design, therefore, the condenser should be laid out with a view of obtaining this result as nearly as practical conditions will permit. In the surface-type condenser, where the heat is transferred through metallic tubes, it is necessary to allow for a certain differential of temperature between the steam and water, and the amount of heat transferred is directly proportional to the differential temperature allowed. If the differential temperature is 5 degrees, the surface required will be twice as great as in a case where 10 degrees differential temperature is allowed. The selection of proper amount of surface for any given location may be determined upon the basis of balancing fixed charges on additional surface against fixed charges and operating expenses of pumping apparatus. As the amount of surface is increased the cost will increase in definite proportion, while the differential temperature required will decrease. The decrease in differential temperature permits of a reduction in the quantity of water to be pumped, and therefore reduces both the size and first cost of the pumps and also the power required to operate the pumps.

The problem is a special one for each installation and should be so considered.

With the jet condenser it should be possible to reduce the differential temperature to a very few degrees, yet it is more common to find the difference greater than in the surface condenser. It is common to see a jet condenser taking water at 75 degrees and discharging at or below 90 degrees when the temperature of the steam is at least 110 degrees. Under this condition the discharge water should be raised to at least 105 degrees, in which case just half of the amount used would be required. The greatest inherent advantage of the jet condenser is wasted by operating in that manner. The writer has seen tests on jet condensers where the differential temperature between entering steam and escaping water was less than two degrees over a wide range in load. When operating on a fluctuating load it may be advisable to allow a somewhat greater differential temperature, but there seems to be no good reason why greater than five degrees differential should ever be allowed in a properly designed condenser. The poor results ordinarily reported are due in large measure to carelessness on the part of the engineer, who simply starts the pump and then lets it run at constant speed.



WATER-RATE CURVE OF STANDARD 1000-KILOWATT TURBINE WITH VARIATION OF VACUUM, STEAM PRESSURE 175 POUNDS, SUPERHEAT 100 DEGREES

In selecting a condenser for any given location, the consideration of weather and climatic conditions, of quantity temperature and quality of cooling water, at all times of the year, the variation in steam results on the unit for varying vacua, and the load conditions of the unit to be operated, are all of importance. The question of floor space has an effect upon the size and cost of buildings, and the ground space is often a most important item where ground is very valuable, as in the large cities.

The weather and climatic conditions are particularly important where cooling towers are to be used, as will be discussed later. The consideration of the water supply is of greatest importance. The quality of the water must be carefully considered. If the water is inclined to scale or to deposit solids when heated, the jet condenser is better suited to its use. If, on the other hand, it does not give trouble from this source at the temperatures employed in condensers but does cause scaling or pitting in the boilers, it is a distinct advantage to use a surface condenser and save the condensation for use in the boilers. In this connection, however, it is interesting to note that if the water being used over and over again is not allowed to come in contact with the air, there is a chance for it to become a very pure distilled water, which would very rapidly eat out iron pipe and would attack the iron in the boilers if it were still very free from all impurities when it entered the boilers. It is a well-known fact that pure distilled water will attack more or less any metal, and has an especially harmful effect on iron and steel. Under ordinary conditions, where the water is discharged into an open pump and then pumped into the heater, very little trouble should be occasioned from this source.

The temperature and quantity of water available are important factors. Where the quantity is at all limited it is desirable that the condenser should be designed with a view to imparting to each pound of water the greatest possible amount of heat. The maximum temperature of the water is the most important factor in determining the size of pumps. Where condensers draw their water supply from sources in which the temperature runs very high during summer months it is again very important to impart the greatest possible amount of heat to each pound of water in order to avoid the necessity for installing and operating an excessively large pumping installation. Having given the maximum temperature of the water, it is a matter of considerable work to figure out the best installation. It is often necessary to operate at lower vacua during summer months, and it is often found that many plants do operate on lower vacua than would be necessary if the condensers were properly designed and operated. In order to determine the size and best operating conditions the effect of a reduced vacuum on the steam results of the unit during those weeks or

*Read before the National Electric Light Association convention, Atlantic City, N. J., June 1, 2, 3 and 4, 1909.

months when the temperature of water is high must be considered.

The accompanying water-rate curve reading shows the effect of reduction of vacuum upon the economy of a standard steam turbine of 1000 kilowatts capacity, with 175 pounds steam and 100 degrees superheat.

These data are also summarized as follows:

Vacuum, Inches.	Steam per Hour at Full Rated Load Pounds.	Increase Over Consumption on 29-Inch Vacuum.	Increase, Per Cent.	Approx. Temperature Exhaust Steam, Degrees.
29	15,350	....	....	77
28	16,550	1,200	7.8	100
27	17,500	2,150	14	116
26	18,550	3,200	20.8	124
25	19,350	4,000	26	132
24	20,000	4,650	30.3	140
23	20,600	5,250	34.2	146
22	21,100	5,750	37.5	151
21	21,600	6,250	40.8	157

Allowing for the differential temperatures required in condenser and tower and for the temperature of the water, the amount of water required for any given vacuum over that of the next lesser vacuum can be determined and the benefits compared with the costs of obtaining it.

It is often possible to effect a very material saving in cost and size of condensers by allowing for a reduced vacuum when the temperature of the water is high. It becomes then a problem of balancing the added cost of fuel, and the like, against the fixed and operating charges on the condensing equipment to determine the most economical installation. If the water rate of the unit is carefully determined by test or can be accurately forecasted by manufacturer's guarantee, the cost of fuel to generate the additional steam required can be estimated easily. Then by plotting the temperature curve of the water supply and allowing for a fair differential temperature, the quantity of water required to condense the steam for full load of the unit can be figured for each season of the year. By comparing this with the fuel costs noted above, the final selection can be properly determined after securing estimates or proposals on various sizes of condensers and pumps.

Since the introduction of the steam turbine, the condensing problem has become doubly important. With engines the gain in economy by the last one or two inches of vacuum is relatively very much smaller than with the turbine. Furthermore, the reduction in first cost, floor space, and the like have demanded different types of condenser. The introduction of the low-pressure turbine also emphasizes the importance of high vacua essential to their successful operation.

The daily and annual load factor on the unit also have an important bearing on the condenser. Where the unit is to be operated continuously at or near full load the conditions noted above will apply, but where the load is fluctuating and averages considerably below the rated capacity, the effect on economy of the unit has important bearing only at hours of full or heavy load and should be considered only for these hours, because the water supply will be ample at other times.

The design of an air pump or dry-vacuum pump involves the general features of the air compressor. The variation in intake and discharge pressure is not great, but the volumes to be handled are enormous, owing to the low pressures. The important items outside the pump itself are, first, to keep the piping system from the point where the pressure goes below atmosphere to and including the condenser and its auxiliaries as nearly bottle-tight as possible, and, second, to cool the air entering the pump and remove from it as much of the water vapor as possible. The first question is one of careful attention and inspection, and is often a very greatly neglected point in plant operation. If the engineer properly inspects the system daily and watches the mercury column or gage closely, he can very quickly detect any unusual amount of air leakage. Yet it is common to note the falling off of one to three inches in vacuum before any attention is paid to the matter, when a fraction of an inch should be an indication that something is wrong and requires immediate attention.

The second essential, namely, the cooling of the air and separation of the moisture, is a matter that must be considered in the design of the condenser itself.

In the jet condenser, particular attention should be given to the air offtake, which should be so designed that all the air must pass in intimate contact with the cold water entering the condenser chamber. In the surface condenser, attention should be paid to the proper distribution of baffle plates in order to accomplish this result as nearly as possible. The writer is of the opinion that in many cases the air should be drawn off through a separate chamber, in which it is cooled as nearly as possible to that of the entering water. This would reduce the volume of the air itself and would greatly reduce the volume of water vapor, and would enable a considerable reduction to be made both in the size of air pump and in the work the pump does.

The compression in the air pump should approach as nearly as possible a true isothermal, in order to reduce the power required for its operation to a minimum.

In operating an air pump many engineers start the pump, set it at its normal speed and let it run regardless of the load. The result is that the air pump does a great deal of unnecessary work, and at times it is pumping steam to a greater extent than air. This can often be quickly checked by slowing down the air pump materially without any effect upon the vacuum.

The surface condenser is used almost exclusively on all the large turbine installations, and has given better results than jet condensers ordinarily show. There seems to be no inherent advantage that would justify any appreciable difference between the two types of condenser. With the large turbine units the steam consumption per unit of output is as low as 14 pounds per kilowatt-hour, and upon this basis the amount of surface per kilowatt of capacity required is very much less than in smaller units. With small units the ordinary installation requires 4 to 5 square feet of tube surface per kilowatt capacity, while on the large turbines the surface required varies from 1.75 to 2.5 square feet. The reduction in first cost per kilowatt of capacity in large-sized units is therefore as great as 50 per cent. The surface-condensing equipments installed at some of the largest stations produce continuously vacua in excess of 28 inches and have reached 29 inches.

There seems to be no reason why a jet condenser should not produce equally good results if properly designed. It is true that the work required of the air pump on a jet condenser installation is in excess of that required on a surface condenser, but the decreased amount of cooling water necessary should more than offset the disadvantage of the extra quantity of air. The first cost of jet condensing equipment would not exceed 50 to 60 per cent. of the cost of surface condensing equipment, and the repairs and maintenance should be much smaller. The surface condenser requires more attention, the surface must be kept clean and the tubes tight, and the best results can only be secured by constant attention.

A condenser of novel features has recently been introduced in this country from European practice. In this condenser the design of the chamber in a measure resembles the ordinary barometric condenser, the chief novelty being in the pump unit. The water pump and rotary air pump are both mounted on the same shaft and can be directly connected to steam turbine or motor, as desired, making a very compact and simple unit. Tests on this condenser have shown frequently that the discharge temperature of the water can be maintained between one and three degrees of the temperature of steam.

The selection of the pump-driving unit for any condensing installation must depend largely upon the other plant conditions. If the exhaust from these units can be advantageously used to heat the boiler feed water, the steam-driven pumps will invariably figure as the most desirable. Where the exhaust from other plant auxiliaries is sufficient for feed-water heating, or where economizers are used, the selection depends upon a comparison of cost of motor and steam-driven pumps and of the expenses for operating them. The general features of the newly-discussed motor- versus steam-driven auxiliaries enters into the problem.

POWER AND THE ENGINEER

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June 1	42,000
June 8	36,000
June 15	36,000

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A Standard of Excellence

We sigh for the days of the arts and crafts, when artsmen and craftsmen labored for the love of it and produced for the pleasure of producing; when each man strove for excellence and each master for reputation, and the incentive was to turn out the best that could be made.

It is more than likely that there never was such a time, but we like to think that there was; to admire the workmanship of the old things which have come down to us because they were made in this way; and to say: "In those days they knew how to do a good job."

As a matter of fact, though, are not things done in this way now if one insists upon and is willing to pay for it?

You want a job of steam fitting or plumbing done. The bids vary widely and you give it to the lowest bidder. The cheapest kind of labor and material that will satisfy the specifications are used. The "solid nickel" caps and sheaths are about as heavy as wrapping paper, and crumple up when one goes to polish them; the wiped joints leak; the fixtures won't stay fixed, and you are at a continual expense which would pay the interest on enough money to have done the job in gilt-edged style so that you could have been proud of it and not constantly fretted and annoyed by it.

It is the same way with everything else. Ask for prices on leather belting and the bids will vary as much as one hundred per cent., but it is foolish to suppose that the low price will procure the same kind of a belt as the high one. For any but the most trivial and transient use the higher-priced belt made from the center of selected hides, properly tanned by a full-time process, is the cheaper to buy.

Most purchasers realize this and are willing to pay the extra price for the all-wool, sterling, high-grade article, but they want to be sure that they are getting it. Put a Dunlap label into a new one-dollar hat and not one man in fifty will tell the difference. Give ten ordinary purchasers a half dozen samples of rubber hose and it is doubtful, if they are not experienced buyers of this class of goods, if the majority of them would select the same sample for the best. The price of cylinder oil is no gage of its quality or cost of production. Of two boilers which look the same to the casual observer one may have rivet joints of high efficiency and be built with carefully rolled sheets, reamed rivet holes and ample bracing, while the other may have a joint copied from another boiler, and not efficient for this one, put into a sheet tortured by battering, drawn together with drift pins and braced as came handiest. It costs less to make a boiler the last way; the boiler made the first way is worth additionally much more than the difference; but how is the ordinary purchaser going to tell whether, when he pays the higher price, he is getting the superior quality?

This subject was considered by the American Supply and Machinery Manufacturers' Association and the National Supply and Machinery Dealers' Association at their recent joint meeting in Pittsburg, a vigorous campaign having been instituted by Charles F. Aaron, of the New York Leather Belting Company and president of the manufacturers' association. After an extended consideration of the subject in the course of which the idea received many warm commendations, it was decided to appoint a committee, equally divided in its membership between the two societies, to investigate the subject.

The discussion developed the opinion that it would be entirely practicable to fix certain specifications setting the standard for first-quality goods in certain lines and that manufacturers of goods made to these specifications might stamp them, with a distinguishing mark authorized by the association, in the same way that the trade name "Naco" is used by the confederated supply associations in the plumbing-supply trade. Such a practice, if the mark were protected against unwarranted use, if all manufacturers who conformed to the specifications were free to use it, and if adherence to the specifications were strictly enforced, would encourage manufacturers to make honest goods out of honest material, and guarantee the purchaser who was looking for real merit that he was getting the superior article for which he was willing to pay. The one thing which must be guarded against is that there shall be any warrant for the impression which the non-users of the mark will seek to create that its use is restricted to a privileged few and not open to everybody who makes goods of the required grade of excellence.

The Electric Light Convention

The annual convention of the National Electric Light Association just held at Atlantic City was phenomenally successful. This is not the customary platitude inspired by a desire to be complimentary; it is a bald statement of fact. The attendance was gratifyingly large, the interest in the sessions was unusually widespread and the quality of the program excellent. Impartial consideration of the program prior to the convention, however, disclosed a serious flaw, and attendance upon the sessions confirmed the prognosis. There were too many papers for the length of time available for their consideration. Two of the morning programs of the general and technical sessions provided seven papers each and the third one contained eight. Now, it is absolutely impossible to devote anything like intelligent consideration and discussion to such a number of papers within the allotted space of three hours. Every paper and committee report presented at this convention was of high merit and real importance, but many of them had to be railroaded through—read in skimpy abstract and undiscussed—because there was no time left for adequate treatment. While it may seem deplorable to omit or postpone the presentation of some good material, that would be far better than congesting the program to such an extent as to neutralize a large proportion of it.

The report of the committee on gas engines, while of undoubted value to many of the delegates, was disappointing to those who were already familiar with the general status of gas-power engineering. Some operating records from gas-power plants, which the committee had collected by much hard work, and which constituted by far the most valuable feature of their work, were transferred from the regular report to a supplementary confidential report presented to the executive committee of the association. Of course we have no knowledge of the character of the suppressed records, but we cannot conceive any good reason why the data from any properly operated gas-power plant should be treated with such uncanny secrecy. Whether the records would have caused apprehension in the ranks of steam-engine builders or consternation on the part of gas-engine and producer men we have not the remotest idea; but having been secured for the information of the association at large, they should have been presented to the association at large and not restricted to the executive committee.

Mr. Smart's paper on turbines, to be printed in next week's issue, deals very frankly with the characteristic features of the several types of steam turbine, and offered excellent opportunity for a lively discussion which might have served to put on record a fairly complete summary of the turbine situation. Apparently the advocates of turbines other than the Rateau were out sailing or fishing and couldn't get back in time. At any rate the discussion was not enlightening.

This brings to mind another point wherein the sessions of this association (and several others) are sometimes weak. No effort seems to be devoted to securing the presence of men especially qualified and willing to discuss important papers. It is easier to advise than to achieve, of course, in all cases, and we appreciate the difficulty of assuring the attendance of busy engineers; but we feel impelled to emphasize the fact that the quality of the proceedings would be greatly enhanced if some means could be devised to procure the coöperation of more of the right men in the matter of discussing the papers. The real usefulness of these meetings depends very largely upon the discussions, which should bring out valuable information not otherwise obtainable.

Gumption

At a time when the results of the late depression are still felt and many a steady, capable engineer is looking for a job, there is a cry abroad in all the wide land for men with "gumption."

The man who knows the joy of a task well done, the man who does not believe that there is just as much in getting rid of a job as there is in doing it, the man who takes an intelligent interest in what is going on about him; the man who sees what has to be done and tries harder to help to do it than to frame up an excuse for not doing so—that is the man with "gumption." Oh, that there were more of him.

Give the man with gumption a job and you can forget it in the confidence that it will be done. Give the other fellow the same job and six weeks afterward, upon a casual inquiry as to the progress of the work, you will find in all probability that the job has never been started. Some trifling difficulty, which the man of gumption would have gone ahead and solved, has stood in the way, or perhaps your question will receive the answer so common with a man of this type, "I have not got around to it yet." "Tomorrow" is his favorite expression, and so often the tomorrow referred to never comes. Then again there are men with just a little more activity. The job will be started, but done in the easiest way. Thoroughness and good workmanship are not incorporated in their code of morals, and the result is a slovenly piece of work or a temporary makeshift when repairs are necessary.

To operate a power plant with economy requires men of gumption. There is no room for the slothful, lazy ones or the put-it-off type. When a boiler bags or the safety valve sticks, it is necessary to correct the evil, not in a day or two, but at once, if the cost of repairs or the safety of the plant are given due consideration. Watch the water level and fire frequently in small amounts. Do not do like the lazy but most ingenious fireman who dozed on his easy chair and the coziest place in the boiler room. An electrical connection to the steam gage and a bell on the bottom of his chair notified him when the pressure had dropped to a certain point and thus served to space the intervals of firing. The feed-water pump could run as it pleased, but was generally given some attention after the furnace was filled with coal. A half-hour's sleep was frequently obtained throughout the day, and what did the cost of fuel or the life and safety of the boiler amount to when compared with his comfort? Direct the same ingenuity to a better purpose, and if you know the safety stop on the engine will not work, take the necessary time to fix it, not within a week or perhaps a month, but at the earliest possible moment.

The man of quick wit or ready perception, the man who sees quickly what is to be done and has the energy to go ahead and do it, is the man who will make his way. There is always demand for men of quality and of gumption.

Give Boilers the Hydrostatic Test Often

While in the discharge of his duty, a boiler inspector applied hydrostatic pressure to a boiler which showed no signs of weakness or deterioration beyond a leaking rivet which repeated calking had failed to make tight. Slight leaks around rivets are not usually considered serious defects and when calking fails to stop the leak, new rivets are put in, as a matter of course, and the job considered as done.

In the case mentioned, pressure was applied before putting in new rivets, perhaps to determine if other rivets might need replacement, with the result that at three pounds above the working pressure a crack about two feet in length opened in the overlapping sheet, close to the line of the edge of the rivet heads.

Failing, as this boiler did, at a pressure of only three pounds above that at which the safety valve was set suggests that periodic applications of the hydrostatic test of boilers might not be bad practice. Like the man who took a bath once a month whether he needed it or not, would it not be a good plan to apply water pressure fifty per cent. in excess of the regular working pressure to all boilers once a year whether it is considered necessary or not?

It is generally understood that the development of cracks in the overlapping sheet is gradual and it is probable that a pressure fifty per cent. in excess of the regular working pressure would reveal a weakness in the sheet before it became dangerous. Where a factor of safety of four or five is chosen, the application of a pressure one-third of itself above the working pressure will probably not approach the elastic limit of the material of which the boiler is made and thus when applied permanently deform the boiler; and if this be true, it would do no harm and would in all likelihood be productive of much good.

In the case of the Harwood boiler at Lynn (Mass.), the engineer's attention was drawn to the crooked seam by pumping steam after the crack had gone clear through. Had a water pressure been put on the boiler six months or a year before then, it is probable that the crack, which had been slowly penetrating the sheet, would have yielded to the applied pressure and shown that a supposedly safe boiler was in reality in a seriously dangerous condition.

Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

The Tower Gas Engine

The Tower Engineering Company, of Buffalo, N. Y., one of the latest additions to the list of gas-engine manufacturers, is building a line of multicylinder vertical engines of the general type illustrated by Fig. 1. The engines are all single-acting, with long trunk pistons, and operate on the four-stroke cycle. Contrary to the common practice in engines of the single-acting type, the valves are operated by means of eccentrics and wiping rockers instead of revolving cams and rollers. The valve-gear shaft is mounted in a housing alongside the cylinder tops, as indicated in Fig. 1 and shown more definitely in Fig. 2. The latter engraving also illustrates the construction of the water-cooled

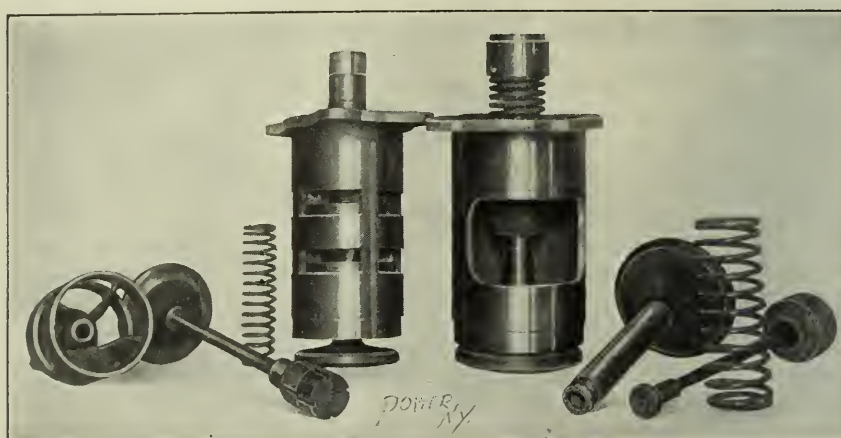


FIG. 3. INLET AND EXHAUST VALVES AND CAGES

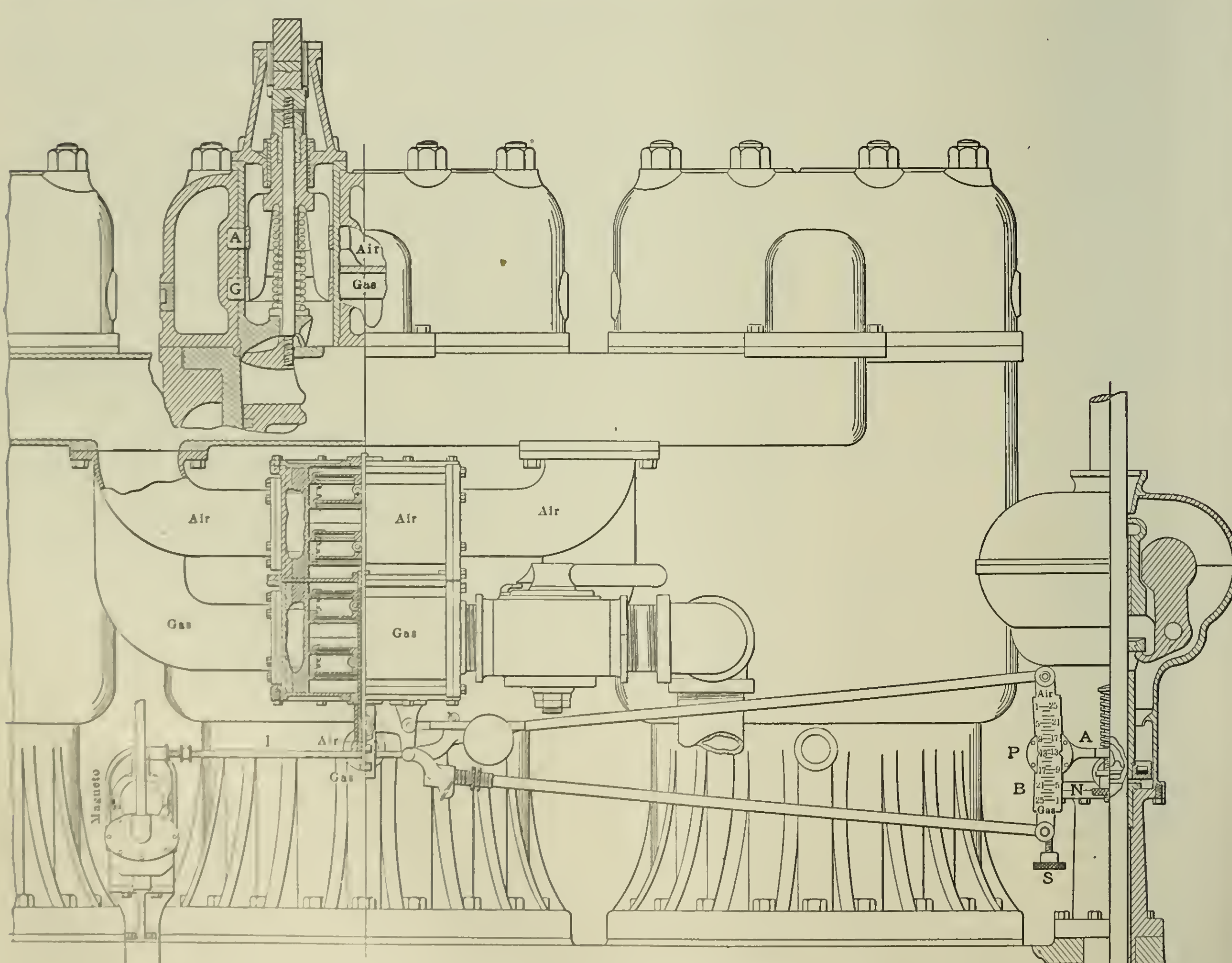


FIG. 5. GOVERNING MECHANISM

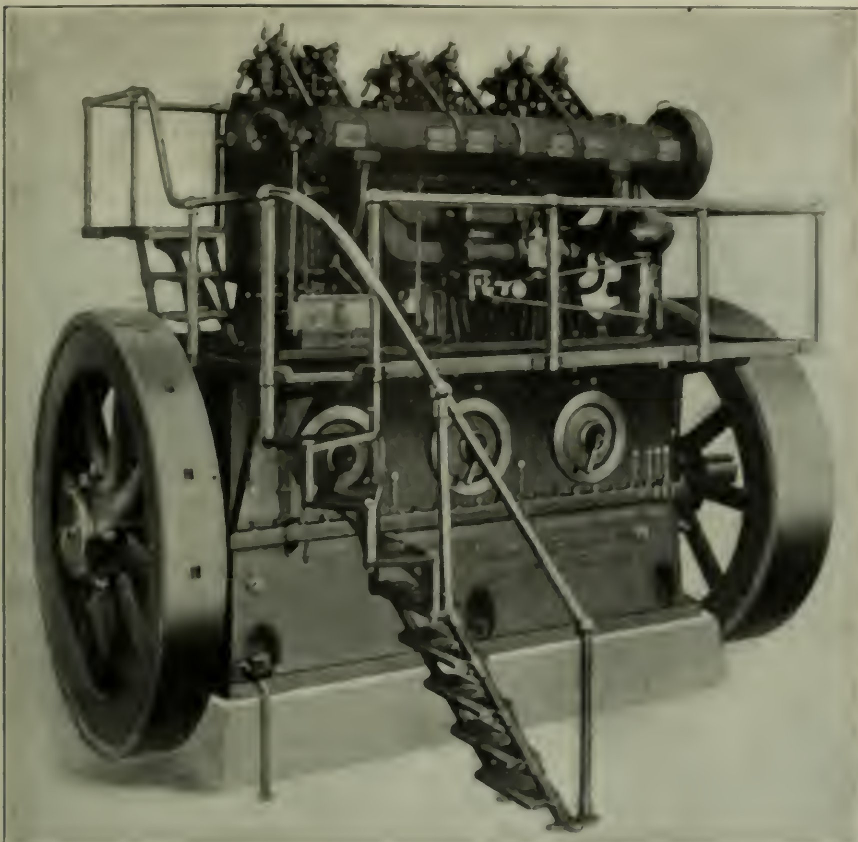


FIG. 1. TOWER GAS ENGINE

exhaust valve, the ribbing of the cylinder water jacket and some features of the lubricating system, referred to later.

The inlet valves are of the usual solid poppet type, set in removable cages, and the exhaust valves are of the hollow mushroom type. Each inlet-valve cage contains a piston mixing valve immediately above the main inlet valve, as illustrated at the left in Fig. 3, which shows an inlet valve, a mixing valve and an exhaust valve, removed from their cages, and also an inlet cage and exhaust cage complete with valves. The small stem with a piston-shaped block on the end, shown at the extreme right, is the water-inlet tube which fits into the stem of the exhaust valve as shown in Fig. 2; the block on the end is a head containing the water inlet and outlet channels, which are connected by flexible tubing with the stationary water pipes.

Speed regulation is obtained by altering the supply of gas and air in opposite directions; that is, when the load falls off, causing an increase in speed, the governor reduces the gas supply and increases the air supply. The compression is not maintained constant, however, as is customary with this general method of governing; when the gas supply is reduced the air supply is increased to a greater extent than that necessary to keep the total mixture constant, with the result that the compression pressure is actually higher at light loads than at full load. The object of this is to avoid "skipping" at light loads, due to the lean mixture. Fig. 5 illustrates the governor mechanism. The face-plate P is mounted on the end of a small shaft which is rocked by the inward and outward motion of the governor balls and is provided with an arm A which engages with a helical spring opposing the outward movement of the balls. This spring is adjustable by means of the thumb-nut N, to regulate the engine speed, and it is merely auxiliary to a pair of main governor springs inside the casing (see Fig. 2), which supply most of the opposition to the centrifugal force in the balls. Across the face-plate P is an under-cut slot in which is mounted a graduated bar B, the position of this bar is adjusted by means of the thumb screw S, and upon its position depends the relative motion of the gas- and air-control valves when the governor changes its position.

Pivotally attached to the ends of the bar B are two reach rods which actuate the air and gas valves in the two chambers marked "Air" and "Gas;" if the governor shifts the upper end of the bar B to the left (due to an increase in speed), the air valve will be opened wider and the gas valve partly closed; simultaneously, the point of ignition will be advanced by means of the supplementary reach rod I extending to the magneto. The air and

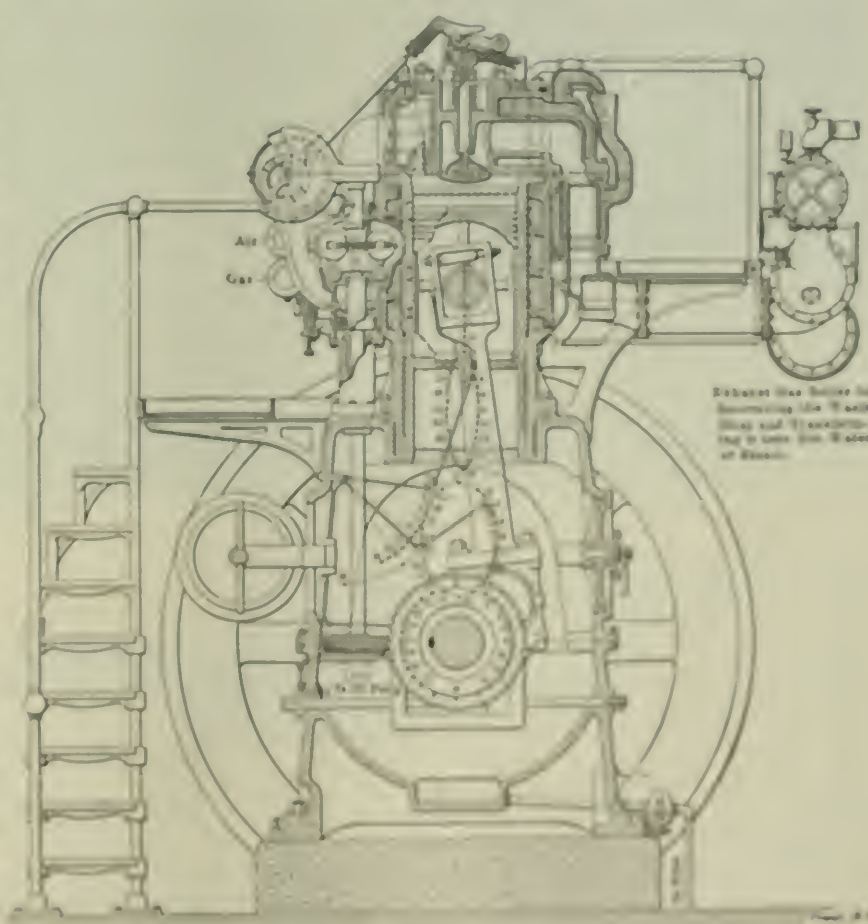


FIG. 2. SECTIONAL ELEVATION OF TOWER GAS ENGINE

gas-control valves are of the spool type, as indicated by the view through the broken-away casing. The air and gas do not mix until reaching the inlet-valve cage, separate headers being provided along the cylinder heads. At the cage, the gas enters through the ports *A* and the air through the lower ports *G*. The mixing valve is provided with spiral ribs on the interior, which give the air and gas a whirling motion conducive to thorough mixing.

Another unusual feature embodied in the Tower engine is the spark-plug mounting. The make-and-break system is employed, with electromagnetic plugs, and two plugs are provided in each cylinder. Both plugs are mounted in a single flanged disk which is set into a cage bolted to the cylinder head, as indicated in Fig. 6. The terminal of the ignition circuit is fixed on the igniter cage and the disk containing the two plugs may be

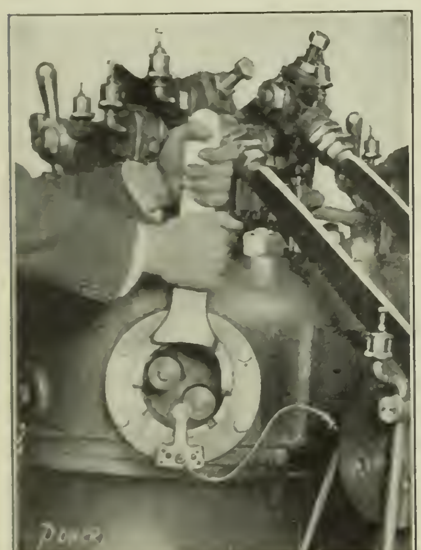


FIG. 6. IGNITER-PLUG MOUNTING

rotated in the cage so as to bring either plug into contact with the terminal. Should a plug become fouled or inactive from any cause, the other plug may be at once put into service by rotating the disk 180 degrees. Low-tension current is used, of course.

Fig. 7 shows a piston and top and bottom views of a cylinder head; in the latter, the gas- and air-inlet channels and the exhaust channel are clearly shown.

The connecting rod is of the marine type, as shown in Fig. 2, with the "big end" divided and bolted together and the upper end slotted out of the solid piece. The adjustments for wear are obvious.

The water jacket carries a spiral rib on the inside to compel thorough circulation of the cooling water. The cylinder barrel proper is a liner having a flange at the upper end which is clamped between the head and the main casting forming the jacket wall; the latter, of course, takes the stresses of operation, and is bolted to the crank case by a large number of nickel-steel studs.

Lubrication is positive throughout the engine. Oil pipes extend from a force-feed pump to the gudgeon pin, the crank-pin, the cylinder walls, the main bearings and the governor bearings.

The engine is equipped with a distributing air valve for controlling the compressed starting air. This valve is actuated by special cams carried on a sliding sleeve that can be thrown into and out of commission by a small lever that simultaneously opens or closes a master valve in the main air supply pipe, located in the head of each cylinder in a check valve; and when the master air valve is opened and the distributing

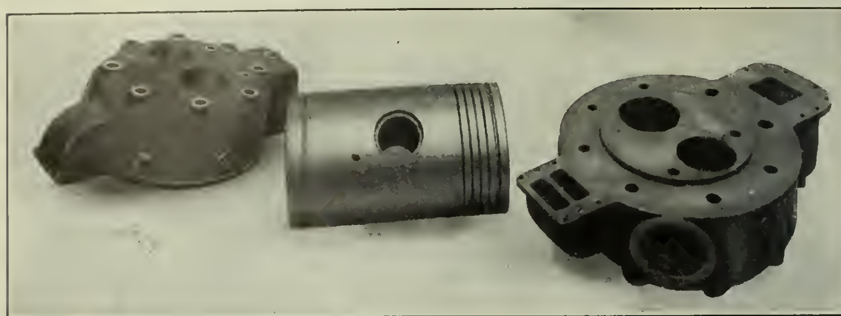


FIG. 7. PISTON AND CYLINDER HEAD

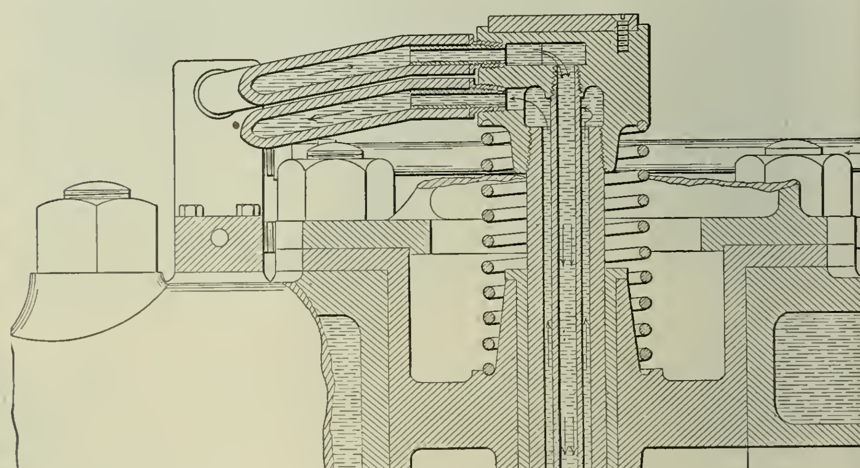


FIG. 4. ARRANGEMENT OF EXHAUST VALVE

valve thrown into position, the cylinder that is on its working stroke receives the starting air just after passing the latest ignition point; and when a cylinder picks up an explosion cycle the higher pressure of the explosion holds the check valve shut against the starting air pressure.

Boiler Explosion at Dowagiac, Michigan

A disastrous boiler explosion occurred at the hoop mill of Geesey Brothers & Coble, Dowagiac, Mich., on the afternoon of May 26, instantly killing five men, two of whom were brothers and proprietors of the mill, and seriously injuring one more, besides making a total wreck of the building. Another brother of the proprietors, who, by a strange coincidence was the nearest man to the boiler when it exploded, escaped with only minor injuries, and it is from him that an account of the events leading up to the catastrophe were obtained, the engineer being among the killed.

It appears that the plant was running along under ordinary load when the belt to a planer ran off and one of the proprietors shouted to the engineer to shut down. He ran to the engine and quickly closed the throttle, when immediately, before the engine had ceased turning over from its own momentum, the explosion occurred. The boiler was equipped with a high- and low-water alarm and a pop safety valve, the latter being screwed directly into the shell of the boiler in front of the dome. It was positively stated that neither the high- nor low-water alarm nor safety valve was blowing at the time of the explosion.

It was a horizontal return-tubular boiler, 36 inches in diameter, by 12 feet long, with double-riveted lap seams, installed in an ordinary brick setting. It went up in the air, scattering brick in all directions, turned over and came down through the roof of the plant about 50 feet distant, landing directly upside down on its steam dome. The age of the boiler was given as nine years. Examination showed that it was not badly scaled, and that the general condition of the metal was good. It happened that the young man in charge at the time, and who was killed, was not the regular engineer, the latter being laid off temporarily. When seen, in regard to the accident, the engineer, who had operated the plant for the past two years, stated that he had never been able to find any defects in the boiler, that the sheets were not burned or blistered, and that the high- and low-water alarm and safety valve had always worked satisfactorily for him, the safety valve blowing at 120 pounds, 100 pounds being the working pressure.

It seems reasonable to assume on the evidence that the boiler had a defect, not easily apparent, presumably in one of the seams, and that the additional strain caused by the sudden stopping of the engine was sufficient to disrupt it, as had the boiler been perfectly sound it should have been able, with its small diameter, easily to have withstood this treatment without injury.

BOILER EXPLOSION AT DOWAGIAC, MICH.

Indiana N. A. S. E. Convention Changed

The Indiana State N. A. S. E. convention, which was announced to be held at Indianapolis, will be held at Evansville, Ind., June 18, 19 and 20. Coincident with this meeting the annual outing of Evansville No. 2 N. A. S. E., will take place on June 20 at West Heights park.

New Jersey N. A. S. E. Convention

The eighteenth annual convention of the New Jersey State Association of the National Association of Stationary Engineers was held at Odd Fellows' hall, Hoboken, Saturday and Sunday, June 5 and 6, beginning at noon on Saturday. There were present delegates from Jersey City, Hoboken, Elizabeth, Perth Amboy, Plainfield, Newark, Passaic, Trenton and Paterson.

Mayor Steil welcomed the delegates to the city, and gave them the freedom of the municipality, while Recorder John J. McGovern cordially seconded the mayor's remarks.

National Vice-President William J. Reynolds, of Hoboken, answered on behalf of the delegates, and the committee on credentials prepared its report.

Dinner was enjoyed at 2 p.m., after which officers were elected, as follows: President, C. L. Case, of Plainfield No. 12; vice-president, Edward Sears, of Newark No. 3; treasurer, James J. Durkin, of Hoboken No. 5; secretary, John J. Reddy, of Jersey City No. 10; conductor, Edward De Groot, of Elizabeth No. 14; doorkeeper, P. J. Mooney, of Jersey City No. 10.

Unfinished business was transacted at the 10 a.m. session on Sunday; at 1 p.m. a banquet was served, and at 2:30 p.m., the delegates went in a body to inspect the North German Lloyd liner "Kronprinz Wilhelm II."

The State association was organized in 1891, and from a handful of members it is now one of the most powerful organizations in New Jersey, having locals in every prominent city.

Hundreds of delegates were present at the opening session and there was considerable enthusiasm over the reports of the secretary and treasurer, showing the progress made during the past year. Jersey City was chosen for next year.

Naval Architects and Marine Engineers

The summer convention of the Society of Naval Architects and Marine Engineers will be held at Detroit, June 24, 25 and 26. Registration will be at the Hotel Ponchartrain, and the professional sessions will be held in the rooms of the Employers' Association, Stevens building.

"Creole's" Turbines to Come Out

Press reports state that the Curtis turbines in the Southern Pacific liner "Creole" are to be taken out and reciprocating engines substituted. It is understood that the Fore River Shipbuilding Company is preparing a statement for publication regarding the "Creole's" turbines, and those of the scout cruiser "Salem."

Personal

J. R. Bibbins has resigned as publicity engineer for the Westinghouse Machine Company, to become associated with B. J. Arnold, director of appraisers of the Public Service Commission, of New York.

J. N. Oswald, formerly of Buffalo and at present connected with the Nagle Corliss Engine Company, of Erie, has been elected a director and appointed manager of the Rapid River Light Power and Transit Company, with plant at Rapid City, S. D., but with offices at Washington, Penn. He will leave for the West the middle of June and would like to get into communication with those supplying material for hydroelectric plants.

Business Items

The Ball & Wood Company, Elizabethport, N. J., has just issued a 22-page booklet, 6x9 inches, describing and illustrating the Rateau-Smoot turbo-generator outfits about which so much has been published in recent issues of Power. The booklet, which is handsomely printed and illustrated, describes these turbines and generators in detail and may be had on application.

The Macbeth Iron Company, of Cleveland, engineers, founders and machinists, builder of blowing engines, etc., and the Bruce-Meriam-Abbott Company, also of Cleveland, builder of gas engines, were consolidated on June 1, the name of the new company being the Bruce-Macbeth Engine Company. Both of the above companies have been long established in Cleveland, and their amalgamation makes one of the largest and strongest companies of its kind. The Macbeth Iron Company dates from the year 1870, having been known until late years as Macbeth & Company; The Meriam-Abbott Company, predecessor of the Bruce-Meriam-Abbott Company, was organized in 1890, and has been one of the pioneers in the manufacture of the commercial gas engine and its development to the present standard of perfection. It is the purpose of the Bruce-Macbeth Engine Company to continue the business of both of the former companies on a much larger scale than before. The manufacture and development of the gas engine will be continued and the former line of work of the Macbeth Iron Company, building of blowing engines and general machine and foundry work, will be conducted as heretofore. It is the intention of the new company to concentrate the two present plants at the former plant of the Macbeth Iron Company, on Center street, northwest Cleveland. Alterations to the present buildings will be made and several new buildings will be erected to accommodate the enlarged business, and the combined equipment of the two companies in one plant will make a very complete and modern shop. The officers of the company are as follows: President, W. C. Bruce; vice-president, C. W. Kelly; secretary and treasurer, C. J. Snow; manager, C. E. Curtiss. The above, with A. D. Macbeth, J. B. Meriam and F. A. Abbott, constitute the board of directors. Mr. Bruce, president, was formerly president of the Bruce-Meriam-Abbott Company; Messrs. Kelly, Snow and Curtiss retain the same positions formerly held in the Macbeth Iron Company.

New Catalogs

Kewanee Boiler Company, Kewanee, Ill. Catalog. Boilers. Illustrated, 78 pages, 6x9 inches.

Superior Iron Works Company, Superior, Wis. Circular. Superior shaking and dumping grates. Illustrated.

The Roto Company, Hartford, Conn. Bulletin No. 1. Tube cleaners. Illustrated, 8 pages, 6x9 inches.

Atlas Engine Works, Indianapolis, Ind. Catalog. Engines and boilers. Illustrated, 96 pages, 8x10½ inches.

Nelson Valve Company, Wyndmoor, Philadelphia, Penn. Catalog. Valves. Illustrated, 220 pages, 6x9 inches.

S. B. Patch & Sons Company, Streator, Ill. Catalog. Patch rocker grate. Illustrated, 16 pages, 4x9 inches.

Motsinger Rotary Engine Company, Greensburg, Penn. Circular. Motsinger double rotary engine. Illustrated.

The Linton Machine Company, 26 Cortlandt street, New York. Pamphlet. Komo steam traps. Illustrated, 3½x6 inches.

The North American Boiler Company, Chicago, Ill. Catalog. Improved standard safety boilers. Illustrated, 7x10 inches.

Help Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

SELLING ENGINEER wanted for steam condensers. Schutte & Koerting Co., Philadelphia, Pa.

WANTED—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. Address "M. M. Co.," Power.

AN ENGINEER in each town to sell the best rocking grate for steam boilers. Write Martin Grate Co., 281 Dearborn St., Chicago.

EXPERIENCED steam engineers to sell Detroit tilting steam traps to users. Address, stating experience, American Blower Company, Detroit, Mich.

Situations Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

WANTED—Position as stationary engineer. Am proficient; twenty years' practice with Buckeye, Brown and Corliss engines; have own tools and indicators; a thorough pipefitter and good repairer; temperate and industrious. Am N. A. S. E. man in good standing. Box 61, Power.

POSITION as constructing or chief engineer, or superintendent of building or buildings; New Jersey preferred. Best of references as to character and ability. Box 60, Power.

YOUNG MAN, age 25, desires position as engineer in charge of office or loft building. A. H. Perna, 422 6th Ave., New York.

POSITION—Single man, eight years' experience, steam-electric plants as chief and assistant. Good references, speak Spanish, prefer Mexico, Hawaii or Spanish country. Employed steam turbo-electric plant in Mexico. Address "R," Box 184, Seneca, Kans.

Miscellaneous

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

WANTED—From 500 to 1500 horsepower of B. & W. water tube boilers in units of 250 horsepower each. Must be in A-1 condition. Inquire of J. F. Cargill, Room 1630, Frick Building, Pittsburg, Pa.

PATENTS secured promptly in the United States and foreign countries. Pamphlet of instructions sent free upon request. C. L. Parker, Ex-examiner, U. S. Patent Office, McGill Bldg., Washington, D. C.

WANTED—Any concern having a small Corliss engine, say, from 75 to 125 horsepower, that anticipates taking this engine out for a larger unit within the next few months, may

Sioux Falls Hydroelectric Development

Vertical Spiral Case Turbines Designed for a 70-foot Head Installed in a Plant Arranged to Take Care of Extremely High Flood Water

BY SIMPSON RICE

The development of the Sioux Falls Light and Power Company, Sioux Falls, S. D., comprising an installation of single-runner vertical-shaft turbines in plate-steel spiral castings, direct-connected to alternating-current generators, is of considerable engineering interest on account of the provisions made to take care of occasional extremely high flood water, also from the point of view of the arrangement and construction of the power house and because of the use of spiral, instead of cylindrical-case turbines, as has hitherto been customary for developments of this character. The plant as a whole represents an excellent example of modern design.

The power house is located on the Big Sioux river about a mile from the center of the city of Sioux Falls, S. D. The river rises in the northeastern part of the State, about 100 miles from the plant, flows in a general southeasterly direction to a point a few miles below Sioux Falls, where it makes a wide semicircular turn eastward, and runs to the north through the city. From its source to the dam at Sioux Falls, the river drains an area of about 1100 square miles and has an average flow of about 1000 cubic feet per second, with a minimum in freezing weather of only 120 cubic feet per second.

Special Features

The principal condition determining the design and arrangement of the power station and its location was that of the extremely high flood water which occasionally obtains at this point. For this reason it was considered inadvisable to place the power house below the old dam at the Coughran reservoir, Fig. 1, where a plant had been carried away by a flood some years before. Several hundred feet above the old dam there is a high rock bank which provides good protection, and at this point the site for the new building was chosen. It was decided that the generators and other electrical apparatus should be placed above the highest flood level (elevation 37), and, in order to do this, vertical turbines had to be adopted, since the difference in elevation between the lowest tail water and flood level is about 33 feet, which exceeds the practical draft head. The selection of vertical direct-connected turbines enabled the foundations to be built so high that they are never completely submerged.

FIG. 2. EXTERIOR OF POWER HOUSE

The location of the station within a mile of the city's center was a prominent factor in reducing the initial investment, as well as the operation and maintenance costs, by eliminating the necessity of step-up and step-down transformers and an expensive distributing system. The design had further to provide for close commercial regulation and large temporary overloads, due to the character of the service, which consists partly of lighting and partly of street railway and power load. The street railway service imposes severe conditions on account of the comparatively small number of cars and consequent sudden changes of load from minimum to maximum, or vice versa. That the design of this plant and the apparatus installed have successfully fulfilled the conditions is demonstrated by the fact that the generating units and auxiliaries have been in continuous and successful operation since first taking load.

FIG. 1. HYDROELECTRIC DEVELOPMENT AT SIOUX FALLS, S. D.

Turbines

There are in this plant three 850-boiler-horsepower, single vertical Allis-Chalmers, type FVF turbines in plate-steel spiral casings, designed for operating under a normal head of 70 feet and at 300 revolutions per minute. The present head is 60 feet, which will be increased to 70 feet by the installation of longer draft tubes. As has already been stated, these turbines were built with spiral instead of cylindrical casings. The better efficiencies to be obtained from the former constituted the chief factor in determining their adoption in this plant, as they represent the most efficient and modern arrangement for medium-head developments of this character. These machines, which are indicated in Fig. 3, are of the reaction type, direct-connected to revolving-field generators, the weight of the rotating parts being carried on thrust bearings.

The turbine gates are of the swivel pattern, operated through regulating shafts and connections. The advantage claimed for swivel gates over cylinder gates for this type of turbine are as follows:

Swivel gates give good efficiency with small, as well as with large gate openings, while the efficiency of cylinder gates is low except in wide open positions, due to excessive hydraulic disturbances.

With the use of swivel gates, the increase or decrease in power resulting from opening or closing the gates occurs uniformly throughout the stroke from wide-open to closed position, which char-

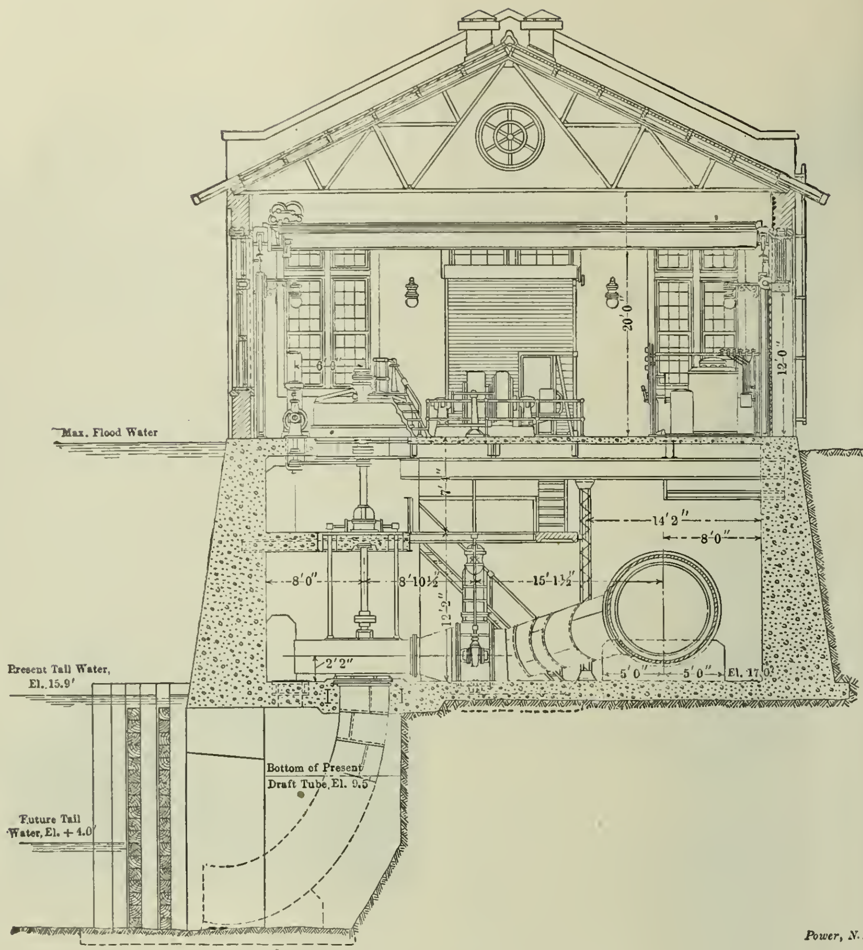


FIG. 3. END ELEVATION THROUGH PLANT

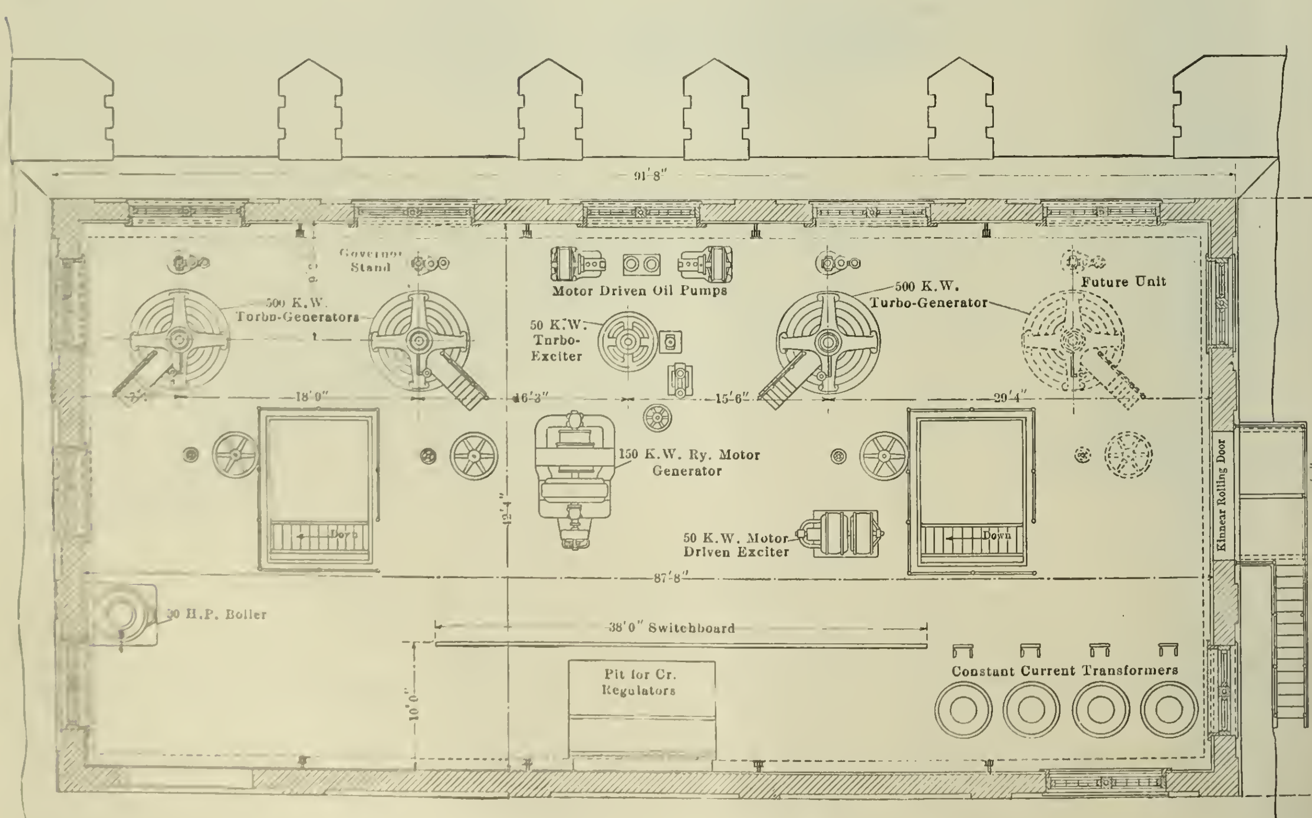


FIG. 5. PLAN OF GENERATOR ROOM

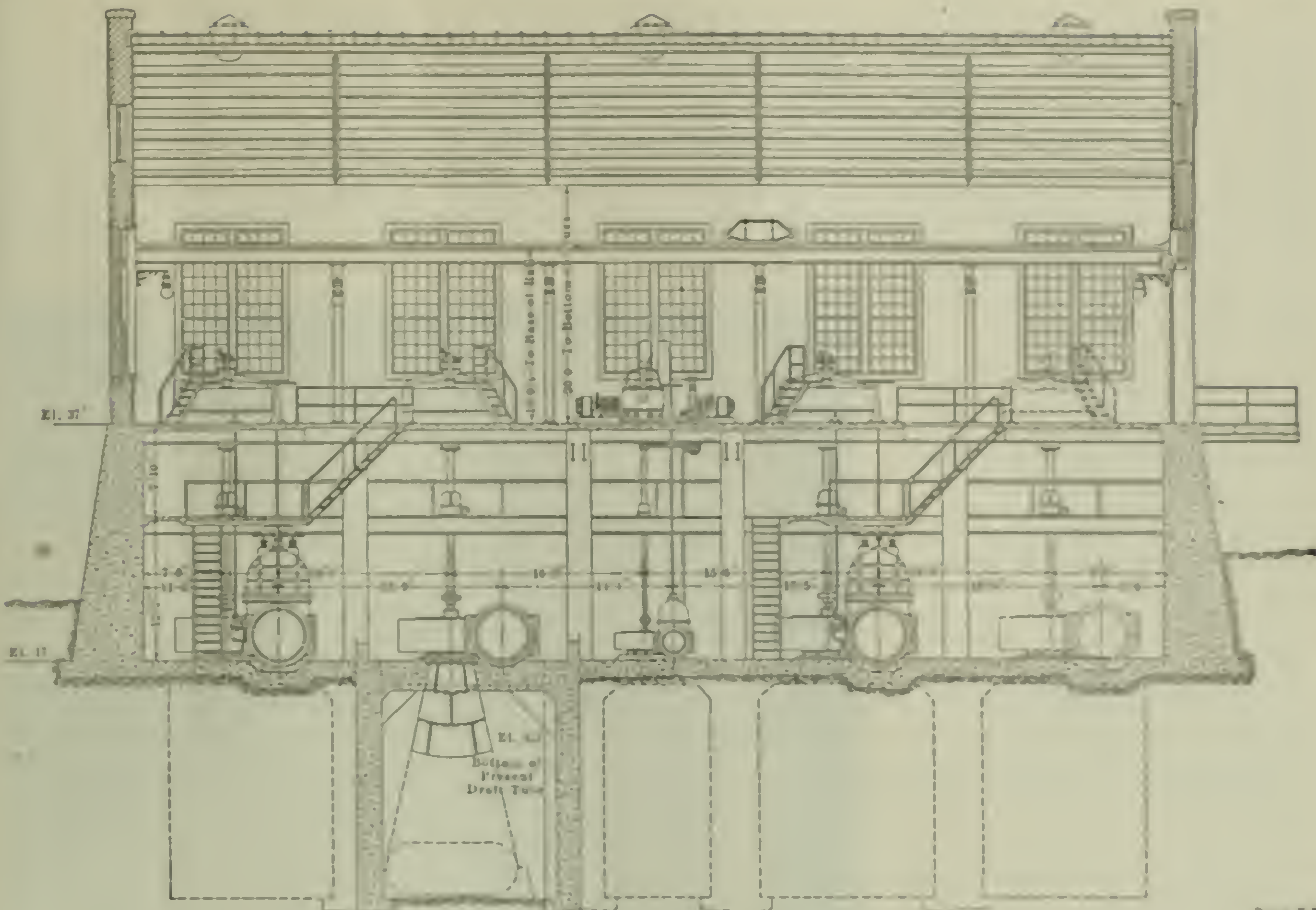


FIG. 4. SIDE ELEVATION OF POWER PLANT

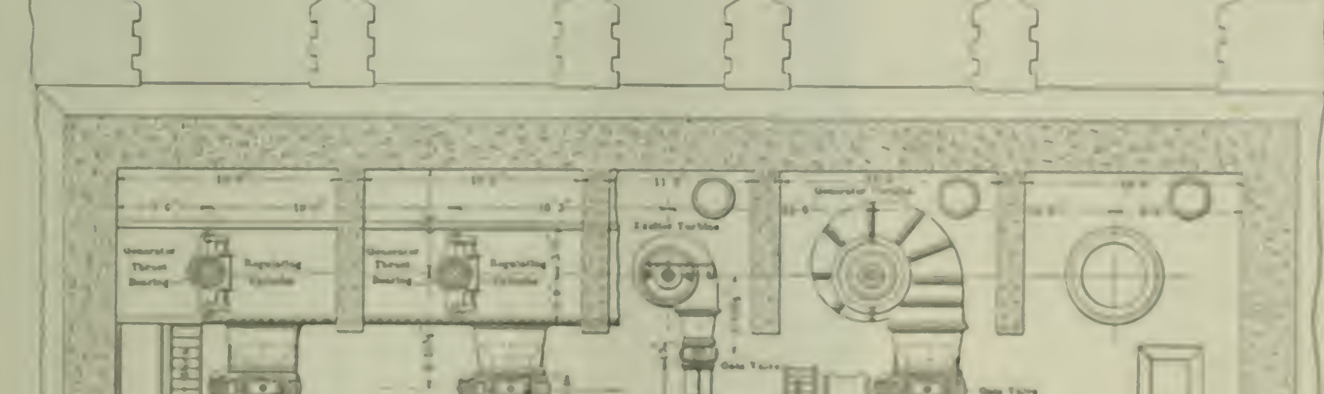


FIG. 5. PLAN OF TURBINE FLOOR

acteristic is necessary for uniformly sensitive regulation from no load to full load. With the cylinder type, a considerable closing of the gates from wide-open position is necessary before any reduction in power is effected. Moreover, at every small gate opening (required for friction load) the friction, eddies, etc., of the water are so great, as it passes through the gates, that no power whatever is developed in the wheel. This, of course, results in poor regulation at full gate and friction load gate opening.

The runners are constructed with cast-iron hubs and discharge flanges into which plate-steel buckets are cast. The efficiencies at 72, 70, 66, 62, 60 and 55-foot heads, were guaranteed as shown by the curves in Fig. 9. The characteristics of these runners enable normal speed to be maintained under a reduction of normal head with but slight loss in efficiency, thus making them particularly desirable for variable head developments. The speed rings made of cast iron are designed gradually to bring the velocity of the water in the casing to that attained in the guide vanes. The plate-steel casings are stiffened by means of angle irons, as shown in Fig. 7. They are built on the speed ring in the form of an evolutionary spiral.

Governors of the oil-pressure type were supplied with the turbines. This governor, which was described in detail, both as to construction and operation, in Power and The Engineer for September 15, 1908, consists of three distinct elements; namely, a source of energy, a means of applying the energy, and a device to regulate the time element during application of the energy.

The source of energy consists of a duplicate central-pressure oil system, as shown in Fig. 8. Each pumping unit is self-contained. The base supporting the pressure tank is of cast iron and contains a receiving tank in which a rotary oil pump of large capacity is driven continuously by a geared motor, and discharges into the pressure tank. It is of ample capacity to operate all the governors in the station, so that one pumping unit may be held in reserve.

The oil pressure from the pressure tank is transmitted to a regulating cylinder containing a piston, which is connected through a piston rod and short link direct to the regulating shaft. The oil acting on either side of the piston, as required, causes the piston to move forward or back, thus operating the gates in accordance with the changes in load.

Regulation of energy is performed by the governor proper, which is driven from the turbine shaft by means of a horizontal belt. The governor consists of a stand upon which are mounted the flyballs, floating lever, compensating dashpot, synchronizing attachment and relay device. The type of governor head used is an extremely sensitive, but absolutely static apparatus. The location of these governors is shown in Fig. 8.

Fig. 12 is a reproduction of a typical chart taken from the recording voltmeter, which shows the regulation effected by the governors in this station. During the period covered by this chart violent fluctuations of load, caused by operations of the street railway, were of constant occurrence.

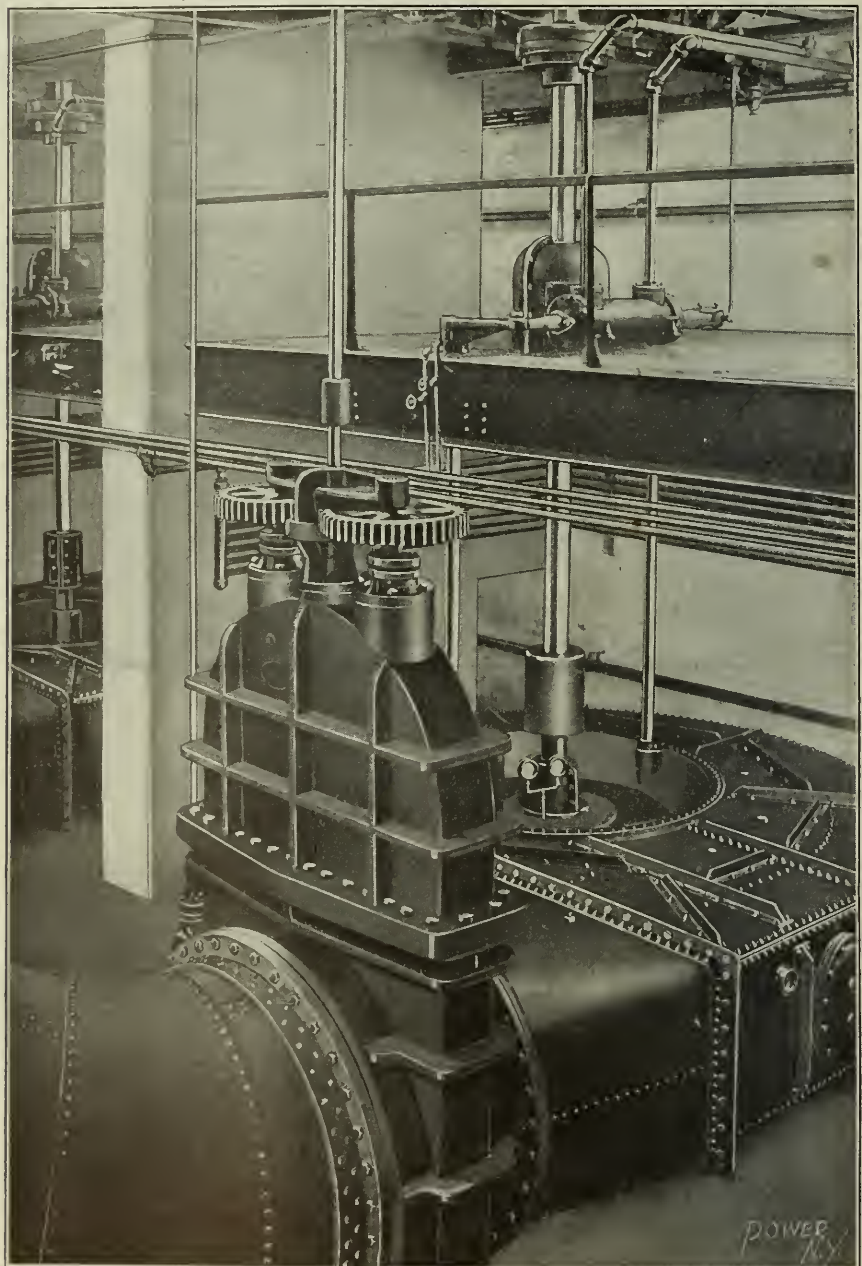


FIG. 7. ONE OF THE 850-HORSEPOWER TURBINES

At present the turbines are furnished with short steel draft tubes indicated in the power-house elevations, Figs. 3 and 4. These draft tubes are to be extended as shown by the dotted lines, and will lead the water from the turbines and discharge it at nearly the velocity of the tail race. This arrangement will effect an increase of over 10 feet in effective head, as well as a material increase in efficiency.

Thrust bearings of the oil-bath, self-contained type are furnished. A view of the outside casing, located on the thrust-bearing floor, with the regulating cylinder, is shown in Fig. 7. Self-oiling babbitted steady bearings of heavy construction are placed on top of the turbine crown plates and another babbitted steady bearing is carried on the bedplates supporting the thrust bearings. The generator shafts, which are coupled to the turbine shafts above the thrust bearings, are also supplied with two steady bearings, one of which is carried by the generator stator at the upper end of the shaft, and the other by a spider supported from the generator base ring.

Exciter Turbine and Governor

The exciter turbine is of the same general design and construction as the main turbines. It is designed for 100 boiler horsepower at 600 revolutions per minute and 60-foot head. The governor of the exciter unit is the standard Allis-Chalmers oil pressure type, Size 1. The principle of operation of this governor is identical with that of the main turbine governors, Size 2, with the exception that the compensating dashpot is omitted, as the variations in load on the exciter turbine do volt, revolving field Allis-Chalmers generators operating at a speed of 300 revolutions per minute. The general construction of these generators is similar to that of the same builder's standard waterwheel type. The stator of each generator is built with laminated armature cores mounted in a cast-iron yoke which rests on a heavy cast-iron base ring bolted to the reinforced concrete floor, as shown in Figs. 3 and 11. The spider carrying the upper steady bearing and brush holders is bolted to the top of the yoke, and the is proposed to install at some future time.

The second exciter unit is a 50-kilowatt, 125-volt, compound-wound, direct-current generator, direct-connected to a three-phase, 60-cycle induction motor of sufficient capacity to take care of the maximum load of the former. This unit is to be used to excite the main generators in case it is desired to use it in place of the turbine-driven unit.

The switchboard is of natural slate about 38 feet in length mounted upon

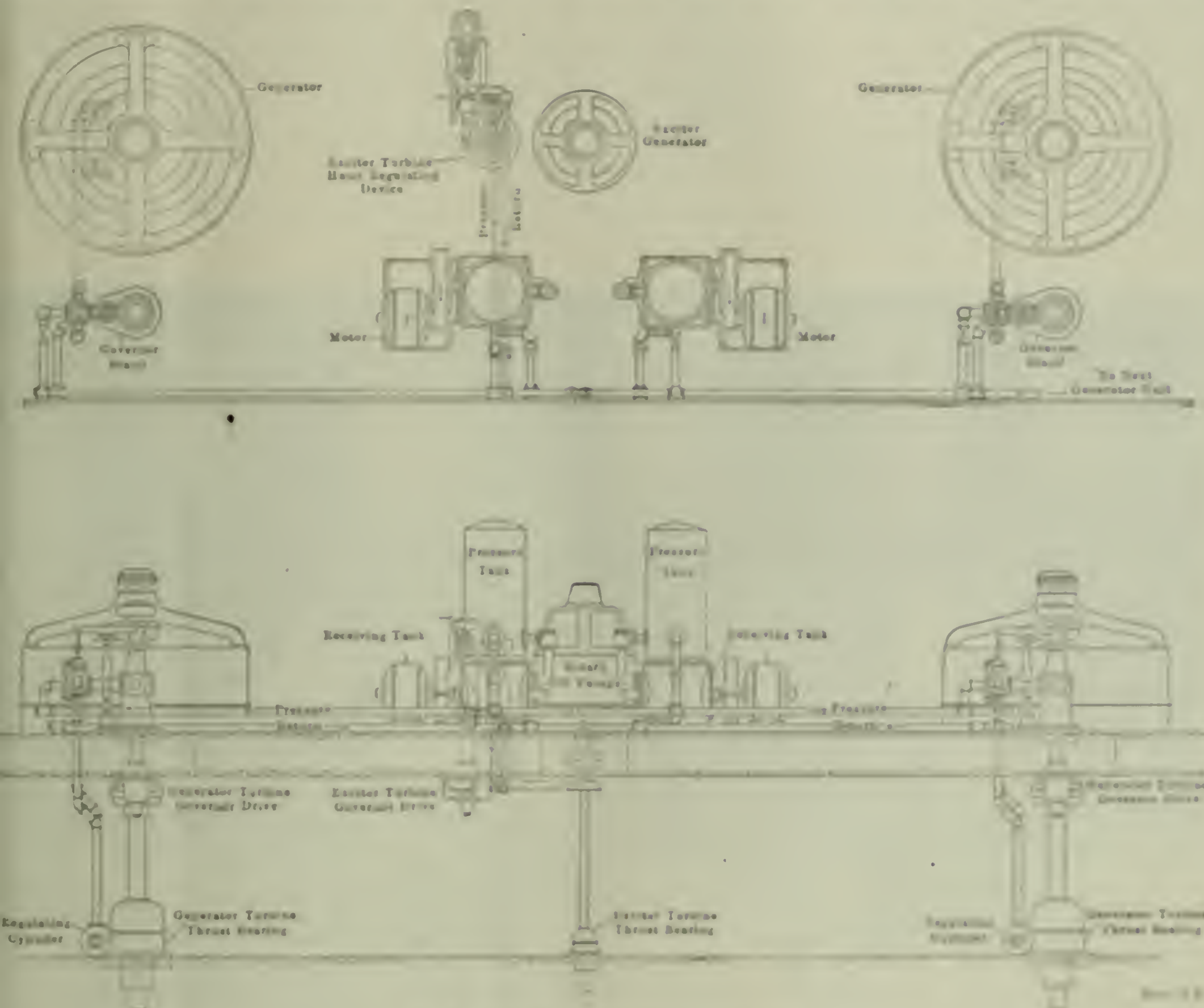


FIG. 8. DIAGRAM OF GOVERNOR CONNECTIONS

not require this auxiliary device. The construction of this governor differs from the main turbine governors in that the governor stand and regulating cylinder are in one piece, making these two elements self-contained. The efficiencies guaranteed with the exciter turbine are shown by the curves in Fig. 12.

Electrical Apparatus

There are three 500-kilowatt alternating-current, three-phase, 60-cycle, 2300- spider carrying the lower steady bearing is supported from the generator base ring. The rotating field has laminated poles, mounted on the spiders which are keyed on the shaft.

For excitation there are two units. One is a 50-kilowatt, 125-volt, compound-wound, direct-current vertical generator, direct-connected to the exciter turbine previously described. This generator is of ample capacity to furnish the necessary exciting current for the three main generators and a fourth generator which it pipe supports 3 feet from the wall. It is composed of: One swinging-bracket synchronism indicator, one double exciter panel, one induction-motor and regulator panel, three alternating-current generator panels, one blank generator panel, two three-phase feeder panels, one blank feeder panel, three 125-volt single-phase feeder panels, one three-phase synchronous motor panel, one blank motor panel, one exciter generator panel, one 125-volt lighting feeder panel, one blank feeder panel and one power feeder panel. The general construction may be seen in Fig. 11. Back of the switchboard is a pit for the regulators. On the walls are lightning arresters for single-phase lines and for three-phase regulators.

Additional installations consist of a 150-kilowatt motor-generator railway set, the synchronous motor being wound for three-phase, 60-cycle, 2300-volt and the generator for 500- to 550-volt direct current; also a motor-generator set consisting of a 2300-volt, three-phase, 60-cycle, alternating-current induction motor, direct-connected to a 50-kilowatt, 500- to 550-volt direct-current generator. Both units are placed on the generator floor.

General Construction and Development

A brief summary of several points of engineering interest in connection with the general development of this water power may be of interest. These can be more readily understood by reference to the plan of the general layout, Fig. 1, and to the drawings and photographs showing the station and apparatus. The substructure of the power house is of reinforced concrete, including walls, foundations and basement. The station foundations are built high enough so that the top will be above the highest flood-water level. The dimensions of the building are 92x46 by 55 feet high, including the basement. The superstructure is composed of red jasper stone quarried in that vicinity, and presents an unusually handsome appearance. The upper floor of concrete is supported by steel beams resting upon steel columns and concrete piers, and carries the three main generators, exciter generator, governors, motor-generator sets, oil-pressure system, switchboard, rotary converters and other electrical apparatus. The gate-valve stands, bypass-valve stands and a small boiler for heating purposes, together with radiators, are also on this floor. The portion of the floor carrying the generators is supported by thick concrete walls forming partitions separating the turbines. See Figs. 6 and 7. A crane loaded on steel pilasters, supported by the station walls, runs the length of the power house, and light is furnished by incandescent lamps. The building is entered on this floor by two rolling doors of steel construction.

Space was allowed in the design of the building for the installation of another main unit at some future time of the same size as the three now installed. Two flights of stairs lead down to the

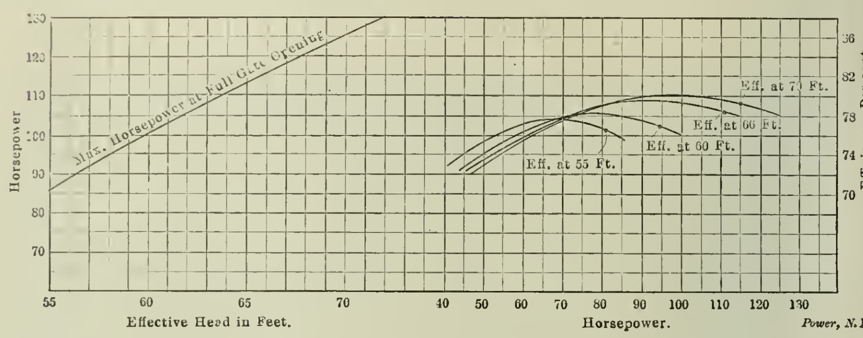


FIG. 9. POWER CURVE AND EFFICIENCY GUARANTEES OF EXCITER TURBINE AT DIFFERENT HEADS

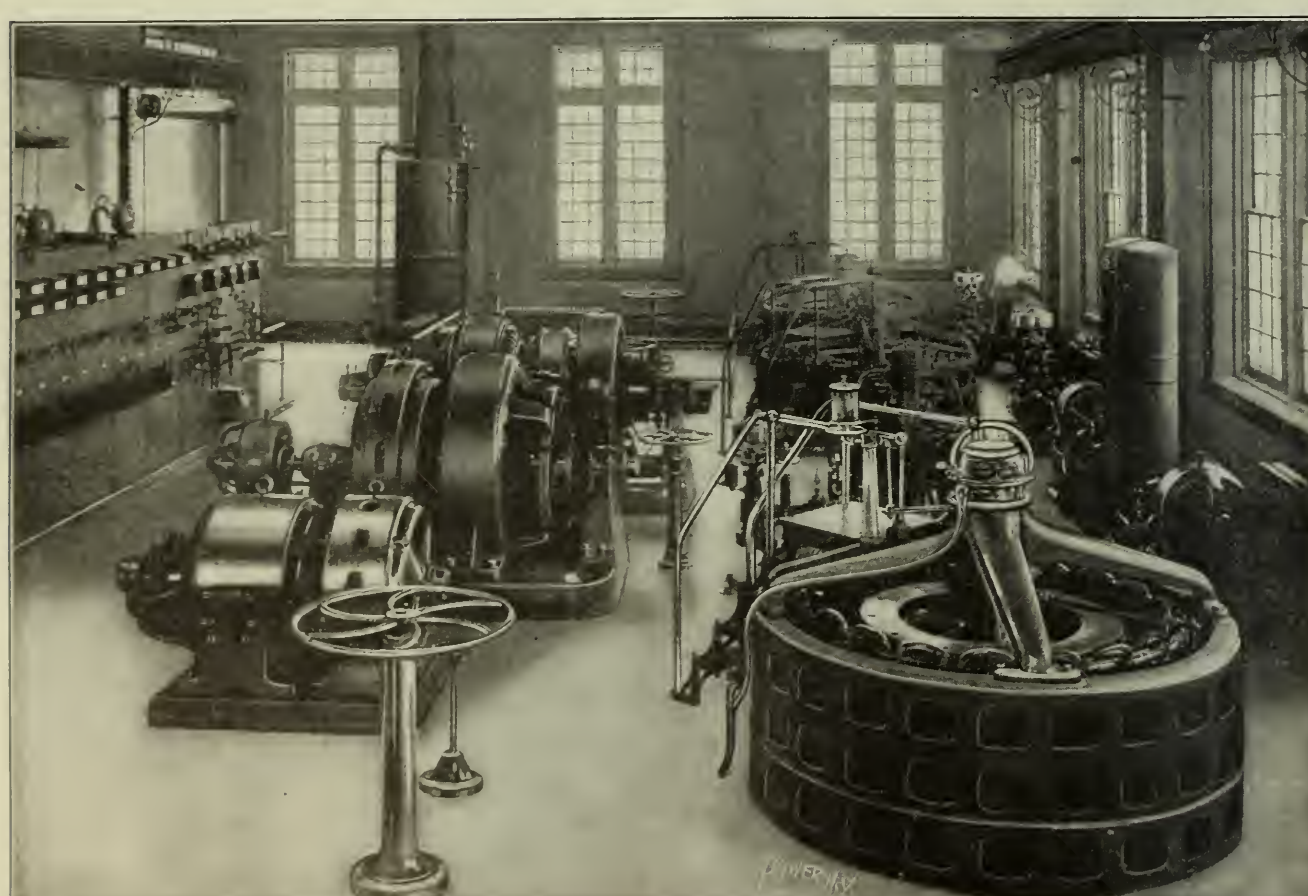


FIG. 11. A VIEW ON THE GENERATOR FLOOR

intermediate floor which carries the thrust bearings and regulating cylinders. This floor is of concrete carried on steel I-beams supported by the concrete piers, which also support the generators on the floor above. A view of the floor may be obtained in Figs. 4 and 7. The basement

designed for slow movement of the water to avoid ice difficulties. All water passing through the racks into the penstock is compelled to flow under an arch so that ice will be intercepted. This method of preventing the ice from entering the penstock has proven exceedingly satisfactory

along the penstock, provision has been made to allow for contraction and expansion due to varying temperature. This is done by means of three plate-steel expansion joints. It has been found that the movement of the penstock due to expansion and contraction amounts to several inches.

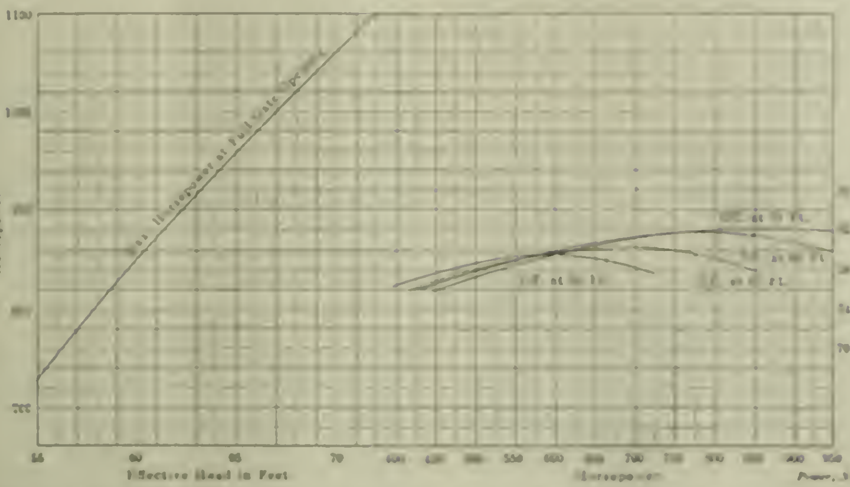


FIG. 10. POWER CURVE AND EFFICIENCY GUARANTEES OF MAIN TURBINE AT DIFFERENT HEADS

The Sioux Falls Light and Power Company was organized in 1903 for the purpose of furnishing power to the Sioux Falls Street Railway Company and other consumers, also to supply current for lighting the city and vicinity. The company commenced operations in 1905. The design and construction of the entire development was executed by the H. M. Byllesby Company, consulting engineers, of Chicago, under the direction of its chief engineer, O. E. Osthoff, and F. Y. Low, who was in entire charge of the construction work at Sandpoint.

The officials of the Sioux Falls Light and Power Company are: E. W. Congleton, president; W. G. Haley, vice-president; George B. Caldwell, treasurer; F. H. Reed, secretary; Arthur Huntington, general superintendent, and C. P. Frost, chief engineer.

floor carries the turbines, penstocks and gates. The penstock is supported on concrete piers resting upon the floor, and has a branch connection to the gate valve of each turbine, Fig. 3. That part of the basement floor supporting the turbine and discharge casing is reinforced by heavy I-beams. Provision is made for installing long draft tubes, as previously mentioned, which will extend down in long radius ells and will be supported by piers on bed rock. Ways are built just outside the foundations in the tail race for stop logs, with a space between for filling with sand bags, etc., so that the draft tube pits may be unwatered for examination when desired.

The dam and retaining walls were built of concrete and are located as shown in Fig. 1. The length of the dam at the crest is 250.4 feet, with a spillway extending the entire length. Its width at the crest is 6 feet and the depth varies from 5 to 8 feet, with a maximum width at the base of 18 feet. The base rests on bed rock. Provision is made for flashboards which increase the height of the dam 30 inches. By the construction of the dam and of about 2000 feet of retaining wall on both sides of the river, the water has been backed up forming a forebay with an area of 10 acres at the low-water line and 20 acres at the high-water line, thus providing a water storage of about 150 acre-feet. This, in addition to a reservoir of 30 acres formed by another dam farther up the river, gives this development ample storage facilities for handling peak loads.

Five sluice gates, 4x7 feet, are built into the dam at its northeastern end at the entrance to the intake. The intake was

in operation. Head gates are placed at the entrance to the intake forebay, so that the ice which is intercepted can be spilled. Two racks, each 12x21 feet, with 1-inch spacing, are built into the intake.

From the forebay the water is carried to the power house through 680 feet of steel penstock 7 feet in diameter. At the foot of the penstock there is a plate-steel standpipe, shown in the exterior view of the station, 16 feet in diameter and 62 feet high, of sufficient capacity to supply water for sudden fluctuations in

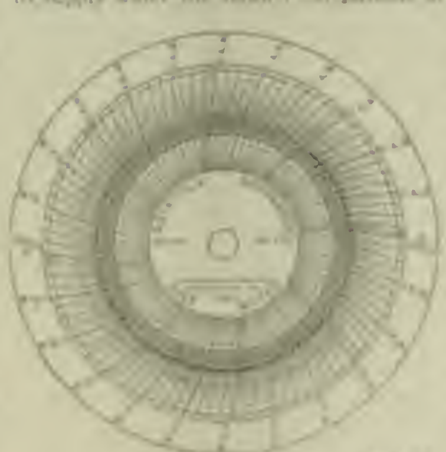


FIG. 12. TYPICAL CHART FROM RECORDING INDICATOR

the load without excessive pressure variations in the pipe line. During the operation of the plant heavy fluctuations on the street-railway load resulting from snow blockades have caused a maximum difference of water head in the standpipe of only 18 inches. At intervals

Scaling and Corroding Substances and Their Elimination from Water for Boilers*

By J. F. William Greth

The evaporation of water, and of water only, as expressed by the chemist's formula, H_2O, occurs in the generation of steam. Few of the natural water supplies are pure, since the carbonic acid absorbed by water when falling as rain enables it to dissolve certain salts of lime and magnesia. Other substances will be dissolved, depending upon the nature of the rocks, soil, vegetation, sewage and industrial waste with which it has come into contact. Among the substances in solution in waters are the following:

Calcium carbonate (carbonate of lime) which is but slightly soluble in chemically pure water, but when carbonic acid is present is dissolved in the water and forms the bicarbonate of lime, which is soluble. Carbonate of lime alone will not form a hard scale, but when present with other substances which cement it, it is apt to form a hard scale.

Calcium sulphate is also quite common in all natural water supplies, and is responsible for the hardest boiler scale. Further, this salt also acts as a cement, causing a hard scale formation with salts which ordinarily would form only sludge or a soft scale.

Calcium chloride is sometimes found in natural waters, but it is very soluble, and

*Abstract of a copyrighted paper read before the Western Railway Club, May 18, 1909.

in the absence of other scale-forming salts will not form scale unless after great concentration. It, however, can be classed among the corrosive substances found in water, as after concentration in the boiler it may be dissociated, liberating hydrochloric acid.

Calcium nitrate has practically the same characteristics as calcium chloride, but waters containing it are comparatively rare.

Magnesium carbonate is more soluble than calcium carbonate, but is ordinarily found in water as the bicarbonate. Bicarbonate of magnesia has all the characteristics of calcium bicarbonate.

Magnesium sulphate is common in natural waters, in which it is extremely soluble. Alone, it will not form scale, but it is broken up by the lime salts, from which scale is formed.

Magnesium chloride is very objectionable, since it not only forms scale but causes corrosion by liberating hydrochloric acid.

Magnesium nitrate has the same characteristics as magnesium chloride, but it is usually present only in very small quantities.

The sulphates of iron and alumina are present in water supplies contaminated with mine drainage, or the waste from galvanizing plants. These substances, when present, act in the boiler exactly like free sulphuric acid, inasmuch as they are dissociated by heat, the acid being set free and the iron and alumina precipitated as sludge or scale.

The oxides of iron and alumina are usually present in small quantities, and have little bearing on the formation of scale.

Silica is also present in small quantities in nearly all waters. It is a scale-forming substance, but since it is rarely present in large quantities, it is usually ignored.

Free sulphuric acid, like the iron and alumina sulphates, is introduced by drainage from mines and galvanizing plants. In the boiler it immediately attacks the metal, forming the sulphate of iron, which the heat decomposes, the hydrate of iron and free sulphuric acid. This acid, liberated, repeats its action upon the metal, and through an indefinite number of destructive cycles. The acid is nonvolatile, therefore the amount of the acid in the water in the boiler is constantly increased by the quantity introduced with the feed, so that the decomposition of the boiler metal is in direct ratio with the concentration which occurs in the boiler.

Carbonic acid is present in its free state in all natural waters. Its presence in the boiler promotes pitting and corrosion. It is also the acid which holds in solution the carbonates of lime magnesia.

Sodium sulphate, sodium carbonate, sodium chloride and sodium nitrate, are neutral, nonscaling and noncorrosive salts, and are not objectionable unless present in excessive quantities.

Steam generation is a continuous process, fresh feed water being supplied to the boiler as the water evaporated into steam leaves it; since none but volatile impurities pass out with the steam, this results in a continual concentration in the boiler of the impurities introduced with the feed water. The nonvolatile impurities collecting in the boiler, manifest themselves as suspended matter, scale, corrosion, or by an increased density of the boiler water.

Suspended matter may be carried in with the feed, or may be due to the accumulation of those substances that are forced out of solution as a result of either heat or concentration, or by the combined action of both.

Scale formation in the boiler is due to the action of heat, pressure, and concentration on the impurities in solution and suspension in the feed water.

Corrosion of the boiler is due to the introduction of gases and acids, or their formation from some of the impurities in solution in the feed water, by the reactions resulting from heat, pressure and concentration.

The increased density of the boiler water is due to the concentration of the sodium salts and of the scale-forming salts, to the limit of their solubilities.

That scale in the steam boiler is one of the great hindrances to economical and safe operation is beyond question. It is feared by all steam users, and their fear of the expense and danger from it is shown by the large number of manufacturers of boiler compounds, purifiers, cleaning machines, skimmers, filters, etc. Scale can nearly always be attributed to the lime and magnesia salts in solution in the water. The character of the scale depends upon the acids combined with the lime and magnesia; on the type of boiler in use; and on the rate, temperature, and pressure, at which the boiler is operated. For instance, the carbonates of lime and magnesia, when present alone, usually form a soft scale. The presence of calcium sulphate sometimes increases its hardness. A calcium-sulphate scale is generally quite hard.

Following are a few of the items which, from an economic standpoint, make it almost imperative to prevent scale formation, or at least to remove it periodically:

The reduced evaporation due to the insulating effect of the scale on the heating surfaces of the boiler.

The cost of labor required for cleaning the boiler and auxiliaries.

The cost of repairs to boilers, necessitated by their being subjected to overheating on account of the heating surfaces being scaled.

The loss of efficiency and earning power of improved furnaces and stokers installed to increase evaporation, which correspondingly increases the concentration of impurities, thus forming a greater deposit of scale, and hence a greater reduction in the efficiency and in the life of the boiler.

The cost of tube-cleaning machines, or of so-called "compounds" introduced into the boiler to prevent the adherence of the scale-forming matter to the shells and tubes.

The loss due to the investment in spare boilers to be put into commission when it is necessary to take boilers out of service for cleaning or repairing.

The waste of fuel due to heat lost in cooling a boiler for cleaning or repairing, and that required again to bring it into service.

The loss due to reduced efficiency of boiler auxiliaries, from lower temperatures of the feed water, especially in the feed-water heaters and economizers, thus materially increasing fuel consumption.

Corrosion

Corrosion is the most dangerous of the various troubles due to impure feed water, and the one in many cases the most difficult to overcome. It is usually due to the acids introduced into the boiler in the feed water, or those formed as a result of reaction between various substances in solution, caused by heat, pressure and concentration; in some cases it is due to the oxygen of dissolved air. The different acids cause different kinds of corrosion, and it occurs in different parts of the boiler, depending upon the nature of the acid.

The action of corrosive acids and salts on the boiler make operation dangerous and add to the expense, as follows:

The danger of rupture or explosion due to weakening of the parts.

The repairs made necessary by corrosion.

The necessity of spare boilers to replace those out of service for repairs.

The heat wasted in cooling boilers to make repairs and the fuel required to bring them into service again.

The expense for boiler compounds to prevent corrosion.

The author then goes on to consider the different methods for preventing and removing scale, as by hand scrapers, chisels, etc., mechanical cleaners, boiler compounds, feed-water heaters and purifiers, both live and exhaust steam, with and without the use of chemicals, and the surface blowoff; and he concludes with an argument in favor of purifying and softening the feed water before it is put into the boiler.

"Social Engineering," by Dr. W. H. Tolman, director of the Museum of Safety and Sanitation, is being translated into French under direction of Vuibert & Nony, publishers, of Paris.

The Standard Oil Company has completed the pumping stations and pipe lines necessary to pump crude oil from the Kansas and Oklahoma oil fields to the Atlantic seaboard, 1500 miles.

Connecting Up Transformers for Synchronizing and Phasing Lamps

By F. J. Foote

The transformers used with incandescent lamps for synchronizing or phasing alternators may be of any capacity down to about 100 watts, the small switchboard transformers being often used for this purpose. The high-tension winding of the transformers must, of course, be suitable to stand the operating voltage; the low-tension winding is preferably arranged to give 50 or 100 volts, so that not more than two lamps will be required in each set.

With transformers there are two methods of connection possible. The method indicated in Fig. 1 is shown on account of its similarity to the direct method described in the previous article.* The primary windings of the transformers are connected directly across the open switches. By properly checking out the connections in a way similar to that to be explained in connection with Fig. 2, one can get good results. The method represented in Fig. 2, however, is the one most frequently used because it is more convenient of application and involves less liability to make errors. The primary windings of the transformers are connected, not across the open switches, as in the first method, but across the "line" or the two leads of a phase. One transformer is connected to the leads above the switches and the others to the leads below the switches, on each phase. The two secondary windings of each pair of transformers are connected together through enough lamps to withstand the maximum voltage of the two secondary windings in series. With this arrangement the lamps will alternate in brightness and darkness just as in the direct method.

It will be seen from Fig. 2 that the primary windings of the transformers are always energized at normal voltage. The lamps will therefore be bright or dark according to the method of connecting the secondary windings. In other words, it is possible to have the lamps either bright or dark at the instant when the phases are in step. There is some difference of opinion as to which is the better of these two methods. I prefer to have the lamps dark when the phases are in step, largely for the reason that with the direct method only dark lamps can be used. In the following discussion it is assumed that the lamps are to be dark when the phases are in step.

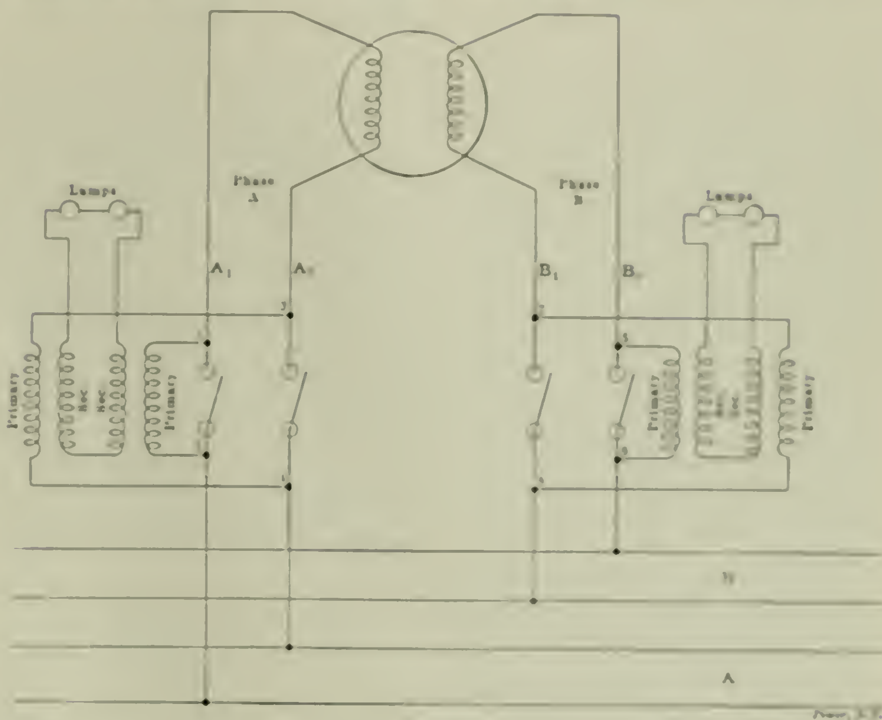


FIG. 1

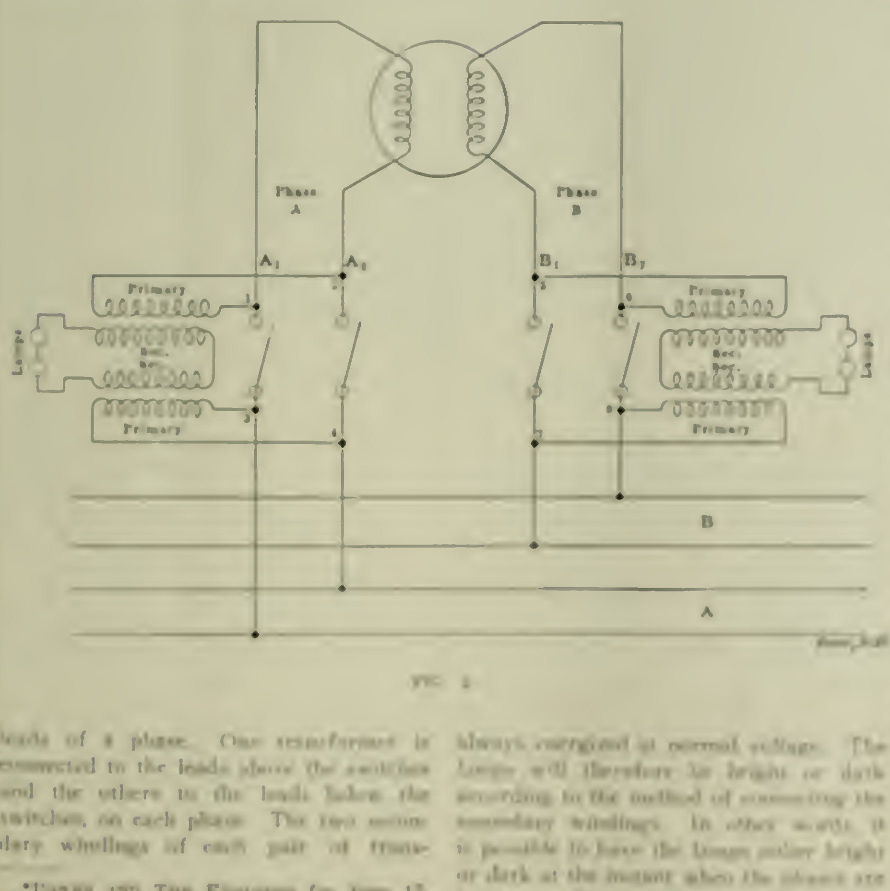


FIG. 2

The one vital point in this method, and the one on which its success or failure in large measure depends, is that of checking out or proving the connections, for one cannot depend on the leads from transformers always coming out of the case the same way. This matter is very simple. All that is required is to connect the primary windings of both transformers of a set in the same circuit and adjust the secondary connections of one of them. For instance, in Fig. 2 one could disconnect the lower transformer primary leads 3 and 4 and connect them to the points 1 and 2. Care should be taken to connect each lead to the other side of the same switch that it was originally connected to; that is, 3 to 1, and 4 to 2. Since both primaries are connected across the same source of current, the secondary relations are necessarily the same as the primary relations, and if the lamps do not show dark under this condition, it is only necessary to reverse the leads of one secondary winding; then the lamps must show dark. When the primary leads are put back in their original position, as in Fig. 2, the checking out is complete for phase A.

Phase B must, of course, be checked out in the same manner, after which the lamps will indicate exactly the same as though they were connected on the direct method.

*Power and The Engineer for June 15, page 1014.

Design and Operation of Cooling Towers*

Comparison of Relative Merits of Natural- and Forced-draft Types; Conditions Which Shauld Determine the Kind to be Selected

BY M. R. BUMP

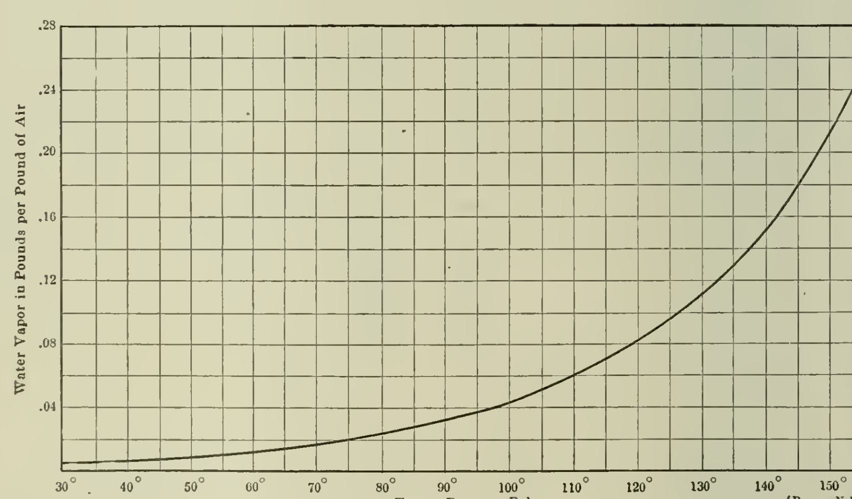
The design and operation of cooling towers is a matter so closely associated with the design and operation of condensers that the combination of condenser and tower must be considered as a single unit and the same general principles applied as noted above. In localities where a supply of condensing water is not obtainable, recourse must be had to the use of cooling towers. The general principles of the tower are in a measure a reverse proposition from those embodied in the condenser. The problem becomes one of dissipating to the atmosphere the greatest possible amount of heat from each pound of water with a minimum expense for fixed and operating charges.

Cooling towers are classified in two general classes, namely, forced-draft and natural-draft towers, the distinction being in the method of circulating the air in the towers. The comparison of the relative merits of the two types is one that involves the consideration of climatic conditions, of ground space, of the cost per unit of surface as compared with the cost of fans plus the operation of fans and of the adaptability of towers of varying capacities to the condenser.

The climatic conditions, namely, temperature and humidity, are of greatest importance in cooling-tower design, and on this account each installation must be treated as a separate problem, and there can be no standard sizes for towers of varying capacities that would be generally applicable to all locations. The greater portion of the heat extracted in a cooling tower goes to supply the latent heat of vaporization of enough water vapor to saturate the air leaving the tower. The balance goes directly to heat the air passing through the tower. During winter months the proportion of the heat that goes to heat the air is much greater than in the summer months and may exceed the amount of heat that is dissipated in supplying the latent heat of vaporization. Taking as an example an air temperature of 82 degrees Fahrenheit and supposing the air to be saturated (raining) at that temperature, and that the air is heated to 92 degrees Fahrenheit in the tower and leaves the tower saturated at that temperature, the heat extracted by each pound of air would be as follows:

To heat the air 10 degrees Fahrenheit would require 2.375 B.t.u. The saturated air at 92 degrees will contain 0.03289 pound of water vapor and at 82 degrees it contained 0.02361, the balance of 0.00928 pound having been accumulated in passing through the tower. The heat required to evaporate one pound of water from and at 90 degrees is 1051 B.t.u., and the heat extracted in evaporating 0.00928 pound of water would be approximately 9.75 B.t.u. Therefore, each pound of water leaving the tower at 92 degrees would carry away 2.375 + 9.75, or 12.125 B.t.u., and the work done by the evaporation would represent about 80 per cent. of the total. If the air entering the cooling tower was not saturated it would be able to pick up a still greater quantity of water and the proportion of heat extraction evaporating would be still greater. In this connection it is interesting to note that where the air entering the tower is comparatively dry it is possible to cool the water below the temperature of the air, and this effect has been noted in several tests on a natural-draft tower in Denver. The effect is, of course, produced by the heat extracted from the water to supply water vapor partly or completely to saturate the air, and this effect will continue even if the water is considerably colder than the air.

Attention should be directed to the accompanying saturation curve for air at 29.92 inches barometric pressure. The very rapid rise in the amount of water vapor required to saturate the air as the temperature increases indicates the greater opportunity for extraction of heat at the higher temperature and it becomes desirable to heat the air leaving the tower as high as possible. This in turn requires that the temperature of the water leaving the condenser and entering the tower be raised as nearly as possible to the temperature of the exhaust steam. For a given range in temperature in the tower it is readily seen that the warm air has a much greater effect, and the reduction of the temperature of the water to or below that of the entering air is more easily accomplished than when it is cold. One pound of saturated air heated from 90 degrees Fahrenheit and discharged as saturated air at 100 degrees Fahrenheit will extract approximately as much heat as one pound of air raised from 0 degree to 40 degrees Fahrenheit and saturated when leaving at that temperature.



AIR-SATURATION CURVE; BAROMETER, 29.92 INCHES

Localities possessing a dry climate are best suited for the use of cooling towers, and it is exceptional to find the temperature of the air very high before or during a rain storm. On the other hand, moist climates do not as a rule have as high temperatures during the summer months. For average conditions a tower can usually be figured safely upon a basis of maximum temperature of 90 degrees Fahrenheit during a rain storm when the air is saturated. On days when the temperature

*Read before the National Electric Light Association convention, Atlantic City, N. J., June 1, 2, 3 and 4, 1909.

is in excess of 90 degrees Fahrenheit the humidity will be considerably below saturation, as a rule, and the capacity of the tower will equal that for the conditions named. Basing estimates upon the air supply as stated, the problem becomes one of determining the amount of surface required.

The amount of heat to be extracted from the water can be accurately estimated by the steam consumption of the unit and the quality of the steam entering the condenser. The temperature and humidity records should then be considered as outlined above and the steam economy of the unit at various vacua compared to note the effects of periods of hot weather and the economical reduction of vacuum that can be allowed rather than to go to the increased expense for larger condensers and towers.

Allowing that the water leaves the condenser at a certain temperature and enters at a certain lower temperature, the quantity of water required is determined. In making these figures it will be seen that the widest possible range in temperature of the water should be secured. Then in cooling this amount of water in the cooling tower the amount of surface required must be calculated. This is one of the most indefinite points in cooling-tower design and is the most important one. The rate of transfer of heat from water to air, either direct or through a diaphragm, varies through rather wide limits. With increased circulation of the air the rate increases, but the exact ratio of increase is not definitely established. The effect upon the absorption of water to saturate the air is undoubtedly greatly increased by rapid circulation of the air. On the other hand, if the air is forced through the tower too rapidly it does not become fully saturated and therefore the quantity of air required is greatly increased. In the ordinary natural-draft tower the greatest care must be used to get full benefit of all the air passing through the tower, while in forced-draft towers there is always more or less water carried away mechanically and the water leaving the tower is seldom saturated, indicating that more air is being used than would be necessary in a properly designed tower.

The rate of transfer of heat from water to air through a metal diaphragm is about 2.5 B.t.u. per square foot per degree per hour. If the outer surface is kept wet the heat transfer is materially increased, and if, in addition, the air is circulated rapidly the rate of transfer can be increased to several times the figure named. In the cooling tower the heat is transferred directly from water to air and the amount of surface depends quite largely upon the rate of circulation of the air, and no definite figures were obtainable upon the transfer in forced-draft towers. By calculating this coefficient upon a natural-draft tower in Lincoln, Neb., a heat transfer of 6 to 8 B.t.u. per square foot per degree per hour was shown upon a series of tests. Using 7 B.t.u. as a basis it is seen that the surface required to produce very high vacua during hot weather would be enormous. Taking the temperature of steam at 28-inch vacuum at 102 degrees Fahrenheit and allowing 5 degrees differential between steam and discharge water, would make the temperature of the water entering the tower 97 degrees Fahrenheit. If the air were up to 90 degrees Fahrenheit in temperature, this would allow a maximum working range of only 7 degrees and the surface required would be 22 square feet per pound of steam condensed per hour. For a differential of 10 degrees the surface required would be 15 square feet, for 20 degrees 7.5 square feet, and for 30 degrees 5 square feet per pound of steam condensed per hour. In each of these cases the vacuum would be reduced and at the 30 degrees differential it would be 26 inches.

In the case of the forced-draft tower the size of fan and power required for its operation would decrease in about the same ratio as the decrease in surface noted above by allowing larger differential temperatures and obtaining correspondingly smaller vacua. In either case the fixed and operating charges on condenser and cooling tower must be balanced against the cost of extra fuel, and the like, required when the vacuum is reduced in order to determine the most economical installation.

Various materials have been used for wet surface in cooling towers. Rough boards have been successfully used, but they take up a great deal of room, and the cost per square foot of surface is high when compared with other materials. Wood blocks, tile, and the like, have been used largely in forced-draft towers, and the results are satisfactory except as to first cost. The use of curtains made of galvanized-wire screens has been tried, but the first cost is high and the screens are not entirely satisfactory in distributing the water. A number of tests have been made with burlap curtains, and the results thus far have been above expectations. The burlap is very cheap and is easily made into curtains. These curtains are comparatively light and easily suspended in the towers. The only difficulty has been to secure a long-fibered burlap so that a portion of the threads will not wash out and enter the piping system. Some of these curtains are now three years old, and the expense for renewal will be nominal. Several suggestions have been made as to tarring or painting the curtains as a preservative, but the cost and value of these treatments are doubtful.

In the design of forced-draft towers, the following conditions must be considered: (1) The tower should be laid out with great care to secure proper distribution of the air and water. (2) The fan capacity should be figured upon a basis of handling saturated air, and the path of the air should be such as to bring the water and air into intimate contact so that the air will leave the tower as nearly saturated as possible. (3) Care must be taken to prevent loss of water by being carried away mechanically with the air leaving the tower. (4) On account of the increased cost of pumping water to high heads, the tower should be as low as possible and the water pumped no higher than absolutely necessary. (5) In laying out the water-distributing system care must be used to reduce the friction head to a minimum.

In combustion work it has been found that in forcing or pulling air through a fuel bed the induced draft which pulls the air through is much preferable to forced draft for securing proper distribution of the air. The distribution of the air in the fuel bed is much more uniform, and especially in gas producers a more distinct advantage is gained in the suction-type producer. More fuel can be burned per square foot of grate surface and with less excessive clinker than with forced draft. The same general principles apply to air distribution in cooling towers, and it is the author's opinion that much more uniform and satisfactory results can be obtained by placing the fan at the top of the tower and drawing the air through the tower. On account of the moisture present it would be necessary to protect the fan blades from rust by galvanizing or frequent painting. The results from combustion work would indicate at least 20 per cent. improvement and would reduce the amount of air required and the power consumed by the fans materially.

In the design of natural-draft towers, the principles are very similar. These towers should be set in as open a location as possible so that full advantage can be taken of winds to aid the draft created in the towers. Where set in open spaces it is advisable to have the sides, or at least a portion of each side, equipped with removable doors so the air openings can be changed to suit the direction of the wind. In the tower the greatest freedom of air movement is necessary, and the design of the water-distributing system must be made with a view of leaving as much free air space as possible. The passage of the air through the tower will create a certain amount of draft caused by the heating of the air and the absorption of water vapor, which further reduces the density and increases the stack effect. The tower can be designed to create a draft sufficient for all the air required, but it is usually desirable to use the added advantage of the winds wherever possible in assisting the air circulation. In spacing the curtains in the tower it is necessary to place them close enough together to get the full benefit of all the air passing; but, as pointed out, the distributing troughs must be laid out to allow as free air travel as possible. If the amount of water flowing down the curtains is too great it will create a counter-effect to the draft and will retard circulation of air in the tower.

An important feature of the tower is to house the air openings properly, to prevent loss of water during high wind storms. If no loss of water occurs, the amount of condensation, if the jet condenser is used, will be more than sufficient to supply the water evaporated in the tower. If a surface condenser is used, the makeup water required in the tower should not exceed and will ordinarily be somewhat less than the amount of water supplied to the boilers. Where a jet condenser is used, the cold-water supply to the boilers can be passed into the tower pit and condenser inlet and the water for boiler supply drawn from the hot water leaving the condenser.

In the design of the water-distribution system, the friction head must be kept down as much as possible when proper distribution of the water is maintained. It is very essential that the water be distributed evenly over all of the curtains or wetted surface, and this as a rule necessitates some experimenting on the tower in order to reach all the curtain with an equal supply of water. An effective means of accomplishing the result is to distribute the water from two or more troughs. The water discharged from the pipe at two or more points in each trough will maintain practically uniform level in the troughs. The discharge from the main troughs should be through vertical slotted openings in the sides, so that the quantity discharged to each curtain will vary as the head of water in the troughs without creating any friction head. The individual troughs supplying each curtain should be made as narrow as possible in order to leave ample space between troughs for air openings. These troughs should discharge through slotted openings, similar to the main troughs, against a metal strip or vane which acts as the hanger for the curtains and on which the water is uniformly distributed across the full width of the curtain.

Cooling ponds with jets scattered through the pond and discharging into the air above the pond are used to some extent. The amount of power required for pumping the water is large, and the first cost, unless the pond is already in existence, is prohibitive. On very still days the capacity is limited, as wind is depended upon for air circulation. On days when the wind is brisk the loss of water carried off mechanically is excessive and the amount of make-up water is consequently increased.

Some very interesting experiments have been made on a combination of condenser and cooling tower in which the steam discharged from the unit enters coils of pipe or chambers over which water is sprayed and air rapidly circulated. This plan has shown some promising results. The amount of water required in the condenser is practically the same as the amount condensed. This plan could possibly be made feasible for small units, but for large units it could not be applied. Fair vacua were obtained on certain tests of this outfit at the Virginia Agricultural college.

The extension of this plan along the lines of the radiator of automobiles leads to a very interesting problem, which merits some study for applications to small units.

The majority of the larger installations in this country are forced-draft towers, while European practice seems to be toward using natural-draft towers wherever ground space permits. With plenty of ground space available the natural-draft tower should receive most careful consideration, and the application of a natural-draft tower to a condenser that will discharge the water practically at the temperature of the steam makes a very desirable combination for the average installation.

Piping Oil from the Pacific to the Atlantic

On December 15, 1906, the waters of the Pacific ocean, for the first time in history, mingled with the waters of the Atlantic ocean, across the Isthmus of Panama. It was not, however, through the great canal, but through the oil pipe line of the Union Oil Company, of California, which was being tested with sea water, under a pressure of 800 pounds, before being put into service. The installation of this line opened the Eastern market for the first time to California oil and gave it opportunity to compete with the product of the great oil combination.

The laying of the line and the construction of the pumping stations were in charge of R. W. Fenn, one of the company's engineers. Six months' time was given the company under its concession from the Government. On April 16, the pipe laying was begun, and the line was completed October 16, six months to a day. Jamaican laborers were employed, in gangs of 70 each, divided into sections. First came the "brushers," cutting all the grass and brush, followed by the "stringers," who laid the pipe in line, end to end.

The next division removed the thread protectors and painted the threads with a preparation of oil and graphite. The pipe-laying gang proper consisted of the men who handled the lifting jacks, jack boards and chain tongs for holding the finished line in place, and 20 men on the pipe tongs, 5 men on each of four pairs of extra-heavy long-handled lay tongs. Another section lifted the next joint with pickups, and the pipe steerer lined it up so the thread would enter properly, while the joint was twirled by the friction of a length of rope passed around it several times and drawn back and forth until the pipe would enter no farther in the collar without the aid of the tongs.

The foreman then sat astride the collar and beat time with his hammer, while the tongsmen "broke out"—two tongs up and two down, with the precision of a military drill.

It is hard to realize the difficulties which presented themselves during the work, which was begun during the rainy season. The Panama Railroad was double-tracking its line and canal construction was going on everywhere. Steam shovels were at work, tracks were being shifted and plans were being changed all the time. There is no wagon road across the isthmus and it was necessary to dodge the heavy dirt-train traffic continually.—*Bulletin American Republics.*

Old and New Water Power Companies

Clemens Herschel, writing of the old water-power companies which sold mill sites and furnished water power at an annual rental, says:

"At the present day, companies of precisely the nature described are no longer being organized. Indeed, the time has come when, in certain cases, it would be materially profitable to convert such companies, and they should be converted, into the modern form of power company which distributes power on wires instead of distributing water through canals, as was the old-time method. The large areas of land hitherto occupied by the canals could then be sold or used for other purposes, the proceeds of such sales possibly paying for the whole improvement, while much power now wasted by hydraulic losses in long canals and at many power plants would be recovered and all the power to be distributed and used would be generated at and distributed from one central power station."

Aluminium paint is made by blowing air or gas through molten aluminium while it is setting and at the same time stirring violently. This forms a spongy or granulated metal that is easily pulverized. The powdered metal is sized and polished.

In 1907, the United States produced 166,000,000 barrels of oil, and in 1908, according to unofficial estimates, the total was in excess of that amount. The United States produces 63.12 per cent. of the entire oil production of the world.

Economy of Four Valve Engines

By Thomas Hall*

The Dean and Wood report, as presented at the Detroit Meeting, in June, 1908, of the American Society of Mechanical Engineers, has so often been misquoted, misrepresented and misused, sometimes for the purpose of injuring prospective business of builders of four-valve engines, that it seems eminently proper for some comment to be made by builders of this type of engine. There is hardly a comment or statement in the Dean and Wood report that has not been twisted and distorted almost beyond recognition. The argument has even been advanced that builders of four-valve engines must realize that the four-valve proposition is a failure, because they had not in any way defended themselves in print since the issue of this paper.

In answer to such comments, I have to say that in so far as builders of four-valve engines with the Corliss-type cylinder are concerned, no defense was called for. The tests were not made on engines of this construction and the adverse comments were made only with reference to the types of engine tested. We indorse many of the statements made by Dean and Wood and shall endeavor in a brief manner to discuss the comments made by them in so far as they pertain to four-valve construction, presenting them in the light in which we understand them.

The first comment which has been widely quoted reads: "There are several features in these results, as follows: The most important is that the four-valve engines, which were built to be more economical than single-valve engines, have utterly failed in their object."

This comment has been quoted in abstract as applying to all types of four-valve engine, without quoting other sections of the paper forming a part of this comment. Dean and Wood made this statement as applying only to the engines tested, and not to four-valve construction in general.

In further comment on the two four-valve engines tested we quote the paper: "These results show that efforts to realize economy by duplication or multiplication of parts, even if ports are shortened and clearances reduced, accomplish nothing. The duplication of valves used in both four-valve engines simply increases the opportunity for leakage."

This comment, fully discussed, would form a very long article itself. We can only, therefore, refer to it briefly. It is an oft-proved fact that increased wall area does increase cylinder condensation and consequently steam consumption. It has also frequently been proved that increased clearance does increase steam consumption, unless compression is carried well up to the admission pressure. There is very little loss, however, if compression is carried well up to the admission line. Any loss that does occur is largely due to condensation caused by the increased wall area incidental to increased clearance. These principles, we believe, are now well recognized by most steam engineers.

As a check on increased wall-area effect, the writer once used thin sheet steel to make a clock-spring shaped coil, having an area nearly twice that of the wall area of one end of the cylinder, including the piston face and port walls. The cylinder head was moved back to obtain unchanged clearance volume. The engine selected was of the single-acting type, which made it necessary only to make the changes for one end. With this added wall area, the steam consumption was increased nearly 25 per cent.

In economy tests of single-valve engines we have many times reduced the steam consumption nearly a pound where compression was low, by adding exhaust lap and thus carrying the compression higher on the card. Neither of these, however, is anywhere nearly as important a factor as leakage. The Dean and Wood comment makes this fact plain. With some designs, if not in first-class condition, the leakage goes so far toward offsetting better steam distribution and decreased clearance that little gain is effected.

The next comment made by Dean and Wood is as follows: "After considering these tests we do not hesitate to advise builders to abandon four-valve for high-speed engines, unless they are prepared to build a really high-class engine, having four Corliss or gridiron valves made and fitted in the best manner." This sentence has been twisted and made to read that Dean and Wood advise abandoning the building of four-valve engines of every type except drop-cutoff Corliss, which is not at all the real meaning of the Dean and Wood comment. Such engines as the Harrisburg four-valve, the Ball four-valve and the Ridgway four-valve, for example, are of the general design and construction referred to by Dean and Wood as the only types having economy possibilities. Very naturally we agree with Dean and Wood to a large extent in this belief, or we would not be building an engine of this construction. This general type is illustrated by the Ridgway four-valve engine.

Continuing the Dean and Wood comment, it reads: "Even then it would be necessary for them to prove that such steam engines of whatever type should have valves that are not only tight originally, but that should become so by wear, if they are not so originally. The wearing process should be a tightening process."

In this connection we believe that practically all Corliss-type valves tend to tighten, except those which span too wide an arc in covering the ports, as, for example, if ports are placed on opposite sides of the valve, as the valve wears smaller in diameter it cannot wear tight, but will do the reverse. The same thing is true of a valve which spans too large an arc only to a lesser extent. Many Corliss engines, but by no means all, are successful in this respect. The Corliss engine reached good economy because of its excellent steam distribution due to its four valves and drop cutoff, and because of the valves tending to wear tight rather than leaky. The Corliss valve does not have a heavy overtravel; it rests during the heavy pressure period of expansion and moves when the pressures on it are light; consequently, its wear is not as serious as it would otherwise be. In many Corliss engines the valve does not span a wide arc and, therefore, it keeps tight more easily. There are, on the other hand, some Corliss engines that do not by any means wear tight. The pressure on the steam valves is the difference between that in the steam chest and that in the cylinder. It is readily seen, therefore, why there should not be heavy movement of the valve during expansion; this means the overtravel should not be more than that required to make it steam-tight. "The strains, the consequent wear and the resultant length of life of the valves and the valve gearing are very nearly proportional to the overtravel." Some makes of four-valve engine have as much as two inches overtravel, while half an inch is ample for steam-tightness. To get a really good valve motion—one which will cut off the unnecessary overtravel and give sufficient port opening—is the most difficult problem of the four-valve builder. Once this is accomplished the motion is very similar, indeed, to that of the Corliss engine, and is adapted to the higher speeds so desirable for direct-connected service.

While the Dean and Wood report calls attention to the necessity of the valve to tend toward tightening, it is well also to bear in mind that the valves and their seats should be of hard close-grained iron and should be well fitted in such a manner that they will start off to glaze at once without having first to make a proper seat. There is seldom any trouble with the exhaust valves, where the Corliss wristplate movement is used to reduce excessive overtravel. The difference in pressure on the two sides of the exhaust valves is almost as great and in some makes greater during their period of movement than that of the steam valves; as a rule, however, exhaust valves give less trouble than steam valves. There are some makes of four-valve engine which give entirely too much overtravel to the exhaust valves as well as the steam valves. The nearer the travel of both steam and exhaust valves approaches that

*Superintendent, Ridgway Dynamo and Engine Company.

of the Corliss engine and yet eliminates the drop cutoff, the less will be the valve and gearing strains and wear of these parts. There are several four-valve engines on the market in which these strains are very apparent when the engines are running. Leakage by the steam valves and piston is more commonly a source of serious loss of economy than that of the exhaust valves. Leakage is very nearly proportional to the length of the edge times the number of edges past which it can take place. If, however, the valve spans too wide an arc, wear makes leakage even more serious. A four-valve engine is purchased in preference to a single-valve engine solely because of better economy. To insure this a purchaser should examine leakage possibilities and the nearness of the valve movement to that of a Corliss engine. Bear in mind that the drop cutoff gives a very different movement to that of a plain fixed wristplate motion.

Possibly the only expression of doubt regarding the Corliss-type four-valve cylinder contained in the Dean and Wood report is the clause: "Even then it would be necessary for them to prove their case." In this connection we have to say that the mere fact of building a Corliss-type cylinder does not by any means insure *maintained economy*, and while we believe this type of cylinder is the proper channel through which to seek economy, we also believe, with Dean and Wood, that the valves must be properly designed and fitted.

In dealing with the foregoing comment by Dean and Wood, we associate with it a part of their next and last reference to the four-valve class of engine, reading as follows: "From the results we are justified in thinking that most high-speed engines rapidly deteriorate in economy. On the contrary slower-running Corliss or gridiron-valve engines improve in economy for some time and then maintain the economy for many years. It is difficult to see that the speed is the cause of this, and it must depend upon the nature of the valves." While we agree with this statement in the main, we believe that many Corliss engines do not maintain their economy, due to bad valve design and construction. We refer to designs in which the valve spans and is depended upon to maintain tightness over too wide an arc of its seat. Also to rough machining and ports and steam chests with sand scale sticking to their walls, a condition not at all uncommon with some makes of Corliss engine. We firmly believe that four-valve engine builders have given greater attention to these details. We do not believe roughly fitted valves with ports improperly cleaned can ever fit themselves and glaze to a condition possible with a properly fitted valve. This, of course, applies equally to four-valve and Corliss engines. We also believe the steam-valve seats should always be fitted with cages of a closer- and harder-grained iron than that used in the cylinder. Some four-valve engines do rapidly deteriorate in economy and naturally so, because of too great overtravel, resultant heavy strains and wear, and some because of necessary seal over too wide an arc of the valve seat. The higher speed may contribute slightly to greater wear, but the nature of the valve and its motion are the real factors determining deterioration or maintaining economy. The valves of Corliss engines do not as a rule span a wide arc and do not have heavy overtravels and, consequently, do not, in the better makes, where properly fitted, deteriorate rapidly. If the four-valve engine is properly designed and built it will, due to its higher speed, exceed the Corliss engine in economy. Cylinder condensation is considerably reduced by the higher speed.

Economies have been obtained with the simple noncondensing four-valve engine that, as far as the writer is aware, have never been reached under the same steam conditions by any other type of engine. For example, a test conducted by Professor Spangler, of the University of Pennsylvania, on a 16x16 Harrisburg four-valve engine, running noncondensing at a speed of 210 revolutions, gave an economy of 22¾ pounds at full load and slightly better at ¾ load, with 125 pounds gage pressure.

A test of a 19x19 of the same make, made by Professor Diederichs, of Cornell, gave 22.77 pounds at full load and slightly better at ¾ load. The steam pressure was about 125 pounds and the speed 205 revolutions, running noncondensing.

We know very little of results obtained from Ball engines, but understand that they have obtained better than 23 pounds noncondensing, with 150 pounds steam pressure. For a tandem noncondensing, 150 pounds steam, they have reached 18½ pounds.

A test of a 19x18 Ridgway four-valve engine, at 200 revolutions and 100 pounds steam pressure, gave results as follows:

Load.				
¼	½	¾	Full	1¼
30.7	24.4	23.2	23.8	25.4

Tests made by this company of this engine gave for its best result at 130 pounds pressure, 21.6 pounds; at 115 pounds pressure, 22.6 pounds; at 85 pounds pressure, 24.3 pounds.

Three later engines of the same size tested by this company gave results at 100 pounds steam pressure, 200 revolutions, as follows:

	Load.		
	½	¾	Full
Engine No. 2306	25.25	22.8	22.7
Engine No. 2307	24.9	23.46	22.65
Engine No. 2308	24.59	22.3	21.9

Engine No. 2308 was tested at 130 pounds steam pressure and gave 20.17 pounds per indicated horsepower per hour. Engines 2306, 2307 and 2308 were not in any way especially fitted up to secure economy but simply built according to our standard practice. The results given herewith on these three engines are those of the first and only tests made on them. The uniformity of the tests from all three engines we believe to be unusual.

The results of tests cited as sample cases, of Harrisburg, Ball and Ridgway, we believe were obtained by men whose integrity, as far as I know, is unquestioned. If better results have been obtained from any other type of engine under like conditions with equal evidence of truth, we will be glad to know of them. There are many four-valve engines of good design which have been in service from six to eight years, with valves in fine condition and practically tight.

To repeat, we believe maintained economy in this type of engine is dependent upon reduction of unnecessary overtravel, properly fitted valves, valves which do not span a wide arc, close approach of the movement of the valves to that of a Corliss engine and good materials.

The foregoing article was referred to F. W. Dean for criticism. His reply follows:

By F. W. Dean

Referring to the foregoing, I wish to state, in order that the matter may be clearly understood, that the paper on the subject of the tests was written by me and then shown to Mr. Wood for criticism. Mr. Wood approved of the paper in a general way, except that he considered that my conclusions were rather broader than the results of the tests warranted. Perhaps he is right in this, but I decided after considering the matter that I would let the paper stand as written.

It often happens in matters of this kind that conclusions are of doubtful meaning, but my general opinion of the matter of the four-valve engines tested was that they were of the kind that are not likely to give economical results; but it is also my opinion that four-valve engines can be designed that will give economical results and which will continue to be economical for very many years. The understanding of my view as stated in the foregoing article is correct. In one place I recommended the abandonment of four-valve engines unless engines having four Corliss valves or four gridiron valves should be built. It now appears that there are three makes of engine of this class which seem to fulfil every requirement for permanent economy.

In one of my comments I stated that it would be necessary for the makers of high-class four-valve engines to prove their case. The reason for this statement was that there were very few tests made up to the time of writing the paper and I was not in possession of data which showed what such engines could do. The results of tests quoted in the foregoing article, however, show without any doubt that engines of this class can give unusual economy for simple noncondensing engines. My opinion is that if people really desire economy with simple noncondensing engines it would be desirable to buy engines of this class. Wherever the exhaust steam can be used this is of little or no importance.

A Reciprocating Engine Enthusiast

By F. L. Johnson

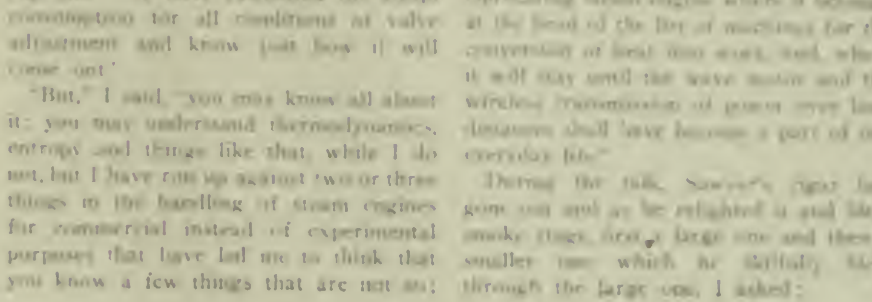
The engineer who is always down on his luck had just left me, after making a "touch" that showed that for once at least luck was with him "momentarially," as the overhead guarantees say. I sat thinking about him and his kind and wondering how an inspector could be influenced or convinced that a man who took such poor care of himself could be trusted with the care of boilers and engines. His address card (minus the address), covered with thumb marks and the emblems of a half dozen engineers and fraternal societies, coupled with the talismanic letters, "M. E.," would lead one to think that such a man, if really in good standing in so many organizations, and if even tolerably clean, would always have work, and never be found jobless and moneyless on Manhattan island. His was perhaps a common if [illegible] predicament. His wages had been reduced by his employer, who was losing money. Without stopping to consider that while looking for a new situation a poorly filled pay envelop is almost infinitely better than no envelop, he left, and with his last dollar bought a ticket for the city and helped to swell the ranks of the great army of unemployed engineers.

As he went out Sawyer came in and seated himself, and looking quizzically in my direction, said:

"I passed your friend in the hall, but I saw him first and gave him no opportunity to notice me. I have known him by sight a great many years as a man of wide experience in losing situations. Somehow he always seemed to strike a perishable job, or if not naturally so, he soon made it one. I never really understood until today how such helpless and incapable men got along in the world, but I see it plainly enough now. There are a whole lot of easy ones like you, who have been moderately successful, and who more or less patiently attend to periodical holdups and thus help to keep them going.

"But I wanted to see you about something else. Some time ago you published some indicator diagrams that I gave you along with some remarks about the necessity for compression and effect on the coal pile. Since that time I have had talks with three professors of mechanical engineering in different parts of the country, who have complete mechanical laboratories under their supervision, and I have asked all of them to try an engine with a fixed load, such as could be furnished by the use of a water rheostat, with different conditions of steam distribution (I called it steam distribution instead of valve setting, because I was talking to professors instead of to engineers), and determine if more or less indicated horsepower would be needed with one condition than with another. Well, each and every one was bored and practically said 'There is no need of doing this. We have calculated the steam consumption for all conditions of valve adjustment and know just how it will come out.'

"'But,' I said, 'you may know all about it; you may understand thermodynamics, entropy and things like that, while I do not, but I have run up against two or three things in the handling of steam engines for commercial instead of experimental purposes that have led me to think that you know a few things that are not so; and I want you to show me. If I have been wrong all these years, I want to know and admit it to all of my friends and take the "joshing" that is due me. I do not care to be the last person in the world to discover that I have been mistaken all the years of my engineering life.'



WHICH DIAGRAM WILL DELIVER THE GREATER AMOUNT OF POWER AT THE RIM OF THE FLYWHEEL?

"I also suggested that this be chosen as a subject for a thesis by some graduating student, but all to no purpose. I got one or two reluctant promises from some of them that an experimental run would be made. Months have passed and I have heard nothing, and I am beginning to think that not one of the professors of mechanical engineering in the country dares to conduct an exhaustive test and publish the results.

"What I am after is this: Here are two diagrams, of equal area and consequently representing equal indicated horsepower, from the same engine. Applying Thompson's rule for finding the steam accounted for by the indicator, I find a slight difference in the amount used per horsepower per hour. But what I want determined by competent, unquestionable expert authority is, which diagram will deliver the greater amount of power at the rim of the flywheel?

"So far as I can discover there has been nothing at all except arguments unsubstantiated by facts, published on this subject and now at a time when the field of the reciprocating engine is being invaded by the gas engine from one side and the turbine from the other, the few who are certain that the engine has not been allowed to do its best want to have some questions settled. With the question of the best steam distribution settled, and after this about a quarter of the extensive experimental work that has been given to the development of the turbine and the gas engine will place the reciprocating steam engine where it belongs, at the head of the list of machines for the conversion of heat into work, and where it will stay until the wave motor and the wireless transmission of power over long distances shall have become a part of our everyday life."

During the talk, Sawyer's cigar had gone out and as he relighted it and blew smoke rings, first a large one and then a smaller one which he skilfully blew through the large one, I asked:

"Why are you so sanguine about the possibilities of the steam engine?"

"Well," he replied, "for a long time designers have been ready to guarantee an indicated horsepower-hour for ten pounds of steam. If they are willing to guarantee this they can deliver a brake horsepower-hour for the same amount, but no man will go to the limit of his ability when making a guarantee. He wants a margin and never promises to give all that he knows he can give. With a horsepower-hour delivered at the rim of the flywheel for ten pounds of steam let into the cylinder, a kilowatt-hour can be delivered at the switchboard at a total cost that the turbine cannot touch."

I was about to tell Sawyer that he appeared to be the most enthusiastic reciprocating-engine advocate that I had met, when a clumsy, worried person, for short, carrying some of the goods on a [illegible] charged right into the office furniture, and in the knocked-off gear that followed my friend remembered another engagement and wended his way to the elevator softly whistling, "Gee! I wish I had a girl!"

Low-Pressure Steam Turbines*

The Rateau-Smoot Compared with the Parsons and Curtis Types
Extreme Accuracy Not Necessary to Reliability and Efficiency

BY C. H. SMOOT

It has now been thoroughly established that the most efficient possible steam engine is a compound unit consisting of a reciprocating engine, acting between boiler pressure and approximately atmospheric pressure, exhausting to a low-pressure turbine, which in turn discharges to the condenser.

Were it not for the fact that high-pressure turbines in large sizes are vastly cheaper than reciprocating engines, it would be a safe prediction that all future plants would include turbines and engines.

It is still a moot question, however, whether the greater cost of combined engine and turbine plant over that for turbine plant alone is authorized by the increased economy.

In any event, however, existing plants equipped with reciprocating engines will show improved economy by running them noncondensing and installing low-pressure turbines.

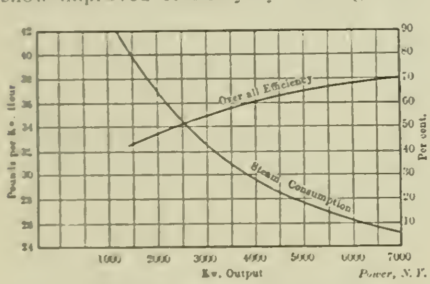


FIG. 1. EFFICIENCY CURVES OF 7000-KILOWATT LOW-PRESSURE TURBO-GENERATOR

It was not until the low-pressure turbine had been commercially developed that engineers fully realized the significance of the fact that the available energy per pound of steam between 150 pounds boiler pressure and 28 inches of vacuum was cut practically in halves by the line of atmospheric pressure.

This fact appears almost like a discovery, because reciprocating engines have heretofore been wholly incapable of utilizing efficiently the energy below the atmospheric line. To obtain the expansion in an engine which can be readily reached in the turbine would require an enormous cylinder, whose friction would consume a large portion of the available energy. The turbine, however, can utilize as effectively the energy between 26 and 28 inches of vacuum as it can utilize the energy between atmospheric pressure and 5 pounds below.

Fig. 1 gives the manufacturers' guaranteed steam consumption curves for a 7000-kilowatt low-pressure Rateau-Smoot turbine at 28.5 inches vacuum with an admission pressure of 16 pounds absolute. At 7000 kilowatts the machine is guaranteed to deliver one kilowatt-hour at the switchboard for 25.7 pounds of steam.

An investigation of the steam consumptions obtained when such a turbine is used to compound high-pressure noncondensing engines will prove of interest. The accompanying table shows the steam consumption, efficiencies, etc., for each of these two units. The figures taken for the steam consumption in both cases are rated very conservatively for machines of large power, the turbine being of 7000 kilowatts capacity and the engines of over 2000 kilowatts each, several of which could be used in conjunction with a single turbine.

	Pounds Steam Pressure Absolute.		Theoretical Steam per Kw.-Hour.	Steam per Kw.-Hour at Switchboa'd.	Combined Efficiency of Engine and Dynamo.	Steam per Indicated H.P.-Hour.
	Admission.	Exhaust.				
Engine	214.7	16	18 lb.	27.7 lb.	65 per cent.	23.4 lb.
Turbine	16	0.75	17.8 lb.	26.6 lb.	67 per cent.	....

Boiler pressure, 200 pounds, no superheat. Vacuum, 28.5 inches on 30-inch barometer.

Steam per kilowatt from combined plant =

$$\frac{1}{\frac{1}{27.7} + \frac{1}{26.6}} = 13\ 6$$

pounds of steam per kilowatt-hour.

The combined mechanical efficiency of heat transformation into electricity represented by these two units working in conjunction is approximately 66 per cent., after allowing for all losses in turbine, engine and dynamo.

This combination of turbine and engine represents the very highest efficiency possible to obtain in any kind of steam engine, since it places to best advantage the reciprocating engine and the turbine, neither one of which can, unaided, accomplish the same result. The figures entering into these calculations are taken conservatively, and it is believed that the rating given to the reciprocating engine of 23.4 pounds per indicated horsepower-hour compound noncondensing is a figure readily obtainable.

Fig. 2 is a logarithmic plot of the available energy in steam for given admission and exhaust pressures. A straight line passing from the pressure at the throttle to the pressure of the exhaust intercepts the central scale at the corresponding quantity of steam per unit of power available in the steam. This figure, divided by the efficiency of the engine, gives the quantity of steam per unit of power developed. The formula from which this plot was made was originally developed by Professor Rateau from the entropy diagram and published in many of his papers on the subject of steam turbines.

The question of the most suitable intermediate pressure for engine exhaust and turbine admission is not so important as it might seem from a cursory consideration. The pressure giving the maximum efficiency for the whole plant is obviously the pressure that allows approximately equal efficiencies of heat transformation into power for engine and for turbine.

In the case of highly inefficient engines, however, such a condition can never be reached, and the intermediate pressure giving a maximum output from the whole plant should be taken as high as the condition under which the engine is working will permit. This latter condition is generally the case in engines working in steel mills doing highly intermittent service, for here, at the very best condition, the efficiency of the engine is always lower than that of the turbine.

The type of engine used in central stations, however, when exhausting in the neighborhood of atmospheric pressure, will show an efficiency practically equal to a low-pressure turbine, consequently very little difference in the plant efficiency will be made if the intermediate pressure is taken anywhere from 3 or 4 pounds below atmosphere to 15 or 20 pounds above. The reason for this wide range in pressure is to be found in the fact that the efficiency curve for both

*Read before the National Electric Light Association convention, Atlantic City, N. J., June 1, 2, 3 and 4, 1909.

engine and turbine has a very flat top within this range, showing but slight rise or fall between either extreme.

Condensing Apparatus

Since low-pressure turbines work efficiently on high vacua, it is well worth while to investigate thoroughly the vacuum of maximum economy, putting on one side the cost of obtaining the vacuum and on the other the economy resulting in the turbine.

With barometric condensers, no real

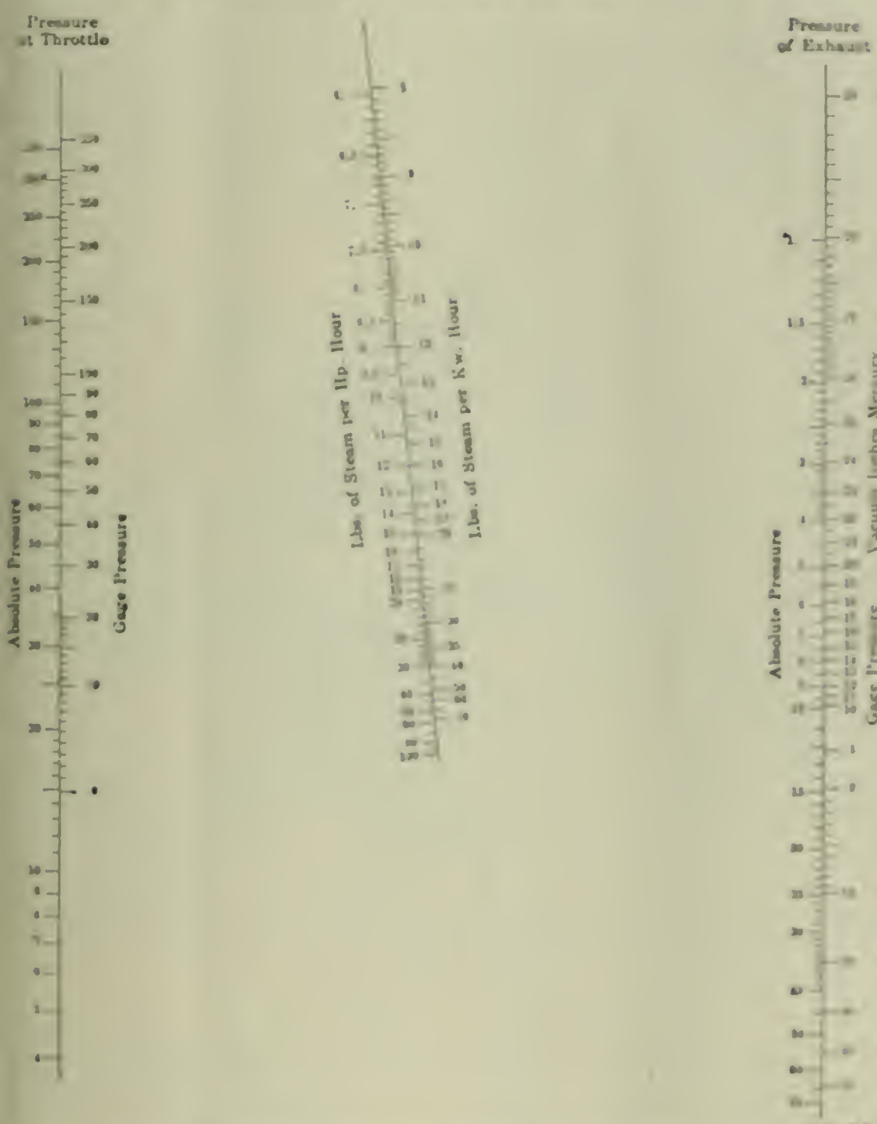


FIG. 2. THEORETICAL STEAM CONSUMPTION OF PERFECT ENGINE

difficulty is encountered in obtaining a vacuum of 28½ inches with water under 70 degrees Fahrenheit, and similar results can be obtained with a surface condenser, provided a large water supply is available which does not require a high lift to reach the condensing vessel.

To obtain a high vacuum with either type of condenser, dry-air pumps are essential.

When working on vacua over 28 inches, because of the low temperature of the steam, barometric condensers require much less water than surface condensers, since, in a well-designed barometric condenser, the water discharged may be within one or two degrees of the temperature of the incoming steam, thus utilizing practically all of its heat storage capacity. A surface condenser, on the other hand, when reduced to practical dimensions, requires a much larger difference in temperature between the discharged water and the entering steam, and consequently more water to carry away the heat.

The limitations of the condensers, which, from a practical point of view, limit the obtainable vacuum, are—in the barometric case, the air pump capacity, and in the surface condenser, the quantity of water.

Under fairly favorable conditions, the power expended to maintain a vacuum as high as 28½ inches on a low-pressure turbine, does not exceed 5 per cent. of the turbine output.

Types of Turbine

The two types of turbine in existence are known as action and reaction machines. To the action type belong the Curtis, De Laval and Rateau machines. The reaction type is represented by the Parsons turbine. In an action-type machine the pressure drop occurs principally in the stationary nozzles, while in the reaction machine a uniform pressure drop occurs in each row of stationary and rotary buckets; consequently, in the reaction type of machine steam leaks around both stationary and rotary blades, thus necessitating that the running clearance between stationary and rotary elements be reduced to the minimum possible value, from which reduction in clearance arises the greatest source of trouble in turbines of this sort, i.e., stripping blades from their stationary and rotary elements.

Stripping of the blades may sometimes be the result of improper fastening of the buckets to the rotor drum. Obviously, the larger the number of rotary buckets, the greater becomes the danger of stripping; first, because each additional blade is an additional possible cause of trouble; and second, because the larger the number of blades, the more restricted the turbine designer is in his method of attachment, owing to the space available and to the permissible cost of construction.

The successful operation of this type of turbine has always depended on most accurate workmanship, together with extreme care in assembling, and thoroughly reliable means to prevent foreign matter being carried by the steam into the turbine.

The close clearances necessary in these machines to show good steam economies is frequently sacrificed in order to obtain greater reliability of operation.

Particular care is also required in starting the larger machines of this type, as they must be brought to a uniform temperature, corresponding nearly to the temperature at which the machine is to work before starting, this being necessary in order to allow the various parts to reach their working temperatures and their corresponding heat expansions.

The importance of this feature is readily seen from the fact that the expansion of the rotor when heated from the temperature of the atmosphere up to that of the working steam often exceeds the clearance between rotor and stator. The process of warming up such a machine is a slow one, because, as steam is first admitted, the upper portions of casing and rotor are heated first, causing them to expand; the lower portions, not expanding as much, give a slight curve to both casing and rotor. This dispersion for the casing portion of the turbine to rise is further augmented by the resistance of the lower portion of the turbine casing to slide lengthwise of the subbase as it is expanded by increasing temperature.

The significance of these features would not appear if it were not for the close-running clearances. An action type of machine, on the contrary, having large running clearances, can with safety be brought up to speed and full load, when cold, in two or three minutes.

In the action type of machine the moving element has no appreciable pressure drop from entering to leaving side of its buckets, and therefore no disposition for steam to leak around the buckets in preference to passing through them; consequently, a large clearance is permissible round the rotary buckets. Furthermore, the rotary buckets are carried by wheels mounted on a shaft and between contiguous wheel elements the stationary diaphragm containing the expanding nozzles can be carried down to the shaft, and between it and the shaft is a running clearance of very much less diameter than that necessitated by the reaction type of machine.

Turbines, in common with all engines, are subject to deterioration with service. The actions tending to lower their steam economy are:

First—A gradual increase in the quantity of steam leaking through clearance spaces, which bypass the active portion of the turbine; and

Second—The wearing of the buckets and guide vanes, distorting them from their proper shape, thus lowering their mechanical efficiency.

The losses coming under the first case are of very little significance in the action turbine, because in such a machine the diameter of the clearance space is small, usually that of the turbine shaft; but in the reaction type of machine the diameter of the clearance space is large and equal to that at the buckets, giving a leakage area much larger than that of the action machine. The clearance is increased with use of the machine, by the wear from steam passing at high velocity, together with the entrained water and particles of dirt.

On both action and reaction machines the buckets are subject to wear, the extent of which depends upon the relative velocity of steam passing over the bucket, the maximum value of which varies inversely as the square root of the number of pressure stages. In the reaction type of machine the wearing of buckets is largely a question of design, and is more or less unaffected by the number of stages. In general it seems probable that the reaction type of machine is subject to a much more rapid loss of efficiency than an action machine, when both causes are taken together.

Reliability of Operation

A turbine is subject to few, but very serious, accidents, which may be classified as follows:

First—Contact between stationary and rotary elements.

Second—Stripping of the blades.

Third—An accident arising through an interruption or failure in action of the auxiliaries employed to maintain the turbine in operation.

The rotary element can come in contact with the stationary element only when the clearance space is small, and when such is the case the intervening space can be bridged by an unequal heat expansion, through foreign matter becoming wedged in the opening, or through a slight loosening of any one of the numerous rotary buckets. If contact is once established, the damage is liable to be severe. It has frequently been stated that the clearance is automatically maintained by the wear which it produces. This may have happened in some instances, but usually the cuttings are welded to the rotary element and pile up, increasing the violence of contact until the heat generated results in serious damage. The damage produced in this manner, through contact of the rotary element, is above all else the most frequent trouble encountered in turbine operation, and every effort should be made so to design and manufacture turbines that this source of annoyance is either entirely eliminated or the probability of this kind of trouble reduced to a minimum.

It appears safe to state that a clearance between stator and rotor less than three-thirty-seconds of an inch is absolutely unsafe, and that a clearance of one-eighth of an inch to five-thirty-seconds of an inch is vastly preferable, so long as the resulting steam leakage is not serious. In the larger action type of machines, clearances of this magnitude produce losses of less than one per cent.

The buckets may be stripped by contact with the stationary element. An action turbine has a very large clearance around its buckets (one-quarter of an inch or more) and therefore is practically free from damage of this character. In this type of turbine the minimum clearance occurs between the pressure diaphragm and shaft. When contact occurs between shaft and diaphragm, the resulting damage is generally a warped shaft, caused by a spot on the shaft becoming overheated and, through its expansion, permanently warping the shaft out of line.

An interesting phenomenon is illustrated when shafts come in contact with diaphragms. No matter how perfectly the rotary elements may be balanced, it is impossible to have an exact coincidence between the geometric center of the shaft and the mass axis of the rotary element. When the machine is running at full speed it rotates as nearly about its mass axis as possible, throwing the shaft slightly eccentric, and when contact is established it occurs first at that portion of the shaft surface farthest from its axis of rotation; consequently, there is always one spot in the shaft which touches the stationary element first and localizes the heating to a small section of the shaft periphery. The heating of the shaft at this spot expands it, thus lengthening one side of the shaft more than the other, causing it to warp slightly out of true, pushing the spot which has been heated by contact still farther away from the axis of rotation and increasing the violence of contact. This can be largely—or entirely—overcome by presenting to the shaft but a very small metallic surface, or by facing the diaphragms with carbon blocks, which, through their nature, are incapable of presenting sufficient resistance to cause a violent heating.

The preservation of a proper clearance between rotor and stator, as between one type of machine and another, is a question of its design and construction. The machine that is so constructed that, when nearly assembled, the running clearance may be inspected, has a great advantage over the machine which must be put together piece by piece.

The vertical machine is at a disadvantage in this respect on account of the necessity of assembling it piece by piece, threading over the shaft successively diaphragms and wheels, thus placing on the erector of the machine a great responsibility and difficulty in maintaining the clearance; for after a wheel and diaphragm have been placed, it is difficult to inspect the clearance. A horizontal machine, on the other hand, eliminates this difficulty almost entirely, for in such machines it is possible to split the machine through its horizontal center and assemble in position each half, then inspect the clearance in both halves.

The turbine auxiliaries are the pumps for lubrication and for supplying the fluid pressure to step bearings. Frequently, also, the governor mechanism includes an auxiliary as a connecting link between the flyball governor and the control valves. Any one of these may cause trouble to the turbine, since its operation is dependent upon them, and their failure results in the failure of the whole turbine.

All of these auxiliaries appear unnecessary, and it would seem that they were introduced as a means of patching up features which might better have been omitted.

Bearings have been lubricated by oil rings for many years, and the bearing of a turbine may be lubricated by an oil ring with the same ease as the bearing of a 1-horsepower motor.

The auxiliaries to maintain in action a step bearing have been made more reliable by the installation of two pumps and an hydraulic accumulator, so that any two of these elements may fail, leaving one in operation. This seems a somewhat elaborate method of increasing the reliability of an essentially simple machine, and perhaps the easiest way to obtain the desired results would consist in omitting entirely the step bearing by placing the turbine in a horizontal position.

A forced-feed bearing lubrication is thought necessary in the reaction type of turbine, because in such machines, having as necessity a close running clearance, he bearings must also be given a close running clearance, which is too small to permit oil to enter the rubbing surfaces unless its entrance is forced. In a vertical-type machine, oil ring bearings are of course an impossibility.

As an example of what can be done in simplifying turbines, Fig. 3 illustrates a Rateau-Smoot turbine. In this machine the bearings are babbitt-lined, self-aligning, water-cooled and lubricated with oil rings. The complete journal bushing can be removed without disturbing any other portion of the turbine except the bearing which is to be opened. Between the shaft and diaphragms the least clearance is three thirty-seconds of an inch, and between buckets and casing the minimum clearance is one-quarter of an inch. The wheels are of the type illustrated in Fig. 10. The buckets are illustrated in Fig. [illegible] and are held astride the wheel periphery by transverse rivets, thus eliminating all metal at the wheel periphery not absolutely required for the bucket attachment.

The governor of this machine is mounted directly on the turbine shaft, and the motion from the flyballs is transmitted by a solid steel link to the steam admission valve, which is of the well-known double poppet balanced type, and controls the machine by throttling the steam, thus varying gradually the amount of steam admitted to the turbine.

The writer thinks that this is a better method of governing a turbine than by means of a series of nozzles which are operated either wide open or closed, for it frequently happens that the load which the turbine is driving is represented by a certain number of nozzles wide open, plus an additional amount less than one complete nozzle opening; consequently it is impossible to maintain the turbine at a constant speed, for a slight increase of speed is necessary to open wide the additional nozzle, and a slight decrease necessary to cause its shutting, thus compelling the turbine to run between these two limits, i.e., the speed sufficient to open the valve and a speed sufficient to close it. This is particularly annoying when turbines are operating in parallel with other turbines having a similar control, or with reciprocating engines, for it is possible that the disposition for slight speed oscillation may fall in step with those of other turbines or engines, and cause fairly pronounced oscillations in the entire system. Instances of this kind have been noticed. With a straight throttling governor, on the other hand, the variation in the amounts of steam admitted to the turbine is absolutely gradual, and a perfect balance can be maintained between the load and the quantity of steam applied to the turbine.

Governing mechanisms in which the flyballs do not control directly the admission valve, but do so through the agency of an intermediate motor or relay mechanical device whose source of energy is independent of the flyballs, are always equipped with a speed-limit device, and advisedly so, because of the intermediate motor, which is a break in the connecting link between flyballs and control valves. The presence of this intermediate motor is required by the large amount of energy needed to operate unbalanced valves, on the one hand, and the small amount of energy available in the flyball governor on the other hand.

A more practical method is to put the control valves approximately in balance and to connect them by solid links to the governor flyballs, which may be given sufficient energy to operate the valves within the speed regulation desired.

Comparison of Curtis and Rateau Turbines

The types of action turbine which have been most fully developed and which represent the most promising features, both in economy and reliability of operation, are the types known as "Curtis" and "Rateau." Both of these types lend themselves to the construction of units in sizes up to the largest single power-producing unit yet conceived.

Aside from very important considerations of general arrangement, the essential difference between the Curtis and Rateau machines lies in the following:

In the Rateau machine steam is expanded successively in a series of nozzles playing on moving buckets which absorb entirely the tangential component of the exit velocity from the nozzles. After leaving the row of moving buckets, the steam, which has been reduced to only sufficient velocity for its flow through the turbine, enters another row of nozzles through which there is a pressure drop creating a second velocity, which is in turn absorbed by a second row of moving buckets, and so on to the exhaust end of the turbine.

In the Curtis machine the pressure drop, which in the Rateau type occurs through two nozzles, is lumped into one nozzle, which often is of the converging-diverging type, in order that the exit velocity may exceed the critical velocity for steam.

The steam from this nozzle is then received by a row of moving buckets, the speed of which, however, is insufficient to absorb completely the tangential component of the original velocity, and therefore the velocity of the steam leaving the first row of buckets represents a considerable amount of energy which is utilized in a second row of buckets by passing it through stationary guide vanes so arranged as to reverse its tangential component, directing the steam onto the second row of buckets.

At present a turbine [illegible] of large [illegible] would have [illegible] [illegible] eight successive steam nozzles and [illegible] rows of moving buckets. The corresponding Curtis machine would probably have four [illegible] steps [illegible] and [illegible] on two rows of moving buckets, making a total of eight rows of moving buckets. Under these conditions, with an admission pressure equal to [illegible] and an exhaust [illegible] of [illegible] inches [illegible], the steam velocity leaving the Rateau nozzles would be approximately [illegible] feet per

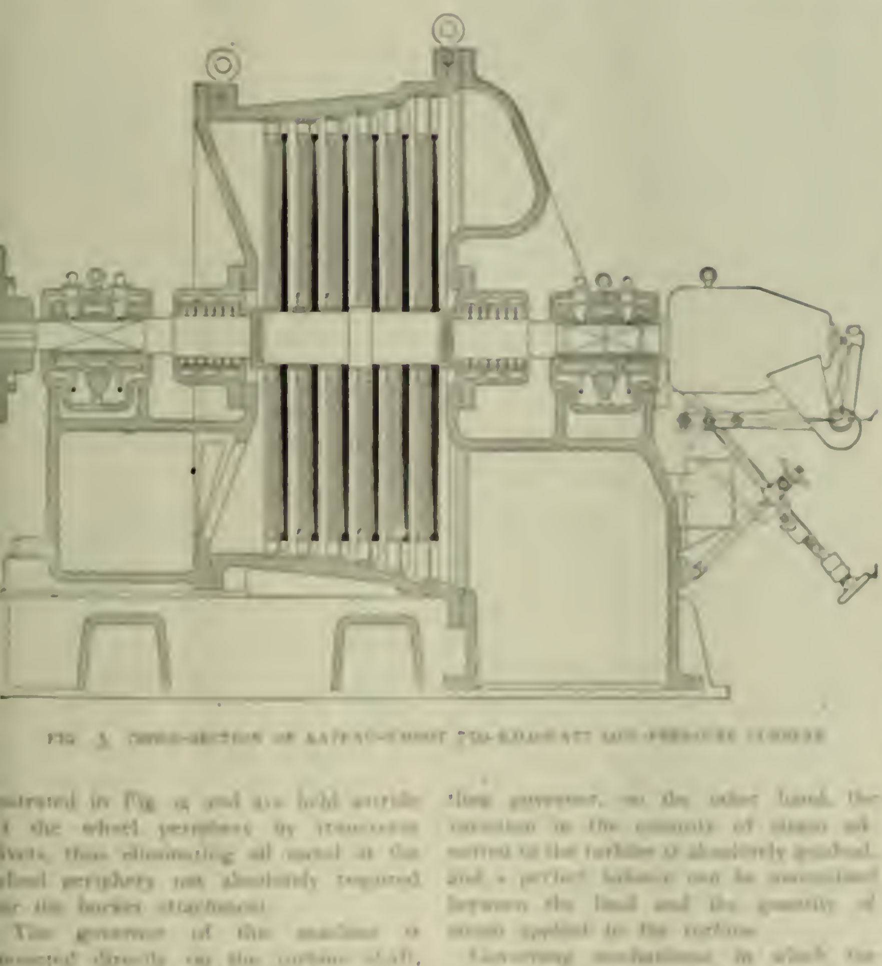


FIG. 3. CROSS-SECTION OF RATEAU-SMOOT 750-KILOWATT LOW-PRESSURE TURBINE

second, and the velocity leaving the Curtis nozzles would be approximately 456 meters, at which condition it enters the first row of buckets. In the Rateau machine this velocity is reduced to just enough for the steam to flow into the next succeeding nozzles, while in the Curtis machine such a reduction is impossible and the large exit velocity from the first row of buckets passes through guide

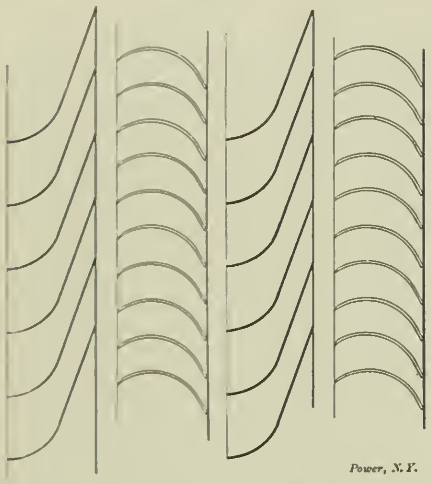


FIG. 4 RATEAU BUCKETS AND NOZZLES

blades, which, without a change of pressure, reverse the steam flow and permit the velocity remaining to be absorbed in a second row of buckets.

It is of interest to note that experiments have thoroughly established the fact that the loss of energy due to friction and eddy currents in a well-designed steam nozzle, in which velocity is created by a reduction of pressure, does not ex-

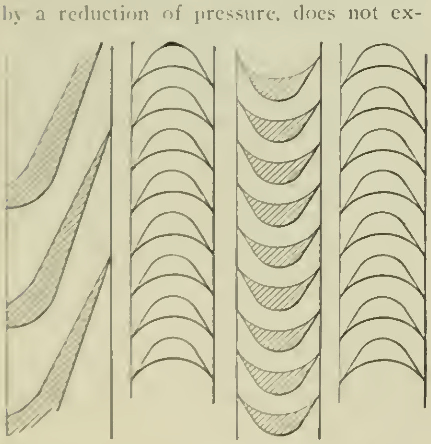


FIG. 5 CURTIS BUCKETS AND NOZZLES

ceed 5 per cent.; and in nozzles of large sectional area comes down to 2 per cent., while the energy loss when steam at high velocity is caused to move in a curved channel—as in the rotary buckets and stationary guide blades of the Curtis machine, which are equivalent to buckets—runs all the way from 15 to 30 per cent.; dependent upon the design, construction, size, etc., of the buckets.

For equivalent pressure drops, the Rateau type of machine has two nozzles, in which the loss is small, and two rows of moving buckets, in which the loss is large. The equivalent Curtis element representing an equal pressure drop has one nozzle, in which the loss is small, followed by two rows of moving buckets and one row of stationary guides, three in all, for which the loss is high. Figs. 4 and 5 show, respectively, the corresponding elements of Rateau and Curtis turbines.

Professor Rateau, in a paper read at the St. Louis Exposition, showed that the maximum possible obtainable efficiency with each type of turbine differed some 20 per cent. with the bucket construction then in use, and that the difference could not be overcome by any feature of bucket construction or design, since whatever is obtainable in one type of machine in the way of reducing losses in buckets is also possible in the other type of machine, the Curtis type having, however, always the additional loss represented by the stationary guide blades constructed like buckets and having losses equivalent to those occurring in a bucket, while in the Rateau type of machine the corresponding element is an expanding nozzle in which the losses are very small. In addition to this, the losses of energy due to shock are greater in the first row of buckets on the Curtis machine, because the entering steam has some 40 per cent. greater velocity than in the Rateau type. These differences cannot be overcome.

Turbine Buckets

Fig. 6 represents a row of buckets, the center portion of which has been increased to give between adjacent buckets approximately a uniform width of steam channel. The angles of entrance for steam at full load and light load are shown by arrows in the cut. Fig. 7 shows the type of bucket employed in the Rateau-Smoot turbine, with the angles of steam entrance for full and light load also indicated.

These figures show that it is a mistake to increase the thickness of a bucket toward the center, as at light loads the entering steam abruptly strikes the rear of the buckets. The loss resulting is doubled. First, there occurs the loss due to the steam shock itself; and, second, the loss due to the fact that the reaction from this shock is tending to drive the turbine backward and not forward.

The writer is quite unable to see any advantage in a bucket which is thicker in the middle, having a crescent section. As a matter of resisting the steam wear, it should be noted that the edges of all buckets, whether of crescent section or otherwise, are the portions principally subject to the steam erosion and are of necessity made thin in order to reduce the steam friction of the jet entering the bucket wheel. When these thin edges are worn the bucket has lost its proper section and becomes highly inefficient, for the crescent section equally as well as for a section of uniform thickness. In addition to this time, which is negative in its character, a crescent-section bucket presents the disadvantage already noted of increased losses on the light loads; but still more serious from the designer's point of view, it greatly increases the weight of metal in the bucket.

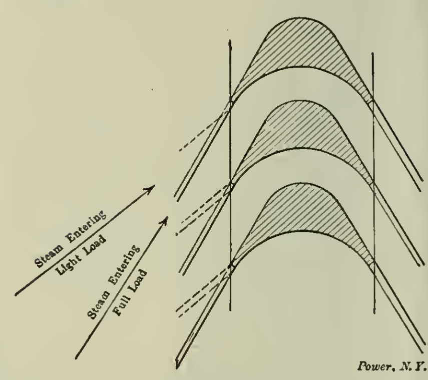


FIG. 6. STEAM FLOW AT FULL LOAD AND STEAM AT LIGHT LOAD IN CRESCENT-SHAPED BUCKETS AND IN BUCKETS OF UNIFORM THICKNESS

At ordinary bucket speeds for the multi-stage type of turbine, the centrifugal force per pound of bucket weight amounts to from 1000 to 2000 pounds, and therefore each additional pound of material over that absolutely necessary adds to the wheel an enormous disruptive effort.

The function of the wheel is primarily to hold the buckets, and if the weight of

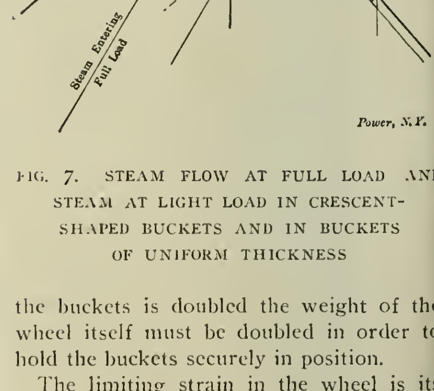


FIG. 7. STEAM FLOW AT FULL LOAD AND STEAM AT LIGHT LOAD IN CRESCENT-SHAPED BUCKETS AND IN BUCKETS OF UNIFORM THICKNESS

the buckets is doubled the weight of the wheel itself must be doubled in order to hold the buckets securely in position.

The limiting strain in the wheel is its elastic limit and not the ultimate strength of the material employed, for if once the elastic limit of a wheel has been exceeded, it is stretched out of its original shape and the running balance destroyed, causing the turbine to become inoperative through the violence of vibration ensuing.

With equal weight, the strongest wheel is the one which has the lightest periphery, for it is the weight of the periphery which produces the strains.

Buckets which are held in position by means of a dovetailed fit are objectionable because of the large amount of weight entailed by the dovetail construction. On the other hand, the bucket which is held astride of the wheel and riveted through by rivets parallel to the shaft has maximum lightness for the strength requisite to hold the buckets in place.

Fig. 8 shows a typical dovetailed method of mounting buckets on their wheel, and Fig. 9 shows the type of mounting adopted in the Rateau-Smoot turbine.

FIG. 8. BUCKETS DOVETAILED

FIG. 9. BUCKETS HELD ASTRIDE

It should be noted that much less metal is required at the wheel rim in the Rateau-Smoot turbine than is required by the dovetail construction. This metal is entirely unable to hold itself against the centrifugal force produced by its rotation and therefore must be carried by metal provided at the center of the disk, a heavy section being a source of weakness rather than one of strength.

The cross-section of the Rateau-Smoot bucket and wheel is taken from a 300-kilowatt, 1500-revolutions per minute low-pressure turbine which can be driven at 3000 revolutions per minute without producing a strain in buckets or wheels exceeding the elastic limit of ordinary flanged steel plate.

Bucket Wheels

Since the original single-wheel turbine, running at enormous speeds, invented by De Laval, various analyses have been made of the strains and strengths of disks turning at high speeds. All of these analyses unfortunately contain as prime assumption a practical fallacy. These wheels have been designed for uniform strains in both tangential and radial directions, and the material of the wheel has been treated as if its elastic limit coincided with its ultimate strength, the point of danger being considered as the elastic limit. The result produces a wheel section whose fallacy will be obvious when it is borne in mind that all metal placed within the radius lettered *R*, Fig. 10, is capable of holding itself and also an additional load, while all metal external to the radius lettered *R* is incapable of holding itself against centrifugal force, consequently it is simply necessary to add sufficient metal within this radius to hold together the entire wheel. When a wheel has been designed for uniform radial and tangential stresses, the section is that shown by Fig. 11, in which it will be noted more metal is added outside of the critical radius than for the wheel illustrated in Fig. 10. The assumption of equal radial and tangential stresses as the basis for wheel design leads to an irrational conclusion, either radial or tangential stress is sufficient to hold the wheel together, as all material suitable for the construction of a turbine wheel possesses in a high degree the property of stretching beyond the elastic limit, and when tangential stresses exceed the elastic limit and radial stresses fall under the elastic limit an infinitesimal stretch in a tangential direction will allow a sufficient elongation radially for the radial stresses to carry their proper share of the load.

While it is true that a wheel is unsatisfactory if both tangential and radial stresses exceed the elastic limit, it should also be borne in mind that either one can hold in position the wheel, regardless of what happens to the other.

For example, in the wheel illustrated by Fig. 10, the maximum stress has been taken at 8000 pounds per square inch, the material being ordinary flange steel. At the position lettered *A*, the tangential stresses may considerably exceed the elastic limit. The radial stresses, however, are much under the elastic limit, and when under test prior to assembling on the shaft the wheel has been brought to double its normal speed, a minute tangential stretch of the wheel allows the radial stresses to reach a sufficient value to hold the outer periphery to the interior central portion, the permanent stretching occurring tangentially but not radially, thus allowing the radial stresses to assume a value sufficient to hold the wheel together.

Turbine Shafts

Starting from a bucket of known weight, a wheel can be calculated strong enough to hold the buckets in place. The heavier the bucket, in equal proportion the heavier the wheel, consequently heavy buckets produce heavy wheels. Heavy wheels reduce the critical speed of the shaft, unless the shaft is also made heavier to offset the effect of the increased weight placed upon it. It is objectionable to use a large shaft, for two reasons. First, because it increases the peripheral speed of rubbing surfaces in the bearings, making them more difficult to keep cool; and, second, because it increases the diameter of the clearance space between shaft and pressure diaphragms, adding to the steam leakage.

Various attempts have been made to operate turbines in which the normal running speed was greater than the critical speed. (The critical speed of a shaft is the speed corresponding to the number of vibrations which the shaft, together with its carried weight, will make, and when given in revolutions per minute is the oscillations per minute which the shaft can sustain when once started oscillating.)

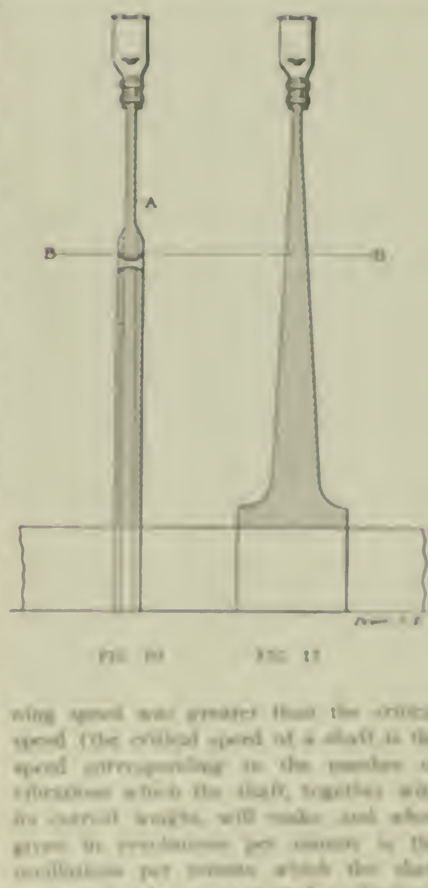


FIG. 10 FIG. 11

The calculation of critical speeds can be carried out by the process of graphical integration and highly accurate results obtained, no matter how complex the distribution of load upon the shaft may be or how widely varying may be the shaft diameter.

The execution of such a calculation, however, is a cumbersome matter, and when the critical speeds of a series of different shafts have been determined in this manner, the corresponding constants go in the following formula for critical speeds:

Critical speed (r.p.m.) = [illegible]

$$g \times 10^6 \times \frac{D^2}{L\sqrt{L \times W}}$$

are determined for all shafts whose essential characteristics are similar to those whose complete analysis has been carried through.

When sufficient experience has been gathered to determine for a given shaft the value of this constant, the critical speed of the shaft may be taken from a logarithmic chart, as shown in Fig. 12, which gives the critical speeds for the value of the constant g equal to 1.05, the value most frequently encountered in turbines of the multicellular type. For turbines whose shaft construction entails a different value of g, the corresponding critical speed may be directly deduced from that given by the logarithmic chart.

Vibrations

A turbine may vibrate objectionably or destructively, depending upon the amplitude of the vibrations. The causes of the vibrations may be found either in a shaft whose critical speed is under the running speed, or in wheels which have strains both radial and tangential near the elastic limit, thus causing a slow and continued deformation of the wheel and consequent shifting of its mass axis. From the dynamo end, vibrations can also be set up if the windings are insecurely held in position and gradually shift their position.

A properly designed turbine and dynamo, when once placed in balance so that the unit runs quietly, should never show a tendency to greater vibration; and, when such is the case, the design is at fault, for the weights carried on the shaft must shift in order to throw the machine out of balance.

Incidentally, this would seem to condemn a turbine and dynamo running on three bearings, for in such a machine any slight disposition toward vibration in turbine or dynamo will be transmitted through the solid shaft and set up vibrations in the other unit, thus causing the turbine to vibrate and its shaft to tremble when the turbine itself is not at fault, but the dynamo is out of balance. I consider the three-bearing machine questionable for this specific reason, in addition to the well known difficulty of maintaining in perfect alinement three bearings. Another serious objection to a three-bearing machine is that the shaft may pound on the central bearing, for the unit endeavors to run as a two-bearing machine running free of the central bearing and oscillating by the clearance given that bearing, thus placing on the central bearing the duty of restricting oscillations and limiting their amplitude by absorbing the blow struck by the shaft at each oscillation.

In vertical machines this sometimes results in very serious damage to the fastenings of the central bearing, for under these conditions it is subjected to enormous lateral strains, capable in some instances of shearing loose the attachment of the central bearing to the supporting framework. I consider it vastly better, although somewhat more expensive, to allow a bearing at each end of turbine and dynamo shaft and to insulate against transmitted vibrations from one to the other by using two separate shafts, placing between the two central bearings a nonrigid coupling which will allow one shaft to bend without transmitting a bending movement to the other shaft.

Oil Ring Bearings

The writer had the opportunity of investigating the action of oil in bearings running at high speed, and ran a 5x13-inch bearing at full speed (1500 revolutions per minute), with normal load with the top cap removed.

The bearing in which the experiment was made was provided with the usual oil grooves and lubricated by rings having a positive pumping action, supplying oil from the oil reservoir to the journal. At half speed and above, oil, instead of being carried into the journal through the oil grooves, squirted upward from the grooves against the direction of rotation, each groove throwing a stream of oil 0.25 inch in diameter several feet into the air, showing that the grooves simply provided vents for the back flow of the oil, which would otherwise have been carried into the journal, through its adhesion to the shaft, and indicating the truth of a theory which we have all held, but with considerable doubt, that a high-speed journal floated on an oil film.

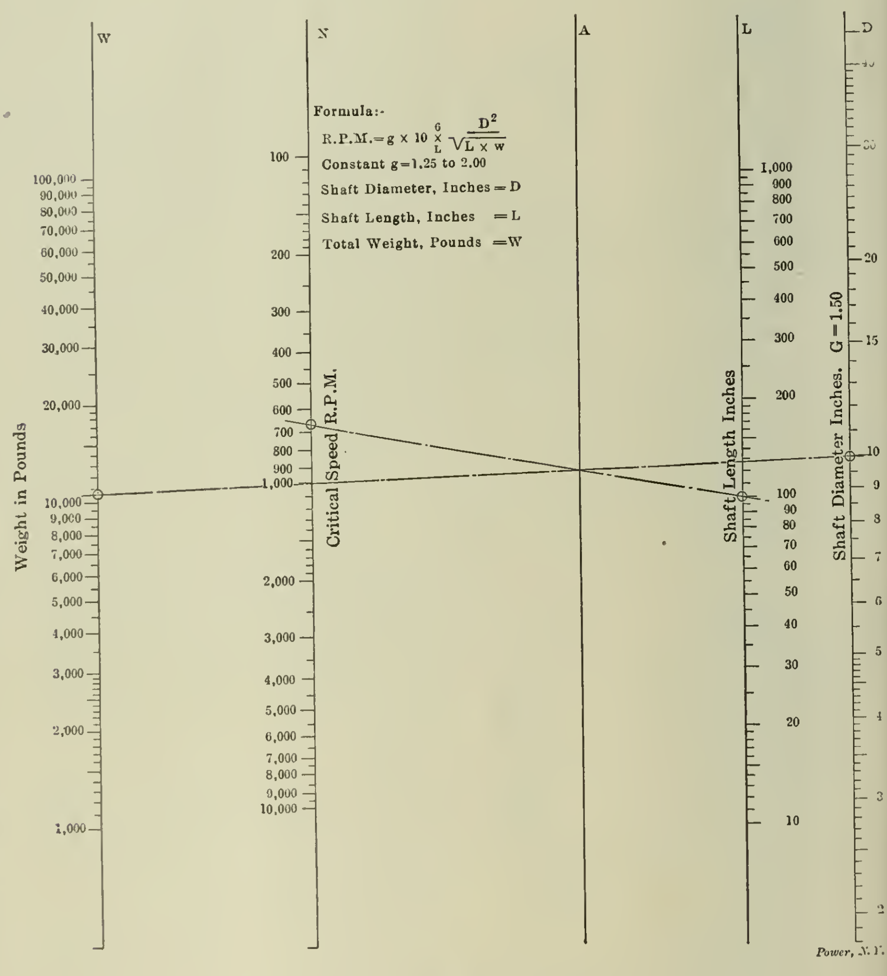


FIG. 12. CRITICAL SPEED OF SHAFTS

Summary

In this paper I have endeavored to show that steam turbines are in no way dependent on accurate workmanship for their reliability, and that simplicity and reliability will always go together in their construction.

I have also wished to express the idea that high efficiencies can be obtained without endangering the reliability of the turbine.

Furthermore, I strongly suggest that owners of noncondensing plants consider the opportunity of utilizing the exhaust of their reciprocating engines in low-pressure steam turbines, and thereby adopt a method of rejuvenating their plants by one of the most efficient methods of developing power from steam.

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

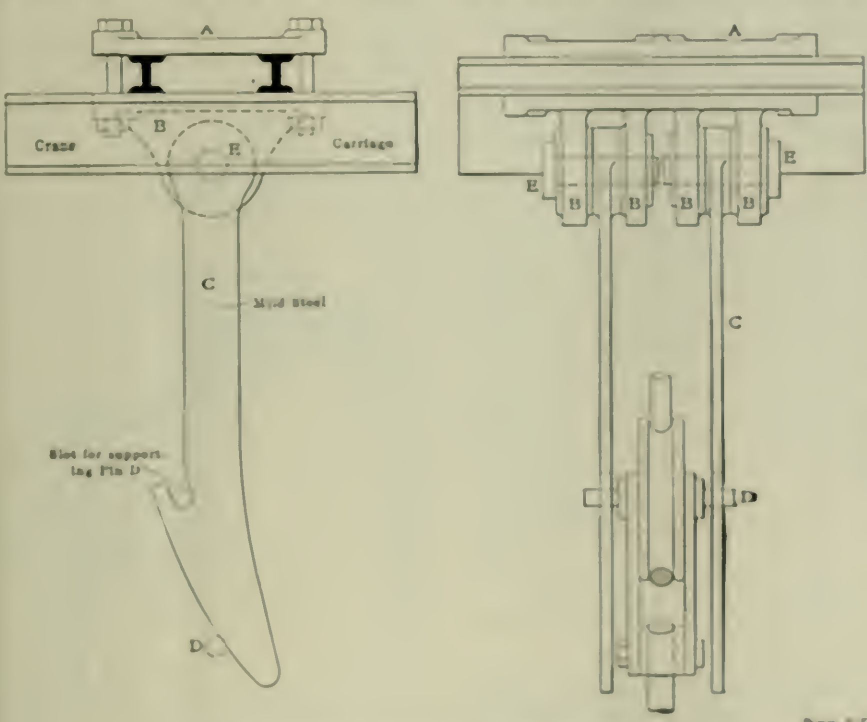
Traveling Crane Trouble Remedied

At one place where I was employed, a rope traveling crane was constructed. When this crane was put into operation it was found that when traveling longitudinally the load suspended from the crane hook swung violently, thus increasing the tension in the rope and the bending in the crane girders, making these stresses more than due to the load itself. To obviate this the following addition was made:

Two short H-beams were laid across the crane-carriage girders as shown herewith. On these beams a cast-iron plate *A* was placed with ears for six bolts, these bolts holding a corresponding plate, made from the same pattern with the two additional ears *B* hard against the under side of the beams. From these ears were hung the links for supporting the load when the crane was traveling, as may be seen at *C*. These links were free to rotate about the pin *E*, so that when the crane was about to travel longitudinally the load was raised, the pin *D* pushing the links *C* aside until the pin *D* was sufficiently high so it could be lowered into the slot provided in the link for it. As the load then rested on these links, the tension was thus taken from the rope. When lowering the load, it was first raised a little, the links *C* were then swung to one side, thus permitting the pin *D* to be lowered clear of the slot.

JOHN DOE.

Glasgow, Scotland.



REMEDYING A TRAVELING-CRANE TROUBLE

Allowance for the Difference in Water Level When Testing Boilers

The A. S. M. E. standard method of testing boilers directs that the allowance for any difference in the water level between that at the beginning and at the ending of the test should be computed, and the amount properly credited. The method of making the computation, however, is not explained.

As there is very little published relating to this phase of boiler testing, the writer believes the following formula will be found useful to those who have not developed a convenient method of doing the work. This formula applies to the case where the water is lower at the end than at the beginning of the test, or

$$A = \frac{C \times W\,(H - h)}{H - K},$$

where

- A = Amount of water, in pounds, to be added to the weight already furnished to the boiler,
- C = Space in cubic feet that must be filled in order to bring the water level to where it was at the beginning of the test,
- W = Weight of a cubic foot of water at the temperature due to the steam pressure,
- H = B.t.u. in the steam at the given pressure,
- h = B.t.u. in the water in the boiler,
- K = B.t.u. in the feed water.

The boiler should be measured, and the volume of the deficit in cubic feet calculated. The weight per cubic foot of the water at the temperature corresponding to the boiler pressure can be found in steam tables of almost any engineers' handbook. The other data required are furnished by the boiler-test log or taken from steam tables.

The following example is given to illustrate the use of the formula:

The log of a test shows boiler pressure, gage, 110 pounds; water supplied to the boilers by the pump, 96,800 pounds; temperature of the feed water, 174 degrees Fahrenheit; deficit at end of test, 25 cubic feet.

According to the formula the feed-water allowance is

$$25 \times 55.75 \left(\frac{1188.8 - 314}{1188.8 - 143}\right) = 1124$$

pounds. The temperature of the steam at 110 [illegible] gage, was taken at 344 degrees Fahrenheit, and the weight of a cubic foot of water at this temperature, according to a table in Kent's, is about 55.75 pounds. The total heat of steam of 344 degrees Fahrenheit, gage, is 1188.8 and the feed water at 174 degrees Fahrenheit contains 143 B.t.u. Therefore, the total amount of water that must be allowed for in the test of the boilers is

$$[illegible] + 1124 = [illegible]$$

pounds.

F. WESSMAN.

Scranton, Penn.

Use and Misuse of Graphite

Graphite properly used is the engineer's friend, and there are numerous uses to which it can be put with very satisfactory results. It is good to mix with oil and use on the bolts and nuts of cylinder heads, steam-chest covers, pipe flanges, etc., because it makes the nuts work easy

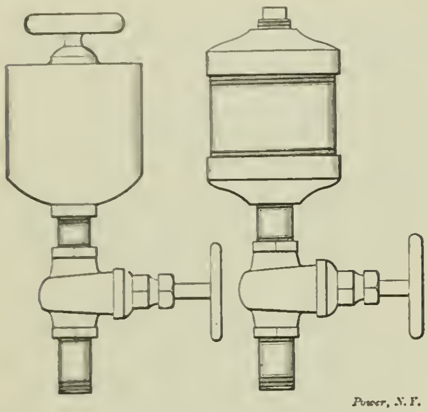


FIG. 1 FIG. 2

when one wishes to break a joint. If the nut and bolt of the rear handhole plate of a horizontal tubular boiler are well coated with graphite, and the bolt, nut and crab covered with a few handfuls of asbestos mortar, they will stand a fierce heat for months, and a wrench is all that will be needed to remove the plate.

Never plaster graphite and oil all over a gasket and then cuss because the packing slides out of the joint when the bolts are set up. Graphite one side of the gasket only. Put the gasket on the plate and graphite the exposed side. The gasket will then come off with the plate and leave the other surface clean and smooth. For this purpose the graphite should be mixed to a thick paste with cylinder oil.

Rod and valve packing for steam should be given a liberal coat of graphite when putting in place. The packing commonly used in the water end of a pump is made of several layers of heavy cotton cloth cemented together with a rubber compound, and it is nothing uncommon for the rings of packing to stick together so firmly, especially in hot water, that the expanding device is unable to set them out as they wear. A little graphite between the rings will prevent their sticking and the packing will run much longer without attention.

As a lubricant for steam cylinders and internal combustion engine cylinders, graphite is undoubtedly valuable, but the difficulties of feeding it discourage many from trying it. To get graphite into a cylinder all that is needed is a small cup with a straight, free outlet.

Fig. 1 shows how a cylinder-oil cup may be made over to feed graphite. Use a gate valve or plug cock, and attach the cup to the steam chest, or as near to it as possible. Fig. 2 shows how a cup may be made of pipe fittings, and, if carefully made of brass, it does not look bad.

Having attached the cup, put in about a teaspoonful of oil and graphite, mixed to the consistency of paint, close the cup and open the valve wide. In my plant I have a 7½x6-inch duplex boiler-feed pump which has had no lubrication except graphite for the past three months, and I have never seen a smoother or quieter working pump, although it is taking the returns direct from a heating system. This pump has been working constantly day and night and every day in the week on about three teaspoonfuls of graphite per twenty-four hours. In the three months we have used in the pump less than two pounds of graphite and hardly a gallon of cylinder oil. It was formerly nothing uncommon to feed a quart of cylinder oil to such a pump every twenty-four hours. This would be 7½ gallons per month, which at 50 cents per gallon, is $3.75 per month, or $11.25 for three months, a matter of $10.35 saved on lubrication in that time. If this amount can be saved on one small pump, what about a plant where there are a number of pumps of various sizes? This same scheme can be used on engines, also, although I should not advise discontinuing the cylinder oil altogether. Aside from economy, this should interest engineers who are using condensed exhaust for feeding boilers.

One reason why some make a failure of graphite as a lubricant is because they use too much, both in cylinders and elsewhere. During my early experience with it the outboard bearing on a 16½x48-inch Corliss engine heated up one day, and as oil failed to produce the desired result, I gave it a bountiful supply of dry flake graphite, and the heating rapidly decreased. I then flushed the bearing with oil and soon had it in normal condition.

H. L. STRONG.

Portland, Me.

Substitute for Sheet Packing

It sometimes happens that the engineer runs out of sheet packing. I find that paper will do the work, sometimes better than rubber; in fact, I prefer oil paper to rubber for water. Oil paper and thin, tough paper are the best, and roofing paper is fine. For small work, and in oil lines, it is better than rubber, as it will not soften and fill up the pipes; it will also stand a high temperature.

In one plant there was a great deal of work to get things going and as we could not readily get any sheet packing, we packed everything with paper and roofing paper from the manhole to the suction pipe of the big pump, using tar paper in the steam lines and manhole.

A recent letter from the engineer says that the most of it is still there and shows no signs of leaking. The worst thing about paper is that if it starts to blow it will mean a new gasket, but it will not blow out entirely.

ALDEN SEARS.

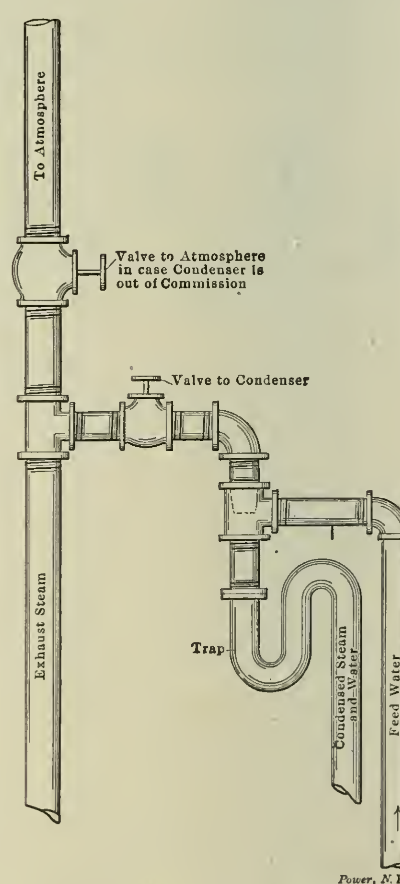
Electron, Wash.

Homemade Condenser

The accompanying illustration is of a homemade condenser made of pipe and fittings; the construction is very simple.

The exhaust steam from the engine, pump or heating system, etc., passes through a tapered nipple which is screwed past the center of the tee. The cooling water enters the side outlet of the tee and condenses the steam, causing a vacuum on the exhaust-steam line.

The trap connected to the bottom of the condenser creates a vacuum on the ex-



HOMEMADE CONDENSER

haust-steam line and water-feed line and also siphons the air out of the tee. It also prevents any water from getting into the exhaust-steam line.

In case the condenser should get out of commission the valve to the condenser can be shut off and the bypass valve opened to the atmosphere.

E. H. MARZOLF.

Bellaire, Ohio.

Handy Homemade Tools

Fig. 1 shows a packing hook used in stuffing boxes where the packing can neither be pulled out nor blown out by steam. The tool is a combination of a hook B and worm A. The latter is first screwed into the packing, then, holding the inner rod B by the faucet handle D in such position that the pendant hook faces the opening in the casing, the two handles being properly marked, the plug C is screwed down into the outside handle, thus forcing the hook to undermine the old packing. With the aid of a common worm hook, driven in a short distance from the tool, and on which most of the pull must be applied, satisfactory headway can be made. The opening in the casing

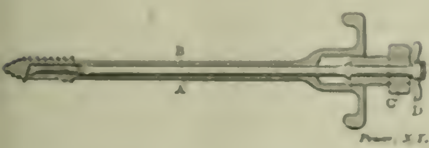


FIG. 1

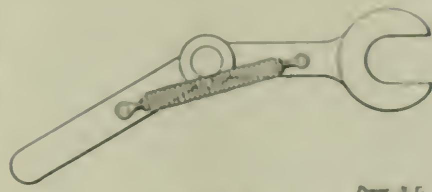


FIG. 3

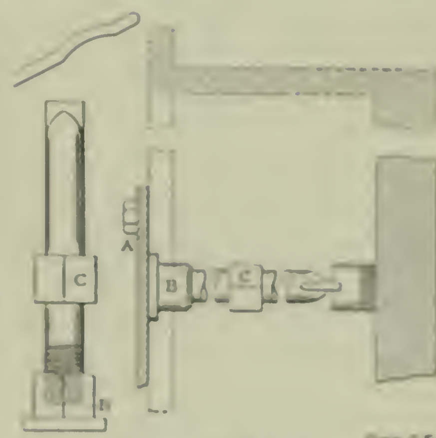


FIG. 5

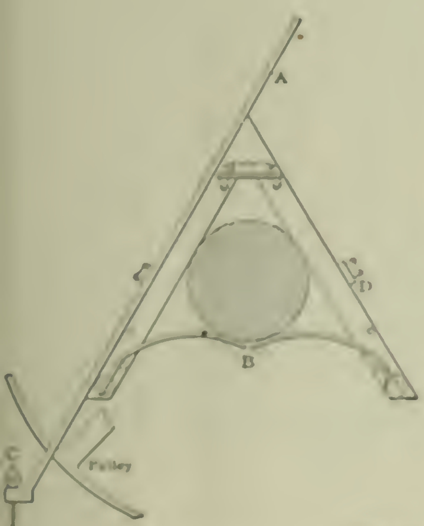


FIG. 2

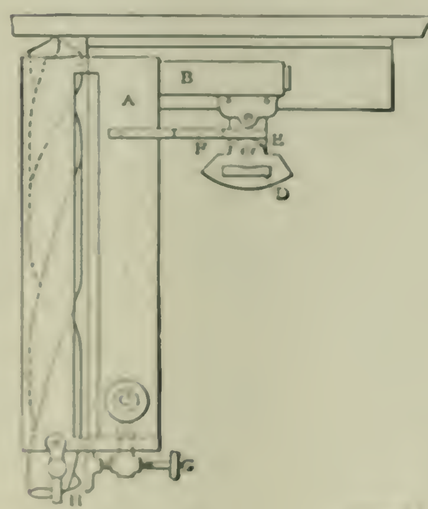


FIG. 4

FIG. 6

should be of such size that the hook will not entirely pass out through it but will become wedged against its containing walls, thus relieving the small junction pin of all pressure when the pull is applied.

The device shown in Fig. 2 is used for leveling shafting by the sighting method, and is worthless unless accurately made. At A is a straightedge, long enough to clear all pulleys and hangers; BB are flat springs to steady the tool after leveling it on the shaft; C is the sight and D is a counterweight, balancing the straightedge.

The sight is movable, perpendicularly, and on the largest-sized shafts should be placed as shown. To accommodate small-sized shafts, simply raise the sight a distance equal to the difference in the diameters. When it is possible to see through all the sights at one time, on a continuous line of shafting, it will be a pretty good job.

In Fig. 3 is shown a wrench, mainly used in connection with a socket wrench for tightening follower bolts. By making the tension of the springs adjustable, and using shims, this wrench will be found very handy for various other purposes, such as for equalizing the tension on the two springs of a governor.

Fig. 4 shows a tool for squaring a drill or tap, when using a ratchet wrench. At A is a piece of steel straightedge, hinged at B to a common try square, and adjusted by means of thumb screw C, so that it hangs exactly parallel to the blade of the square, and slotted almost its entire length to facilitate sighting the drill. When the edges of the drill are seen to be parallel to both square and straightedge then the hole will be bored at right angles to the face. The tool is particularly handy when a narrow surface is to be drilled, as then an ordinary square can be used to square the drill in one direction only. A small level is shown at D. This is used when the surface is uneven, in which case shims are placed under the stock of the square. It is also used where several holes are to be drilled at the same angle in the direction of the length of the work, as it is adjustable, swinging on the pivot E. When two or more holes are to be drilled at a certain angle in the other direction, the narrow width of the work, the swinging straightedge is used, which is tilted to the proper angle by means of the adjusting screw C, the flat spring F serving to keep the screw in contact with the blade. The two small thumb screws G and H are used to square the shank of taps. The tool is meant for ordinary work and is not supposed to be used where micrometrically correct drilling is required.

Fig. 5 shows a tool to back out the glands of condenser tubes. The method used at a large electric-light station is to back out as many as possible by the hand-tool method; then the plate A, of any desired width, is fastened across the face of the condenser, using the cover bolts to secure it. Placing the thin end of the tool in the slot of the gland, the jacket box B is backed up firmly solid against the plate A. The pitch of thread on the box should correspond with that on the tube gland. A monkey wrench applied at C will soon make that gland start. The plate A should be wide enough to cover at least five or six rows of tubes. The number of glands saved will soon pay for the time and trouble of making the device.

Fig. 6 shows a pair of fiber tongs, used to replace glass-inclosed, spool-holding fuses on very high-voltage oil switches. The shallow bag is used to catch the broken glass, and the tongs to close the spring end clamps.

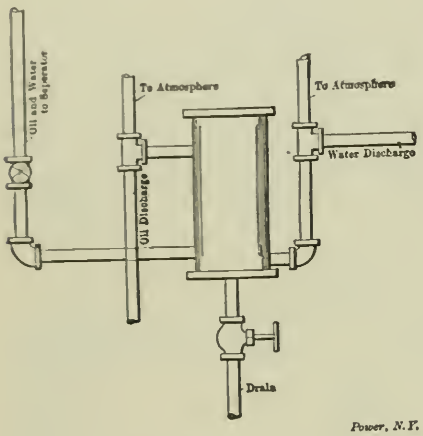
M. O. Ricker

Framingham, Mass.

Homemade Oil Separator

The accompanying illustration is of a homemade oil separator, constructed of pipes and pipe fittings.

The condensed water and oil are fed through the bottom of the separator. The oil discharge is taken from the top and the water discharge from the bottom.



HOMEMADE OIL SEPARATOR

Both the oil and water discharge outlets have nipples to the atmosphere to prevent siphoning.

E. MARZOLF.

Bellaire, Ohio.

Sarcastic Advice

If the water in the boiler becomes so low that the plates are heated red hot, build a hot fire and turn on the cold-water pump. This will contract the overheated metal and all your troubles will be over in a few moments.

If the governor sticks, causing the engine to run away, don't get excited and close the throttle. Engines so affected invariably stop of their own accord in a few minutes.

If the safety valve leaks, hang a little more weight on the lever. An old 8-inch gate valve will be about the right weight.

Do not monkey with the blowoff. Let it fill up with scale. Then it will not leak.

If the boilers are so full of water that heavy slugs are coming over into the engine cylinder, you can judge of the quantity by holding the ear near the cylinder head. Water will clean the cylinder out.

A bag in a boiler does not hurt anything. It will soon fill up with scale.

A babbitt lined wrench should never be used on those polished nuts of the engine. It might slip off and skin your fingers. Use a pipe wrench or a hammer and cold chisel.

Do not clean the soot off the tubes oftener than once a week. It is hard on the tubes, cleaning them so often.

Engineering papers are like scientific books, all theory and of no practical benefit to anyone. A dime novel is much more interesting and costs less; besides, "book men" have not got a very high standing in the engineering profession.

I do not know anything about an indicator and do not want to know anything about it, for it is an abominable nuisance and should never be permitted in an engine room.

JAMES JORDEN.

Barberton, O.

More Frequent Internal Inspection

Milton Heglin, on page 939 of the May 25 number, misses the true purpose of my letter of March 9. I did not make a sweeping condemnation of boiler inspectors. He knows full well that most of them are conscientious men of high purpose. But he also knows that men have their limitations, that no one is infallible and that some are not unwilling to make an "absent-treatment inspection for revenue only," to borrow a phrase the editorial on "Boiler Inspections and Explosions" in the May 25 number. What I aimed at was simply to impress upon engineers and boiler owners the importance of *more frequent* internal inspections of boilers. I cited a few concrete cases to show that in many cases such inspections proved profitable. For it must be obvious that very few people would go to the trouble of making an internal inspection of a boiler right on the heels of an inspection by an insurance inspector unless there was some chance of being rewarded for their work. In other words, the boiler owner and engineer must see good reason for the undertaking. Mere checking up of the inspector's work is not a sufficient reason.

The writer has no grudge against boiler inspectors. Whether he is or is not selling boiler-cleaning devices does not alter the truth of his premises. They are generally accepted where people have gone to the pains of investigating. In some cases, investigations even become unnecessary—the facts force themselves upon us. Proof of this is seen in the editorial mentioned. The writer contends that the day of the auditor has not passed. Over and over again we are brought face to face with the fact that checking up (in whatever field it may be) means economy and safety. And no boiler inspector should be chagrined because his inspection report is not taken as the final word in the matter.

Mr. Heglin himself unwittingly gives one good reason why we should take some inspectors' reports with a grain of salt. "Another phase of this question," he states, "is that a great many owners, managers and superintendents become very indignant when told the boilers need better cleaning, maintaining that they have a good engineer, who knows his business, and that the boilers have never given them trouble from being dirty; and there it ends."

Suppose your inspector, instead of ordering the insurance canceled until the boilers were cleaned and kept in a less dangerous condition, preferred to be considered a "good fellow." Does it take long to guess what he might do? Is it not true that there are more men who want to be "good fellows" than who want to be somebody else? Is it not conceivable, then, that where there is no imminent danger, where conditions are safe enough, your good-natured inspector will jolly along the engineer and superintendent by saying something about the remarkable cleanness of their boilers? A boiler can be terribly inefficient because of scale and still be safe. The inspector is not a consulting engineer employed to point out possible economies in operation or to recommend appliances. If his suggestions are obnoxious, why should he volunteer them and become a boor? And he is right.

Now, don't misunderstand the writer's position. If possible, give us a more efficient inspection service. But efficient or otherwise, I hold that for economy's sake alone it will pay the owner and the engineer to make frequent internal inspections of their boilers.

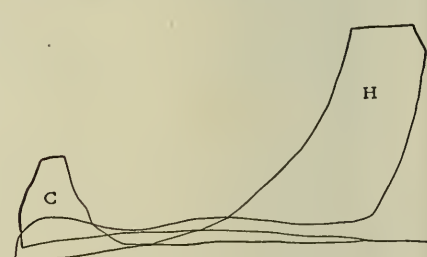
H. E. GANSWORTH.

Buffalo, N. Y.

What Was the Trouble?

The accompanying indicator diagrams were taken from the high-pressure cylinder of a Westinghouse horizontal cross-compound Corliss engine.

Before the defect shown on the card occurred, the dashpots closed the steam valves properly. After the trouble started, the crank-end dashpot refused to close



WHAT CAUSED THE TROUBLE?

its steam valve when the trip released the hook, the valve being closed positively by the movement of the valve gear.

No trouble was experienced at the head end in getting the dashpot to close its valve, and as soon as the defect was remedied, the crank-end dashpot worked as before, very satisfactorily.

It might be remarked that the crank-end steam valve was in proper working order in regard to workmanship and valve-gear arrangement, and that the trouble was not due to the dashpot, and no attendant had disturbed the valve gear. What caused the trouble and the appearance of the card?

J. W. Stoliker.

Shelton, Conn.

Steam Engine Testing

In testing steam engines to ascertain their performance, or to discover any cause of loss of power or illegitimate steam consumption, it is often thought necessary to know the quality of the steam in the cylinder at each point in the stroke.

Referring to the indicator diagram in Fig. 1, it is necessary only to draw the saturation curve for a quantity of steam equal to that taken into the cylinder at each stroke, plus that in the clearance. Then the quality of the steam at any point in the expansion is equal to the ratio of the volume of the steam in the cylinder at this point, to the volume shown by the saturation curve for the same pressure. These two volumes are represented by the lines AB and AC. Therefore, $X = AB \div AC$.

In some cases of "jacketed" cylinders with high ratios of expansion, especially in the cases of multiple expansion, the expansion curve crosses the saturation curve. This shows that there is superheated steam in the cylinder. Beyond this point the ordinary method of determining the quality will not apply.

Some years ago Power published a formula for determining the quality of superheated steam in a cylinder. The formula there given was not homogeneous, contained R, the latent heat of vaporization, and gave X the quality, which in the case of superheated steam means nothing.

My formula is practically homogeneous, does not contain R and gives the degree of superheat direct.

Referring to Fig. 2, P, V and T of the formula are the pressure, volume and absolute temperature at any point on the saturation curve; p, v and t are the pressure, volume and absolute temperature at any point on the expansion curve.

It is desired to find the degree of superheat at the point B. Select the point C on the saturation curve so that $P = p$. Now considering dry and superheated steam as a perfect gas, which it very closely approximates, volume V may be divided into T equal parts $= V \div T$, each part representing the increase in volume that will be caused by the increase of one degree of temperature. Now to increase the volume from V to v, it will be necessary to raise the temperature as many degrees as $V \div T$ is contained in $v - V$, or

$$\frac{v - V}{\frac{V}{T}}.$$

But the number of degrees of temperature necessary to raise steam from its volume at saturation to any larger volume is its superheat at that point. Therefore the degree of superheat at that point is

$$D = \frac{(v - V)\,T}{V},$$

or

$$D = \frac{(AB - AC)\,T}{AC}$$

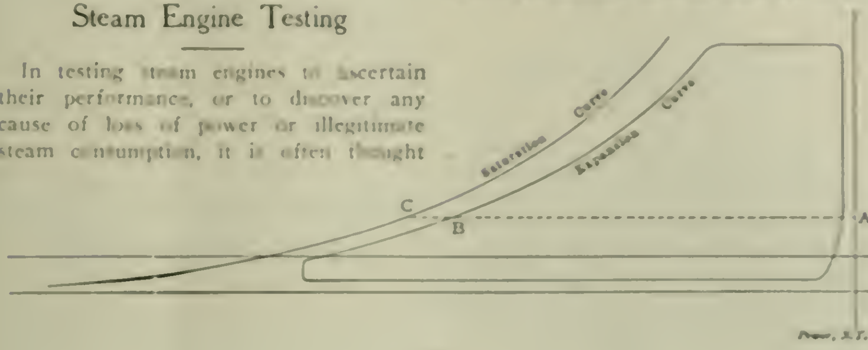


FIG. 1

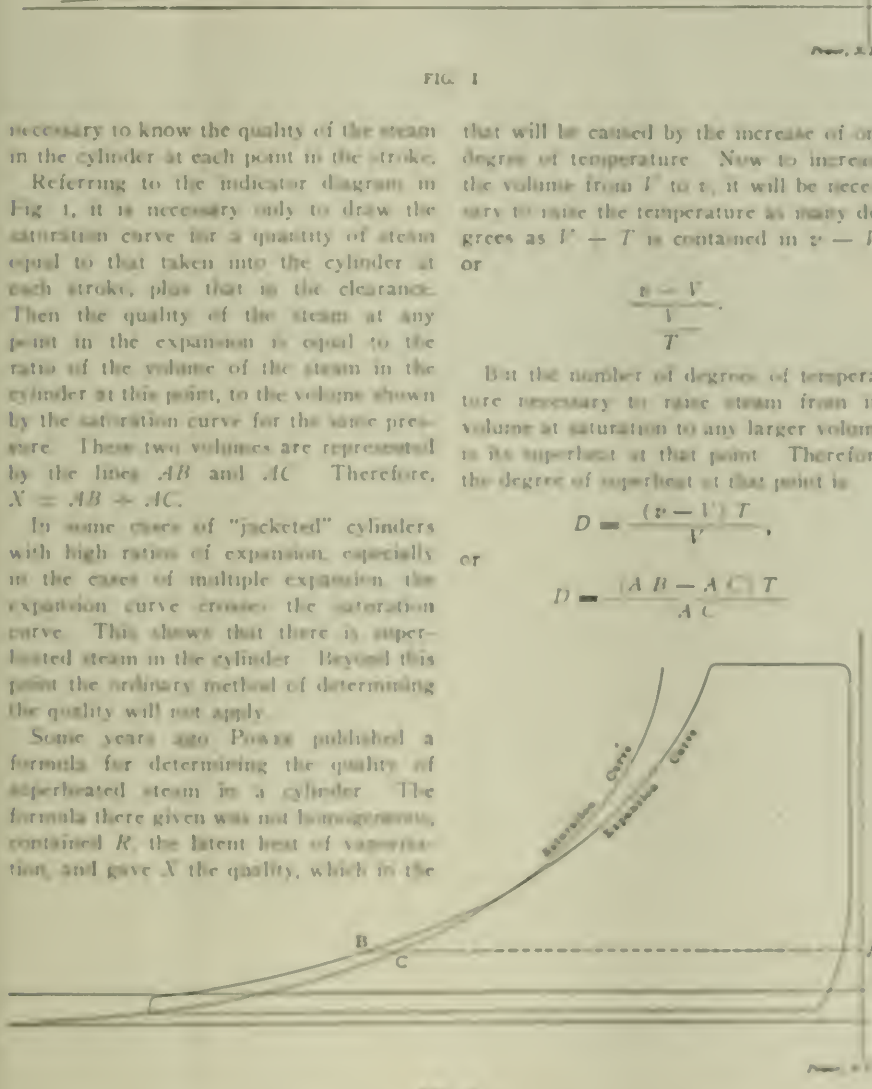


FIG. 2

on Fig. 2, which may be figured out in actual quantities from any indicator diagram where the expansion curve crosses the saturation curve by simply scaling the lines AB and AC in inches or any other unit, and from a steam table, taking the T that corresponds to the pressure at the point C.

J. H. Wiswar, Jr.

New York City.

Expert Advice

In the April 13 number, H. E. Samuels has an article on the actual cost of power. It is quite true that an engineer can figure his power cost, including charges, depreciation, taxes, etc., but does he? A very large proportion of the engineers cannot do this because they are not given the opportunity. The cause for this is, first, many of the engineers will not take the trouble, even if the information is given them, to enable them to make these figures; and, second, the plant owner is unwilling to give the engineer the information necessary for him to make a careful estimate.

As a rule in the moderate-sized plants the engineer is not only the engineer in the steam plant, but he also has to care for a very large part of the machinery throughout the plant, and has little time to look into the finer points of his plant and to discover where the leaks happen and take means to prevent them. The matter as it stands today is such that the average plant can be very materially assisted by the employment of an expert to go over it carefully in connection with the engineer if he can succeed in inducing the engineer to coöperate with him, determine where the plant is at fault and remedy these places. As far as this is concerned, it has one great objection, mainly because of the jealousy or ill feeling caused by jealousy, or any other feeling of the engineer, who apparently feels that he should be left alone to work his own will on the plant, and that the calling in of any outside assistance is a grave reflection on his ability.

This may or may not be true. An engineer, if he is a true engineer, is always glad to learn; and if his plant is not working to its best advantage, he should be exceedingly glad to have an opportunity to learn how it may be made to do so and take advantage of this opportunity so that the same troubles will not happen again. It is no reflection upon the ability of any engineer to have an expert called in to advise him, because the expert has had experience in a number of plants of widely varying characters. The engineer has probably been confined to one, two or three plants of very nearly the same general type. His duties, besides operating the engine and boilers, have been so numerous that he has not the opportunity to make studies into the various features of his plant, and has not had the time to study out how this plant study can be made, without serious loss of time. The expert can and will put him in a position to make these studies systematically and easily without loss of time or interference with his regular duties.

There is another point which Mr. Samuels does not seem to realize. There always seems to be a feeling between the engineer and the employer, such that it is very hard for the engineer to get the employer to believe things may be done to improve the plant, to advantage; whereas if the engineer is backed up in his opinions by an expert, the work can be done and is done. There is quite as much trouble in the engine and boiler room due to the dictation of an employer with reference to the kind of coal, oil, etc., as there is from lack of attention of the engineer to his duties; also because the employer expects the engineer not only to be the engineer of his plant, meaning by plant the steam end, but also to look out for every bit of shafting and machinery there is in the plant. This is not the province of the steam engineer. His duties should be to keep his steam plant running continuously and at the same time as economically as possible, and the employer should take careful notice of the recommendations of his engineer.

I am not recommending the employment of a supervising expert continually on the staff of the manufacturing company, as has been suggested by a number of people in your paper. I believe that if an expert is employed who is competent, he can give the engineer the points necessary to enable him to carry on his work successfully; and the expert will not be required to visit the plant at stated intervals. It is wise, however, when any trouble occurs or the power cost seems excessive, to call in an expert to see if he can discover the difficulty, as his wide experience will enable him to find troubles which the continuous service of the engineer and his long service in the same plant make him believe that it is inherent in the plant to have certain defects or certain losses, which cannot be reduced. The expert, however, not having this experience, examines carefully the records and notes those which seem to be excessive, and looks for the cause. Having found it, he suggests and tries a remedy.

The main trouble, therefore, seems to be too many duties for the engineer imposed by the employer; a belief of the employer that the engineer should do well with little or no encouragement; a resulting lack of interest in the plant by the engineer; and a gradual deterioration, which needs remedying and which can be done most cheaply and quickly by the employment of an expert. There is no question in my mind that the engineers can and should wake up to their opportunities; and that the employment of an expert, which is now of very great advantage to most manufacturing companies, could be made less necessary. To my mind it can never be entirely obviated, because the engineers do not wake up, the engineers do not have an opportunity to study and visit other plants, keep in touch with the advancing scientific knowledge, and are, therefore, at a disadvantage as compared to the expert whose opportunities are so much greater. If the engineer of most plants would be willing to put aside his petty jealousies against the expert and work with him, it would be much to his advantage. This fact is very well expressed in the April 13 number, under the heading of "Drops of Ink to Make You Think."

HENRY D. JACKSON.

Boston, Mass.

Expanding Boiler Tubes

When leaking tubes of horizontal return-tubular boilers are located in or near the center and are thickly covered with a hard scale, which prevents them from coming out of their own tube holes, even when hammered and a chain tackle is used to pull them out. The majority of engineers cut off the bead, if there is any, and rip the tube with the bur inside and close the ends in as usual. This is all right, but after the tube is started out and is only 8 or 10 inches outside the hole, and cannot be driven out any more from the other end, they try a chain tackle, and hammer the tube for hours with very little result and with a strain on the tackle nearly pulling the boiler from its settings.

I have seen nine such tubes which could not be taken out of their own holes. The proper thing to do would be to cut out all the tubes and jump them through the manhole or handholes if there are any, but in many cases they do not want to take out all the tubes and only want to remove the leaking ones. The only remedy for such tubes is to cut them off when they are stuck out of the hole 8 or 10 inches and rip and close the end of the remaining part of tube in the boiler as before and push the tube back into the boiler out of the way for the present until you get a roller tube expander, and roll the tube hole (that is, in the tube head) larger, which is only upsetting the plate and can be done very easily if you have an expander 1/4 inch larger than needed to roll the tubes, but if you have not an extra expander the same expander will do if you use a strip of sheet steel about 1/4 inch thick, 3/4 inch wide and 5 or 6 inches long if they are 3/4-inch tube holes, having made the tube holes larger, the tubes can be pulled out easily; and when putting in new tubes it will be necessary to use a ferrule of either copper or sheet-iron strips, about 1/16 inch thick, 3/4 inch wide and long enough to fill the holes when the new tubes are in place. The tubes can be put in without ferrules if the ends are heated and opened out with a wooden plug or drift driven in several inches, thus making bell-mouth tubes of them.

STEPHEN C. CAFIERO.

Brooklyn, N .Y.

Equivalent Straight Pipe for Globe Valves, Bends and Elbows

The accompanying data sheet gives the lengths of straight pipe which are equivalent in resistance to globe valves, bends and elbows. The table is calculated from the following:

d = Diameter of pipe in inches,

A = Length, in inches, of pipe equivalent to globe valve,

A' = Length, in feet, of pipe equivalent to globe valve,

B = Length, in inches, of pipe equivalent to bends and elbows,

B' = Length, in feet, of pipe equivalent to bends and elbows,

$$A = \frac{114\,d}{1 + \frac{3.6}{d}}.$$

$$B = \tfrac{2}{3} A = \frac{76\,d}{1 + \frac{3.6}{d}}.$$

$$A' = \frac{9.5\,d}{1 + \frac{3.6}{d}}.$$

$$B' = \frac{A}{18} = \frac{6.33\,d}{1 + \frac{3.6}{d}}.$$

The formulas for A and B are taken from the catalog of the Ingersoll-Sergeant Drill Company.

SIDNEY C. CARPENTER.

Plainville, Conn.

EQUIVALENT STRAIGHT PIPE FOR GLOBE VALVES, BENDS AND ELBOWS.

Pipe diameter.	Equivalent Straight Pipe due to				Pipe diameter	Equivalent Straight Pipe due to			
	Globe Valves		Bends and Elbows			Globe Valves		Bends and Elbows	
	Feet	Inches	Feet	Inches		Feet	Inches	Feet	Inches
1	2	1	1	5	11	78	7	52	5
1¼	3	1	2	1	12	87	8	58	6
1½	4	2	2	10	13	96	6	64	4
2	6	9	4	6	14	105	6	70	4
2½	9	9	6	6	15	114	5	76	4
3	12	11	8	8	16	124	1	82	9
3½	16	5	10	11	17	133	6	89	0
4	20	0	13	4	18	142	6	95	0
4½	23	9	15	10	19	151	8	101	1
5	27	7	18	5	20	161	0	107	4
6	35	8	23	9	22	180	2	120	1
7	44	0	29	4	24	197	10	131	11
8	52	5	34	11	26	216	8	144	5
9	61	1	40	9	28	230	0	153	4
10	69	10	46	7	30	254	5	169	7

The Rathbun Engine Test

In the issue of April 6 occurs an article entitled, "Test of a Vertical Engine," giving the economies of a 12x13, 100-horsepower, Rathbun, single-acting, vertical engine. Owing to the extremely low economies shown, I have taken the

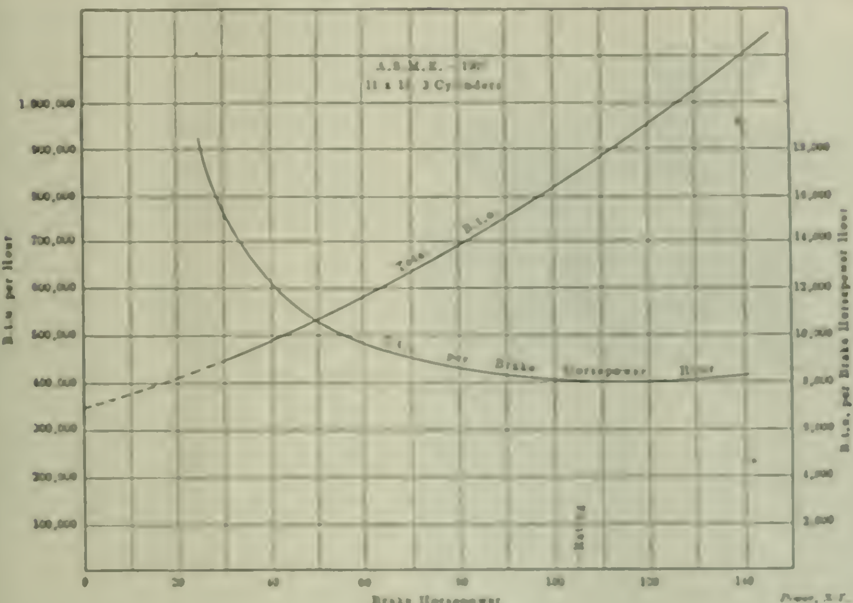


FIG. 1

trouble to analyze the results therein presented, and believe it will be of interest to other readers to do likewise. Allow me to say at the start that I should have no desire to question the accuracy of these results if they did not, by reason of the extraordinary economies claimed, reflect on the entire gas-engine industry outside the Rathbun engine. If the Rathbun company will publish all the facts, so that the public will be able to judge what economies this engine is really capable of, then may one feel justified in taking at face value these extraordinary statements.

To come down to figures, I submit reproductions, drawn exactly to scale, from two published tests from Rathbun engines of about the same size. Fig. 1 is reproduced from a chart accompanying a test record from a three-cylinder 11x13 natural-gas engine which was presented by Mr. Rathbun before the American Society of Mechanical Engineers in 1907. Fig. 2 is the chart from the two-cylinder 12x13 natural-gas engine described in POWER AND THE ENGINEER, April 6. I have added to these charts certain other curves necessary for a rational comparison of results, namely, the line of total B.t.u. consumed per hour at various loads extended back to the origin. As the total consumption line in Fig. 2 was not plotted to complete scale, but only to about 18 horsepower, it is somewhat misleading to one not familiar with the meaning of such curves. To Fig. 2 I have also transferred the total heat line from Fig. 1,

and we have the curious condition that while the two-cylinder engine required at no load, only about 25 per cent. of full load gas, the three-cylinder engine required nearly double this amount. Moreover, the shape of the total heat consumption lines is quite different in the two cases. The intersection of a tangent from the origin shows that while the three-cylinder first engine gave its best economy at about 130 brake horsepower, the second engine gave its best economy at slightly under 100 horsepower, which, considering the respective ratings, represents a singular difference in the performance of the two engines.

FIG. 2

In Mr. Rathbun's A. S. M. E. discussion he says:

"The inference seems to be obvious. Design an engine that will give a brake horsepower of 8000 B.t.u.; proportion the clearance so that the maximum indicated thermal efficiency is obtained at 20 per cent. below the maximum horsepower. This will give an engine an overload capacity of 25 per cent. with practically uniform efficiency. This proposition undoubtedly offers difficulties, particularly on some designs, etc."

I do not believe that Mr. Rathbun is serious when he proposes 25 per cent. overload capacity. In any event, the performance of his 12"x13-inch engine shows that he has not done what he proposed.

Coming down still further to details, I do not find in any of these results the necessary indications of accuracy to permit the results to carry conviction. In my own engineering work I have never considered a curve in any sense authoritative from a quantitative standpoint unless the points from which it is plotted are somewhat available. It is extremely easy to extrapolate or interpolate from irregular results without full warrant. These economies, if accurate, represent the highest thermal efficiencies in small engines that have ever been claimed in gas-engine practice. It is due to the public that the Rathbun company enlighten them more in detail as regards the actual figures—how they were obtained, what corrections were made, etc.

It is usual practice to reduce gas consumption to standard gas of 60 degrees 30 inches. Yet, the article of April 6 says: "The gas averaged about 1,000 B.t.u. per cubic foot at the temperature at which it passed the meter, so that the thermal efficiency of output was practically ... per cent." In the first place, this is not a sufficiently tangible expression of economy to be of any value. In the second place, this per cent., on a thermal basis, is equivalent to not quite 8500 B.t.u. per brake horsepower-hour.

The speed regulation was given as 4.5 per cent. It is not customary to speak of speed regulation except between no load and full load. The speed curve, however, shows a rapid drop between 35 and 70 horsepower. If this speed curve were carried back to zero load, the speed drop would be excessive and entirely beyond the limits of good generator practice.

The article speaks of the advantage of automatic adjustment of ignition, which is advanced on light loads. If the results were so extraordinary, why does the light load heat consumption shown in Fig. 1 appear nearly twice that of Fig. 2? As I understand it, this feature was to be of assistance on light loads, especially in point of economy.

In view of the foregoing, I believe it is incumbent upon the Rathbun company to explain its position on this question of economy in full detail.

KENNETH C. MCALPIN.

Chicago, Ill.

[In justice to Mr. Rathbun we explain that the temperature at which the gas passed the meter, about 50 degrees Fahrenheit, was inadvertently cut out of the article by the member of the staff who handled it. The efficiency figure was inserted by the same editor, and as the exact figure would be 29.22 per cent., on the basis of the data furnished, "practically 30 per cent." is not far out—EDITORS.]

Repairing a Broken Cylinder

The liability of wrecking steam cylinders of engines driving air compressors or blowing engines equipped with mechanically operated inlet and discharge air valves, and connected to a common receiver with other compressors, by allowing them to turn in a reverse direction when the throttle valve on the steam cylinder is closed, is well illustrated by accompanying photograph.

The engine in question is one of six Norberg Corliss cross-compound condensing blowing engines, compressing air to 50 ounces per square inch, and all discharging into a common receiver.

There are gate valves to cut out each engine (300 feet distant) attached to the main drum where individual blast pipes enter the drum. When necessary to stop the engine in case of accident or minor repairs, the custom is generally to stop and hold the engine from turning in a reverse direction by unlatching the high-pressure wristplate, raising the steam valve, and then admit steam to one end of the cylinder, move the piston to one end and leave steam on with the throttle open. The engine cannot move when left in this condition. This is done only when small repairs are needed, such as loose nuts or bolts or in keying up. At all other times the valve is closed on the blast line and the throttle is not closed until the air pressure is all off the engine.

The primary cause of this broken cylinder was that the engineer in charge,

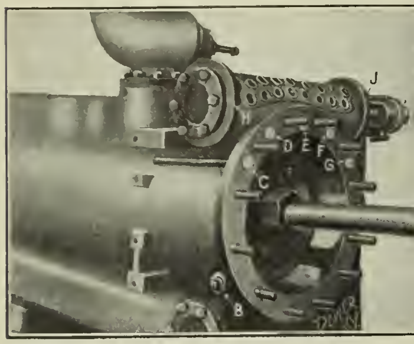


FIG. 1

in stopping to tighten a loose truss rod on the main eccentric rod, closed the thottle and did not unlatch the wristplate.

While making this repair the engine started to run backward driven by the air pressure in air cylinders, and before the engineer could reach the throttle, open it and latch the wristplate into the gear, the cylinder cracked across the top of the back steam-valve chamber as indicated by the line drawn across the top of the patch and the dotted line down through the side of the valve-chamber bonnets.

The brass box on the crosshead pin was crushed back out of shape and the key sheared in the crank ⅛ inch. No

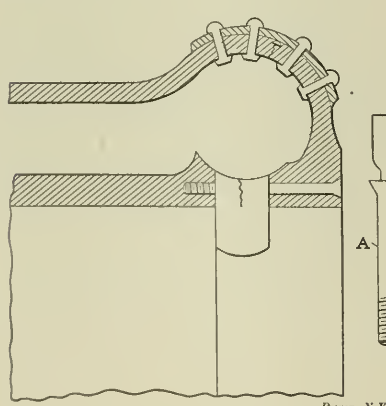


FIG. 2

damage was done to the piston, piston-rod or cylinder head.

If the cylinder relief valves had been attached to this engine the probabilities are that no damage would have been done, as they would have opened and relieved the pressure.

The point *B*, Fig. 1, shows where we have since drilled and attached eleven 2-inch spring relief valves.

As the engine was needed to blow a furnace with, repairs were effected by fitting a patch of 5/16-inch steel over the crack in which we had previously cut a dovetailed groove and filled it with "Smooth-On."

Patch and cylinder were drilled for a double row of ¾-in rivets, figured to give a joint efficiency of 70 per cent.

The cracks extending down through the bonnet flanges into the cylinder were dovetailed out and an annealed copper wire calked in. Two 1-inch bands of swedish iron were shrunk around the bonnet flanges as shown at *H* and *J*.

The broken portion was further strengthened by drilling through the flange of the cylinder back through the steam port under the valve and putting in bolts *C*, *D* and *E*. These holes were drilled 13/16 inch through to the steam port and then drilled 1⅛ inches into the metal beyond the port. The ⅞-inch hole only was tapped out, and a bolt put in, as shown in Fig. 2. The portion of the bolt marked *A* was used to screw into place and then twisted off, and afterward filed down smooth. Bolts marked *C*, *D*, *E*, *F* and *G* were put through the flange as shown on side of the cylinder, and fastened with a nut.

As the crank was found to be tight, the cylinder head was put on and the engine slowly heated up to allow the cement to dry. Pressure was gradually put on and small leaks around the patch were calked. The jacket was put back on the cylinder and except for the rings *H* and *J* on the bonnet flanges projecting a trifle above the jacket the engine is to all appearances as good as ever. It has been running constantly for two months, and has neither leaked nor shown any signs of distress.

A new cylinder put in position ready to run would cost $600. The repairs cost less than $100, including material and labor.

G. L. FALES.

Copperhill, Tenn.

Braces Were Sprung

While visiting an electric-lighting plant, I happened to look in through the bottom manhole of a 72x16-inch return-tubular boiler that was being washed out, and I noticed that some of the tubes in the bottom row were sprung sidewise, in some cases almost touching one another; also, the two through braces were sprung up about 4 inches. The superintendent said the boiler had been that way for six months and he thought it all right.

If those through braces were straightened out, would the tubes spring more or would the through braces stretch again?

W. E. MCCLELLAND.

Saskatoon, Can.

The National Electric Light Convention

Low Pressure Steam Turbines, Gas Engines and Producers and Grounding of Secondary Circuits Prominent Topics at Recent Meeting

The thirty-second annual convention of [the] National Electric Light Association, [he]ld at Atlantic City in the week ended [J]une 5, was not the usual, to-be-expected, [su]ccess; it was an astonishing eclipse of [al]l previous conventions of this organiza[tio]n. In point of numerical attendance, [qu]ality of program and real interest mani[fe]sted by the delegates, it was a record [bre]aker.

The meetings were held on the new [M]illion Dollar" pier, where the exhibi[ti]on hall was also located, and the open[in]g of the convention was preceded by a [re]ception and ball in the exhibition hall [on] the evening of May 31. The center [of] this hall is provided with a splendid [po]lished floor for dancing, and one-half [of] the floor was kept clear for that pur[po]se. The music for dancing was sup[pl]ied by a small string band, and the [ce]lebrated Filipino orchestra, located in [a] gallery at one end of the huge hall, [re]ndered high-class music between the [da]nce numbers.

On Tuesday morning, June 1, the con[ve]ntion was formally opened by President [W.] C. L. Eglin, and welcomed by Mayor [Stoy], of Atlantic City. The president [th]en delivered his annual address, in the [co]urse of which he indicated the ad[va]ntages derivable from the policy of es[ta]blishing State sections of the associa[tio]n wherever it is feasible to maintain [the]m.

The sessions of the convention were [di]vided into four classes: General, cover[in]g committee reports and papers not [st]rictly belonging to one of the other [th]ree divisions; Technical, dealing with [en]gineering papers and discussions; Com[m]ercial, devoted to business methods; and [Ac]counting, the scope of which is indi[ca]ted by its title. The sessions of the [lat]ter divisions were held separately, and [o]n account of the large amount of work [to be] done, parallel sessions were held in [di]fferent parts of the pier on the third [d]ay of the convention. The first day was [de]voted to committee reports and papers [i]n the General division, which do not [co]me properly within the field of this [jo]urnal.

Developments in Storage Batteries

The first paper of interest to Power [re]aders was one by Joseph Appleton, en[ti]tled, "Advanced Information Regarding [D]evelopments in Storage Batteries," in [w]hich the author presented a compari[so]n of a modern high-duty "Exide" cell [an]d the standard Manchester cell, such as the Edison stations have used for several years, and pointed out improvements which have been made in recent years in end-cell switches and automatic boosters. The comparison of battery cells may be tabulated as follows:

FIG. 1. 175 [illegible] GAS PRODUCER [illegible]

	Manchester.	Exide.
Number of plates	[illegible]	[illegible]
Weight of cell, pounds	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

The two cells are of the same size, but the Exide plates are the thinner, permitting the use of 11 plates in a tank which holds only 49 Manchester plates. As an example of the latest development in the application of a storage battery to smooth out a power-plant load curve, the author cited the installation in the huge steel plant at Gary, Ind., where two series of 125 cells each are connected in parallel.

The complete battery is capable of discharging [illegible] amperes, [illegible] [illegible]. The battery is used to smooth out the fluctuations in both the [illegible] and direct-current loads, the former being [illegible] to the battery by [illegible] rotary converters.

Recent Developments in Electric Apparatus

A paper with the above title, read by E. W. Allen, was rather disappointing. The author contented himself by outlining the general features of a 14,000-kilowatt Curtis turbine-generator unit of 6600 volts and 60 cycles, a small belt-driven direct-current dynamo, a 1000-kilowatt split-pole rotary converter, a 2000-kilowatt frequency-changer, and a 3000-kilowatt transformer. All of the information presented in the paper, and much more, can be found in the literature of the various manufacturers.

Gas Engines and Producers

The report of the Committee on Gas Engines was the first paper presented in the Technical division of the convention. In the absence of J. B. Klumpp, the chairman of the committee, the report was presented in abstract by Irving E. Moultrop, of the committee. The report consisted chiefly of elementals with which all interested readers of Power have had ample opportunity to become familiar. "Producers using anthracite coal have been in use continuously for 10 or more years, giving absolute satisfaction." Several types (of bituminous producers) have been on the market in recent years and have been operating with more or less success. Some gasify the entire product of the coal [including ash?] while other types necessitate the use of auxiliary tar-extracting plant to obtain gas suitable for engines. "The quality of producer gas varies with the grades of fuel and the method of operating the producer, but the fixed carbon of all fuels is the basis of producer action and the yield of gas."

By far the greater part of the report consisted of rudimentary statements such as the foregoing and elementary descriptions of the principal types of apparatus and methods. This statement is made not in a carping spirit but as an explanation of the relatively small amount of space which we devote to the report. The elementary information referred to is of value to those who are entirely unfamiliar with the subject, as most central station managers probably are.

The committee described briefly the general features of the gas-power plants of the American Locomotive Company, Richmond, Va.; American Steel and Wire Company, at Worcester, Mass.; Boston Elevated Railway Company, Boston, Mass. (two stations); Charlotte Consolidated Construction Company, Charlotte, N. C.; Georgia Railway and Electric Company, Atlanta, Ga.; Merrimac Chemical Company, North Woburn, Mass.; Milwaukee Northern Railway Company, Port Washington, Wis.; The Norton Company, Worcester, Mass.; Swift & Co., New York City; The Phoenix Tube Works, Brooklyn, N. Y., and the Watson-Stillman Company, Aldene, N. J. The printed report also contained illustrations of a number of representative gas-power plants, most of which have been fully described in this journal, and illustrated descriptions of the Loomis-Pettibone, R. D. Wood, Westinghouse and Pintsch producers. Of these, the new double-zone bituminous producer of the Westinghouse Machine Company is the only one that has not been described at length by the engineering periodicals. Fig. 1 is an exterior view of this producer, Fig. 2 a sectional elevation and Fig. 3 a chart of average test results. From Fig. 2 it will be evident that the cleaning equipment is considerably smaller than that commonly required with other types of producer. The gas, which is taken off at the middle of the generator, passes to a small wet scrubber and thence to a horizontal holder from which it is drawn by the rotary exhauster. The vaporizer surrounds the central portion of the fuel bed, where the two zones merge; consequently it abstracts heat from the gases delivered by both zones. The upper zone is practically a simple down-draft bituminous producer in which most of the green fuel is coked; the lower zone is an up-draft coke producer, supplied with coke from the upper zone. The supply of air and steam to each combustion zone is adjustable independently, of course, so that the proper balance between the two zones may be preserved.

In the discussion following the presentation of the report, M. R. Bump called attention to the producer plant of the Western Chemical Company at Denver,

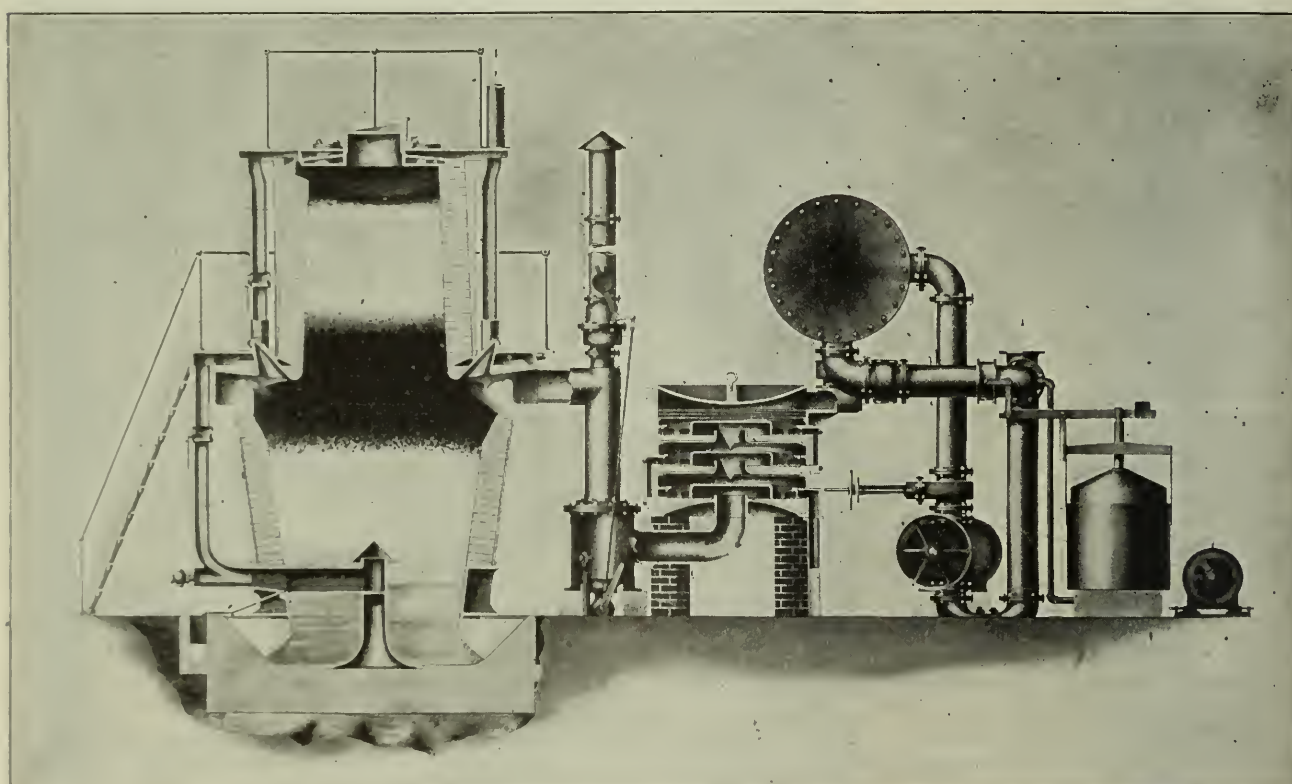


FIG. 2. SECTIONAL VIEW OF 175-HORSEPOWER WESTINGHOUSE BITUMINOUS GAS PRODUCER RECENTLY TESTED AT EAST PITTSBURG

where lignite is gasified, the gas used in engines and the carbon dioxide in the exhaust gases is utilized for charging soda-water fountains.

George R. Stetson gave some results of a year's experience with a pressure producer and engine equipment operated in conjunction with a steam plant at New Bedford, Mass. He said that his experience indicated that the producer is the principal source of whatever troubles occur in a gas-power plant. The steam engines take very readily to the handling of gas engines but boiler firemen do not so readily learn to handle producers intelligently. He also found it difficult to keep producer men because of the unavoidable escape of carbon monoxide gas, his being a pressure plant.

water-proofed. Exploring tubes connected through flexible rubber hose to a 24-inch U-tube of glass were inserted throughout the different parts of the condenser and air pump, in order to make a thorough survey of the interior of the condenser under operating conditions. With a vacuum of 28½ inches and the injection water at 50 degrees Fahrenheit, the amount of air drawn up through the discharge column and from the upper spray plate of the condenser was enormous. The drop of vacuum between the turbine base and the air pump was easily located, but later, by slight modifications in design, was considerably reduced. All indications seemed to show that the more readily the air was permitted to reach the air-suction connection the less was the drop in

ably cheaper to clean one 6000-kilowatt condenser than to clean eight boilers representing the same amount of station output.

In reply to a question by Mr. Chesney, the author stated that in Denver it occurred many times when the air was very dry that the water when leaving the water tower would go below the temperature of the atmosphere, due to the low humidity of the air. Some records, he said, showed that the water leaving the water tower was 6 degrees to 10 degrees below the temperature of the atmosphere. As to the difficulty of keeping the water free from air, he said that by constructing a sunken sink beneath the cooling tower, he had been able to secure water as free from air as the average water supplied

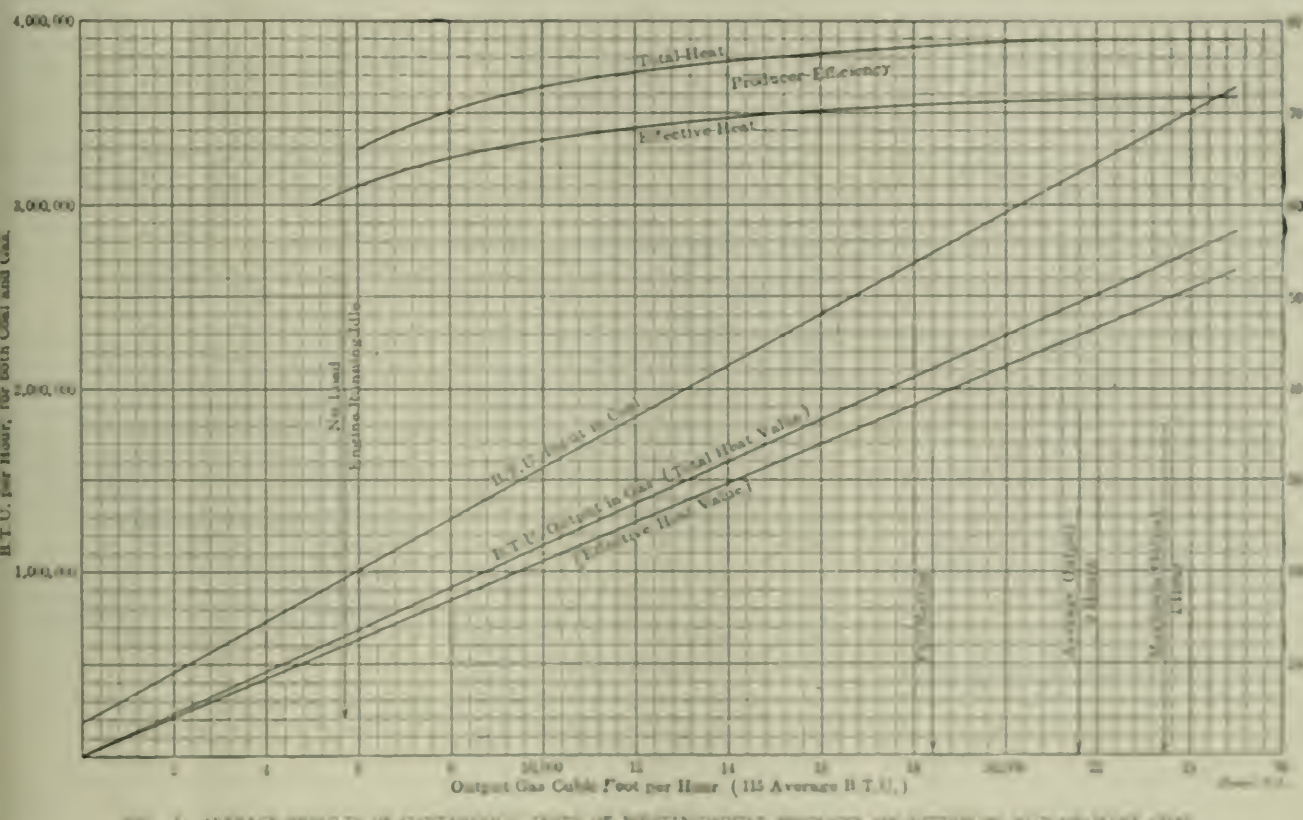


FIG. 3. AVERAGE RESULTS OF CONTINUOUS TESTS OF WESTINGHOUSE PRODUCER ON PITTSBURG RUN-OF-MINE COAL

Condensers and Cooling Towers

The next paper was one by M. R. Bump, devoted to the design and operation of condensers and cooling towers. The section of the paper relating to condensers was printed in the June 15 number of Power; that referring to cooling towers will be found elsewhere in this issue.

Discussing Mr. Bump's paper, A. R. Chesney described some interesting experience made with barometric column condensers used with 3000-kilowatt Curtis turbines. Six-inch bull's-eyes of heavy glass were installed at frequent intervals along the length of the discharge column of the condenser and the condensing chamber and the whole interior lighted by means of incandescent lamps, properly

vacuum. While this trouble with air does not exist in the case of a surface condenser, the many advantages in the barometric column type, such as freedom from repairs, low first cost, and readiness for duty at all times, make it well worthy of careful consideration. With this type of condenser a vacuum of 28 inches or over can be reached with an injection temperature in the summer of 85 degrees Fahrenheit, while in the winter months the vacuum is considerably higher. The quality of the feed water must also be carefully considered in choosing the type of condenser, as with very poor water the surface condenser, with a certain amount of make-up water added from the city mains, will keep the boilers in first-class operating condition. It is consider-

from any stream that is used for condensing purposes.

Reactance Coils in Generating Systems

P. Junkersfeld, of the Chicago Edison Company, presented a brief but meaty paper pointing out the advisability of using reactance coils in the main leads of large alternating-current generators and between different sections of the busbars in order to prevent damage to the machines when a short-circuit occurs on the external circuit. Where large powers and high voltages are dealt with, the automatic circuit-breakers used with machines and circuits of lower voltage or smaller power are not effective. This is particularly true with respect to bushing-delivery generators, because of their high speed and relatively low frequency. With such generators the instantaneous current produced by a short-circuit may be as high as 50 times the normal full load current. An automatic circuit-breaker, even if it could open the circuit absolutely, could not operate quickly enough to protect the generator from the enormous momentary shock inflicted by such an increase in current; hence the advisability of using reactance coils in the circuits. Ordinarily, these do not cause a serious drop in volatge, but a practically instantaneous

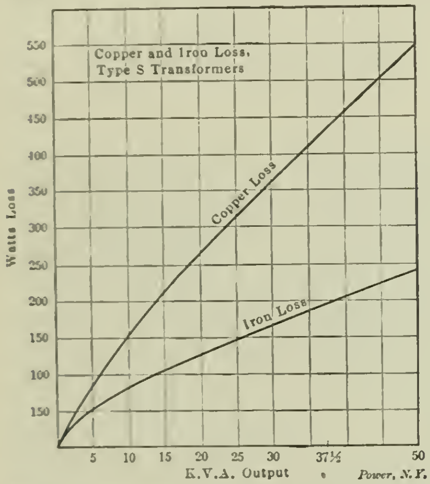


FIG. 4. IRON AND COPPER LOSSES OF TRANSFORMERS OF RECENT DESIGN

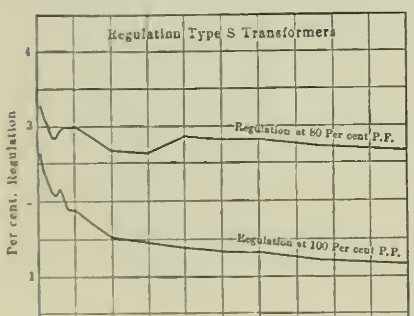


FIG. 5. SHOWING REGULATION OF TRANSFORMERS OF RECENT DESIGN

rise of current, due to a short-circuit which would ordinarily increase the current fifty-fold, will greatly increase the reactance of the coil and thereby choke itself down to a much less destructive overload.

In the discussion of Mr. Junkersfeld's paper, A. S. Loizeaux presented a contribution on the design of reactance coils for the protection of turbine-driven generators. Dr Charles P Steinmetz pointed out that reactance coils inserted in the neutral connections of three-phase generators will protect the machines only from internal short-circuits; in order to protect them from short-circuits on the lines, the reactance coils must be inserted in the main leads of the generators.

He commended Mr. Junkersfeld's suggestion to use coils between sections of the station busbars but said it was unnecessary to have them normally cut out by switches arranged to open automatically at overloads.

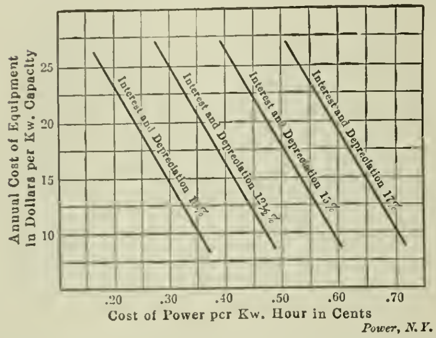


FIG. 6. SHOWING RELATIVE VALUE TO CENTRAL STATION OF TRANSFORMERS OF DIFFERENT EFFICIENCIES FOR VARIOUS VALUES OF COST OF POWER, INTEREST AND DEPRECIATION

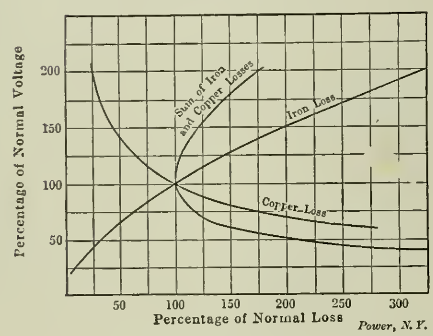


FIG. 7. SHOWING CHANGE OF LOSSES WITH IMPRESSED VOLTAGE

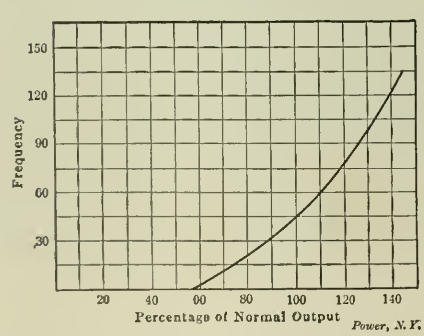


FIG. 8. SHOWING CHANGE OF OUTPUT WITH FREQUENCY

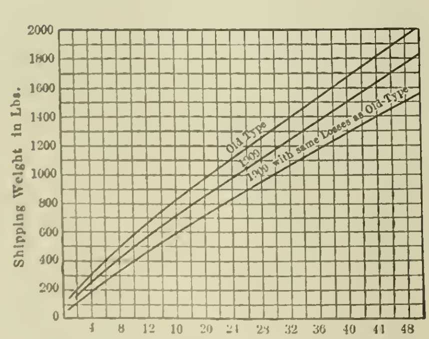


FIG. 9. COMPARISON OF WEIGHTS OF TRANSFORMERS

Improvements in Transformers

The history of transformer development was briefly traced in a very comprehensive paper by E. G. Reed, and the latest forms of construction were described in detail. The author presented several charts showing the characteristics of modern transformers, among which were Figs. 4, 5, 6, 7 and 8; these, with their captions, are self-explanatory. The improvements due to the use of silicon steel in transformer cores were referred to briefly, and the author pointed out that while the use of this alloyed steel gave

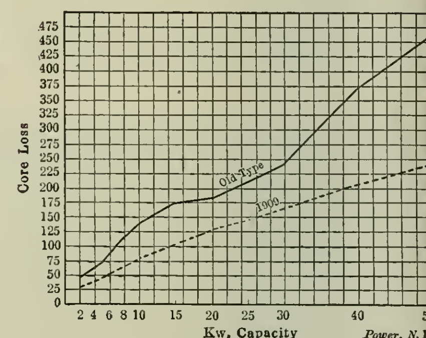


FIG. 10. COMPARISON OF CORE LOSSES IN TRANSFORMERS

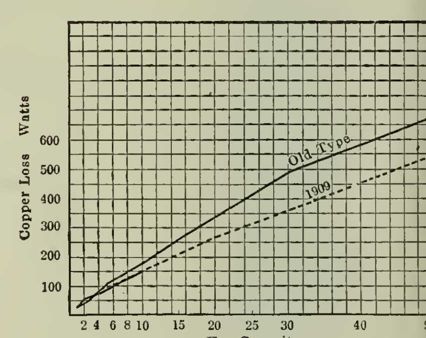


FIG. 11. COMPARISON OF COPPER LOSSES IN TRANSFORMERS

lower core losses for given conditions and therefore permitted the use of smaller cores for given outputs at given efficiencies, the cost of the transformer was not reduced because the new silicon steel is more expensive than the steels formerly used.

This latter point was also brought out in a paper by W. A. Layman entitled "The Practical Aspects of Recent Improvements in Transformers." Mr. Layman's paper was rather more analytical than Mr. Reed's, and brought out more clearly the improvement in transformers which has been effected within the past five years or so. Figs. 9, 10 and 11 present graphically the chief comparisons of the old and new types, the improvements being due entirely to the use of steel containing a high percentage of silicon—about forty times as much as the old steel. Mr. Layman also presented the following comparison of all-day efficiencies:

Size of Transformer		1 Kw.	10 Kw.	50 Kw.
All-day losses in kilowatt-hours	1906	903	4,187	14,415
	1909	610	2,646	8,760
Saving in kw.-hrs. per day		293	1,541	5,655

The foregoing comparison was based on 24 hours of core loss and 5 hours of copper loss per day.

In order to facilitate the parallel operation of transformers, Mr. Layman suggested, manufacturers might advantageously include in their published tables of data the impedance of each size and type of transformer regularly built. With these data before him the user could predetermine accurately the division of load that he would obtain by paralleling transformers of different sizes or makes. The author also suggested that buyers of transformers should require the seller to specify the magnetizing current (primary current when the secondary circuit is open) and the impedance of each transformer. [The former is the determining factor in all-day efficiency, under given load conditions, and the significance of the latter was just explained.]

In discussing Mr. Layman's paper, W. S. Moody said that the effect of silicon upon the permeability [magnetic quality] of the steel varies; at low magnetic densities the magnetic quality is improved and contrariwise at high densities (100,000 lines per square inch and over).

Low Pressure Steam Turbines

In a paper of the above title, C. H. Smoot presented an interesting analysis of the physical features of the various steam turbines as well as a discussion of their application to the use of low-pressure steam from high-pressure engines. This paper is printed practically in full on another page of this number.

The discussion of the paper was disappointingly meagre and spiritless.

Some Unique Power-house Features

In a paper of the above title, G. L. Knight described some forty unusual features found in various prominent central stations. Among these were the following:

The Boston Edison Company has increased its furnace economy considerably by lengthening the arches over its Roney stokers by about 3 feet 10 inches. The arch brick now becomes practically incandescent. The company has also added small individual accumulators to control the oil pressure at the turbine step bearings. The large accumulators originally installed maintain the pressure on the oil pipe main and each of the small accumulators controls the steam supply to the step-bearing pump of its particular turbine unit.

The New York and Brooklyn Edison Companies have increased the output of their boilers very much by the use of large grates. The boilers are hand-fired with anthracite coal, and the grates are 12 feet deep by 12 feet 7 inches wide, sloping toward the bridge wall with 16 inches difference in elevation between the front and back of the grate. The fire door is set at an elevation of 2 feet 10 inches above the firing aisle. Over the furnace are built three reverberatory arches with steel, I-beam skew-backs built into the steel columns of the boiler setting, these arches being placed at sufficient distances apart to afford ample area for the passage of the gases. The arches become practically incandescent and have greatly improved the furnace economy. The side walls of the boiler are arched between front and bridge wall, so that in case of repairs the brickwork below the arch may be removed without disturbing the rest of the setting.

In the power house of the Hudson and Manhattan Railroad Company, at Jersey City, two 5000-kilowatt Curtis turbines are equipped with three condensers, one on the outside of each turbine and one between the turbines. The exhaust from each turbine to the condenser on each side of it is led through three circular cast iron pipes, each equipped with a gate valve. The three gate valves are connected by gearing to a small engine for closing or opening the gates quickly and simultaneously. Each condenser is equipped with the usual auxiliaries, and the arrangement permits taking out a condenser for tube or other repairs without shutting down a turbine.

A pneumatic system for handling ashes in the power plant of Swift & Co. at Chicago comprises a closed chute into which the ash hoppers discharge and which leads to a general tank or hopper at such a hight as to allow the ashes to be discharged from its bottom into the usual ash pocket. The tank or hopper is kept under vacuum by an exhauster connected to the top of the hopper. Two gates are placed across the mouth of the tank at the bottom, the gates being operated alternately so that when the top gate is opened a quantity of ashes fills the space between the gates; the top gate is then closed and the lower one opened, the ashes falling to the pocket without breaking the vacuum in the tank. When the gates of the individual ash hoppers are opened the rush of air to the tank carries with it the ashes and water discharged from the ash hoppers, which are carried to the tank at great speed.

A dry-tube condenser of 18,000 square feet of surface is said to give the same results at the No. 2 Waterside station of the New York Edison Company that are obtained from condensers of the ordinary types having 25,000 to 30,000 square feet. The dry-tube condenser is similar to the usual type of surface condenser excepting that the shell is rectangular in cross-section and deflecting plates are provided for the purpose of carrying the exhaust condensate to the sides of the condenser instead of letting it drip over the tubes. The incoming exhaust steam therefore comes directly in contact with the cool tubes instead of meeting a film of water over each tube. The advantages claimed for this condenser are lower first cost, fewer tubes, better vacuum and hotter water of condensation.

Motor-generators versus Rotary Converters

This perennial topic was the text of a paper by F. M. Farmer, of the Electrical Testing Laboratories. Mr. Farmer presented a general exposition of the operating principles of converters and motor generators with the various standard methods of regulation and presented the results of some efficiency tests made on representative machines in regular operation. The results were most favorable to the ordinary rotary converter with synchronous booster regulation; the induction regulator converter came next in the scale of efficiency, the split-pole rotary converter third, the induction motor-generator fourth and the synchronous motor-generator last.

It would have been very interesting in connection with the efficiency tests to determine the distribution of the losses among the various parts of each equipment. The available time was too short to admit of this being done, but estimates from manufacturers' specifications give the following:

In converter equipments the loss in step-down transformers is about 15 per cent. of the total losses, induction regulator or synchronous booster, about 40 to 50 per cent., converter, about 30 to 40 per cent., low-tension cable, about 5 per cent. In motor generators the losses are probably about equally divided between motor and generator.

The following operating notes were obtained from the engineers in charge of the particular machines on which the tests were made, and from the operators. They are therefore opinions based on experience.

The synchronous converters on the Brooklyn Edison system are all started from the direct-current side, and, since storage battery current is always available in the substation, no other starting provision is made. The Boston Edison Company follows the practice of starting its motor-generators from the direct-current side, although provision is made for starting both the induction and synchronous machines from the alternating-current side.

The time required to start and get into service was reported the same for all equipments, except one, as three to five minutes. The exception is the split-pole converter, which requires one to two minutes more because every change made in the field, to adjust the alternating e.m.f. while synchronizing, affects the speed also. In case of emergency, other things being equal, preference would be given to the induction motor-generator over the synchronous motor generator and the synchronous booster converter over the other two types of converter. It may be noted that, of the various starting synchronous apparatus, the direct-current method is used by both of these companies, as it means the least disturbance to line. Where direct current is not available, an alternating-current starting motor on the shaft (extended) would probably give the best results.

In motor-generators the voltage and power factor are quite independent, but in synchronous converters a change in voltage at a given load produces more or less change in the power factor, hence more or less manipulation is required every time the voltage is changed. One of the author's charts shows the extent of this change in power factor with change in voltage, load and main field current remaining constant. The induction regulator converter and the synchronous booster converter lowered the power factor markedly at light loads with increase in voltage, but at 75 per cent. load and over the change was not appreciable. Of the three types of converter the power factor of the split-pole is least affected at any load. This is probably due to the fact that in this machine there are compensating windings on the main magnet poles in series with the auxiliary pole so connected that the main pole flux is decreased or increased when the auxiliary pole is increased or decreased respectively, causing the total flux to be automatically kept practically constant.

Converters with induction regulators and synchronous boosters have a practically constant power factor at all loads with constant direct voltage. The split-pole converter shows a slight falling off in power factor with increase in load.

The author's conclusion was that the answer to the problem "motor generators versus synchronous converters" for lighting and power work depends to a great extent on the circumstances in each individual case. In general, the data given in the paper indicate that the use of motor generators would not be justified except possibly on 60 cycles or where the alternating-current supply fluctuates badly. The principal advantage of the motor-generator is its flexibility and the entire independence of the direct-current system from the alternating system. If the high-tension alternating-current supply is reasonably free from fluctuations, these features are of small value and are more than counterbalanced by lower efficiency and increased first cost. Comparisons of the various types of synchronous converter are at the present time in favor of the synchronous booster converter, but the split-pole machine is so recent a development that improvements in design, which will undoubtedly be made, may improve the efficiency curve and the operation of the machine to such an extent that this conclusion may be modified or even reversed.

In the brief discussion of Mr. Farmer's paper, W. L. Waters manifested considerable satisfaction at the relatively unfavorable showing made by the split-pole converter. He didn't say he was glad of it, but he might as well have done so.

Grounding Secondary Circuits

The committee on the Grounding of Secondaries in its report expressed the unanimous opinion based on three years' continuous study of the subject and extensive correspondence and conferences with prominent engineers all over the country, that secondary circuits up to 150 volts should be grounded and the grounding of circuits of more than 150 volts prohibited. There have been very few, if any, fatalities from 150 volts but many cases at 200 volts and thereabout.

The only feasible method of protecting persons from circuits of 200 volts and over seems to be to install the apparatus in such a manner as to make it difficult for the user to stand on the earth or to be otherwise connected with the ground while touching lamps or motors. This would mean installing lights so that they would be out of easy reach, controlling them with wall switches, and keeping them away from gas and water pipes, telephones, etc. It would also require motor equipments so placed that the attendant must stand on dry boards or rubber mats, and not be within reach of metal framework of buildings, metal floors, grounded pipe rails, etc. The best ground, all admit, is a connection with an underground metallic water-pipe system. In many cities this exists, but its use is not always permitted. In nine cities with which we are familiar its use is prohibited. The committee suggested that the members of the association do a little missionary work in convincing water-works engineers and managers that when secondary alternating-current wires are connected to water pipes no current flows unless a transformer breaks down or a cross occurs; that should such an accident occur it would in nearly all cases cause a fuse to blow and immediately cut off the current; and that, in the event of a current flowing, it would be an alternating current, which, it is generally believed, produces no electrolysis. Where underground mains are not available other methods must be resorted to. The old method of a copper plate buried in coke, prescribed by the Underwriters, is not always reliable and in some cases has been found to be worse than useless. Iron pipes an inch or more in diameter, driven eight or ten feet into the ground, have in some cases been found to be very satisfactory, while in other cases valueless.

A recent suggestion has been made to saturate the ground around the pipe, at frequent intervals of time, with salt water. Tests thus far made show that this is an excellent method and that after a few applications of the salt water the ground becomes permanently moist and a good conductor. The committee suggested the placing around the pipes, and rather near the surface, of a quantity of rock salt, which will, because of its hygroscopic nature, draw the water and thus produce a ground of low resistance and one that would also remain permanent; the committee preferred, however, to have tests made of this in various parts of the country before giving it full indorsement. The report cautions users of this method to take great care in making the connection between wire and pipe, as the presence of salt will tend to increase corrosion. The pipe itself will doubtless corrode, but a plain iron pipe will last perhaps ten years, while one of galvanized iron will be good for several years longer. Brass pipe would last almost indefinitely and would not add materially to the total cost.

Dr. Steinmetz, P. Junkersfeld, Philip Torchis and other well-known central-station men agreed that all circuits up to 150 volts should be grounded, but objected to the prohibition of grounding circuits of higher voltages. On motion of Dudley Farrand this recommendation in the report was referred back to the committee for further consideration and report.

New Officers

The election of officers for the ensuing year resulted as follows: President, Frank W. Frueauff; first vice-president, W. W. Freeman; second vice-president, John F. Gilchrist; secretary, Frank M. Tait; executive committee, Frank W. Frueauff, W. W. Freeman, Dudley Farrand, A. J. Decamp, George H. Harris, R. M. Searle, Alexander Dow, Charles L. Edgar, Arthur Williams, C. A. Stone.

Studying High Voltages

With the purpose of studying enormously high voltages a short experimental transmission line has been built in Sweden which is adapted to operate at 500,000 volts. A special form of transformer is used to furnish this high electromotive force. Circulating oil is used for insulation between the high- and low-tension windings. The line is supported on the suspended type of insulators 11 feet apart. Tests of the surface discharge showed that a wire of 10 square millimeters (0.0155 square inch) cross-section would discharge at 35,000 volts, of 20 square millimeters at 50,000 volts, of 100 square millimeters at 200,000 volts, and of 250 square millimeters at 390,000 volts. As the tension was raised to 480,000 volts, the noise grew very loud and sparks leaped from the insulators. At night the glow of the discharge could be seen 2½ miles away.—*The Engineer* (London).

ormulas for Computing the Results of Gas Analysis

By Frank B. Shields

For calculating the pounds of air per pound of coal, having analyzed the chimney gas and knowing the percentage of carbon in the coal:

Pounds of air per pound of coal

$$= \frac{\text{wt. O in chimney gas} - \%\ \text{O in air (by wt.)}}{\text{wt. C in gas} - \%\ \text{C in coal}}$$

$$= \left(\frac{\%\ C\ \text{in coal}}{0.231}\right)$$

$$\frac{\text{wt. O in 100 liters of gas} \times \text{wt. per L.}}{\left[\begin{array}{l}(\text{vol. } CO_2 \text{ in 100 L. gas} \times \text{wt. per L.} \times \frac{12}{44}) + \\ (\text{vol. CO in 100 L. gas} \times \text{wt. per L.} \times \frac{12}{28})\end{array}\right]}$$

$$= \left(\frac{\%\ C\ \text{in coal}}{0.231}\right)$$

$$\frac{(\%\ CO_2 + \%\ O + \tfrac{1}{2}\ \%\ CO)\ 1.429}{\%\ CO_2 \times 1.965 \times \frac{12}{44}) + (\%\ CO \times 1.251 \times \frac{12}{28})}$$

$$= 0.1153\ (\%\ C\ \text{in coal})$$

$$\left(\frac{\%\ CO_2 + \%\ O + \tfrac{1}{2}\ \%\ CO}{\%\ CO_2 + \%\ CO}\right). \qquad (1)$$

This formula (1) gives exactly the same value that would be obtained by going through the longer calculation in which each of the components—carbon dioxide, carbon monoxide, oxygen and nitrogen—is considered separately. It may be further simplified if one takes into consideration the fact that, in nearly all cases, the quantity (% CO_2 + % O + ½ % CO) is equal to twenty. We should expect this to be almost constant, for it represents the oxygen of the air after it has passed through the furnace and combined with some carbon, and since the oxygen content of the air does not change appreciably, the only variations in the foregoing quantity must be due to a loss of oxygen by its combination with the hydrogen and sulphur contained in the coal. Neither of these losses would be taken into account in the course of an ordinary analysis with the Orsat apparatus. The results of a very large number of determinations show that if the quantity (% CO_2 + % O + ½ % CO) is taken equal to twenty, scarcely ever is an error as large as 2 per cent. incurred. Making this substitution in formula (1) gives the simpler formula:

Pounds of air per pound of coal =

$$2.31 \times \frac{\%\ C\ \text{in coal}}{\%\ CO_2 + \%\ CO} \qquad (2)$$

In most series of analyses, the percentage of carbon in the coal will be a constant; and if there is substituted this value of the per cent. of carbon as found by chemical analysis—suppose, for example, we use 83 per cent., which is fairly representative—we have the approximate formula:

Pounds of air per pound of coal =

$$\frac{191}{\%\ CO_2 + \%\ CO} \qquad (3)$$

For calculating the percentage of heat lost in the chimney gas, being given an analysis of the gas, its rise in temperature, the percentage of carbon in the coal and its heat value:

$$\textit{Per cent. of heat lost} = \frac{\text{heat lost in gases}}{\text{heat value of coal}} =$$

$$\frac{\text{heat in gases from 1 kilogram of C} \times \%\ C\ \text{in coal}}{\text{heat value of 1 kilogram of coal}} \qquad (4)$$

The heat in the gases from 1 kilogram of carbon is equal to the sum of the volumes of each gas multiplied by the weight per liter, by the specific heat, and by the rise in temperature. The volume of each gas is obtained by first finding how much carbon dioxide and carbon monoxide are necessary to contain one kilogram of carbon and then from the relative proportion, as found in the gas analysis, the corresponding volume of the other gases can be calculated. Matters are very much simplified (with but slight sacrifice of accuracy) by considering the gas as a mixture of two components—the carbon dioxide and the remaining gases. From the following table it is evident that the constant, *specific heat × weight per liter*, is about the same for all of the gases to be considered, except the carbon dioxide:

Gas	Specific Heat Multiplied by Weight per Liter
CO_2	0.463
CO	0.308
O	0.311
N	0.307

If 0.307 is taken as the value for all the other gases, an error of less than one-half of 1 per cent. will be incurred. With this explanation, let us take up the calculation. All values are based on atmospheric pressure and 0° Centigrade.

1 kilogram of carbon

$$= \frac{44}{12}\ \text{kilograms of } CO_2$$

$$= \frac{44\ 000}{12 \times 1.965}\ \text{liters of } CO_2$$

$$= 1866\ \text{liters};$$

and since any carbon monoxide would represent the same amount of carbon as an equal volume of carbon dioxide, then

$$1866\ \text{liters} = \text{vol. } (CO_2 + CO)\ \text{from 1 kilogram of C}$$

Let

x = % CO_2 in chimney gas (by analysis);

y = % CO in chimney gas (by analysis).

Then

$$\left(\frac{x}{x+y}\right) 1866 = \text{liters } CO_2 \text{ in gas from 1 kilogram of C}$$

and

$$\left(\frac{100-x}{x+y}\right) 1866 = \text{liters of all other gases}$$

Heat lost in gases =

$$[0.463\ (\text{vol. } CO_2) + 0.307\ (\text{vol. other gases})]\ R.\ \text{in}\ T \qquad (5)$$

Substituting equation (5) in (4):

$$\textit{Per cent. heat lost} = \frac{(\%\ C\ \text{in coal})\ R.\ \text{in}\ T}{\text{heat value of coal}}$$

$$\left[\frac{x}{x+y}\ (1866)\ 0.463 + \frac{100-x}{x+y}\ (1866)\ 0.307\right]$$

$$= 0.2864\left(\frac{\%\ C\ \text{in coal}}{\text{heat value}}\right) R.\ \text{in}\ T$$

$$\left(\frac{200 + \%\ CO_2}{\%\ CO_2 + \%\ CO}\right) \qquad (6)$$

This equation (6) gives values which are about 0.5 per cent. low, for it does not take into account the loss of heat due to the formation of water vapor from the hydrogen in the coal. And so the results found by the foregoing equation should be increased by this amount.

When the same kind of coal is being used right along, the values for the per cent. carbon and heat value of the coal will disappear into the constant, giving the expression:

Per cent. heat lost =

$$\textit{constant}\left(\frac{200 + \%\ CO_2}{\%\ CO_2 + \%\ CO}\right) R.\ \text{in}\ T \qquad (7)$$

For average coals of the four classes mentioned in the following table, the corresponding constant may be used in formula (7) with very close results:

Kind of Coal	% C	Heat Value	Constant for Form. (7)
Lignite	51	5500 cal	[illegible]
Bituminous	[illegible]	7500 cal	[illegible]
Semi-bituminous	[illegible]	8400 cal	[illegible]
Anthracite	83	7700 cal	[illegible]

One calory equals 3.97 B.t.u.

A direct-current shunt dynamo will only self-excite and develop pressure for one direction of rotation corresponding to the remanent magnetism. A German electrical engineering firm makes use of this fact to provide a means for obtaining a unidirectional current irrespective of the direction of rotation. Two shunt machines are coupled in any suitable manner and connected in series. The shunt coils are wound in opposite directions, so that for either sense of the rotation only one machine develops pressure. It is advisable to supplement the remanent magnetism by an auxiliary winding separately excited. The two machines may also be combined in a single machine.

It is stated that in the oil fields of Baku, Russia, engineers are studying the use of natural gas for firing instead of using crude oil as before. A simple centrifugal apparatus consisting of a centrifugal fan working through pipes leading to the wells, thus creating vacuum, is more generally employed. In this way the natural gas issuing from a well is collected and stored, to be used either under boilers or in gas engines.

POWER AND THE ENGINEER

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June 8 36,000
June 15 36,000
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Contents

Removes all the Carbon

Henry Duncan, of Spring Valley, Ohio, has got it now. According to the Dayton *Daily News* this gentlemen has invented "a chemical preparation which, poured upon the coal, removes every particle of carbon; hence, smokeless combustion." We wonder that the suggestion has not occurred to somebody before. The cobbler of Altoona has shown (?) that ashes will burn as well as coal, if you sprinkle salt and oxalic acid upon them, and won't smoke; ergo, add something to the compound to kill out the carbon, sprinkle it upon the coal and when the carbon is gone, burn the ashes.

The Twelve Hour Shift

The engineer of an electric-light plant was found asleep one night while on duty. That by itself may not have amounted to much but the cause of his going to sleep is significant. Five 300-horsepower cross-compound engines and a twelve-hour shift with an engineer and an oiler on watch—these were the conditions, which are doubtless duplicated in many instances.

It is no wonder that the engineer was asleep. A twelve-hour shift is enough to render any man physically unfit to perform his duties with justice to himself or his employer. This is a fact, however, which many power-plant owners and managers fail to appreciate, assuming, apparently, that a man is as "fit" after working twelve hours as when he first went to work. Such long hours are injurious to the engineer's health and dangerous to those around him because of the liability of accident resulting from error in judgment on the part of a man with a tired brain.

The power-plant owner who will deliberately sacrifice the health and mental development of his engineering force can adopt no more systematic method of reducing the efficiency of his men than by employing the twelve-hour shift. Few men, after working twelve hours in a hot, stifling engine room, care to do other than plod home like an overworked truck horse when released, eat supper and go to bed, knowing that the same conditions will be encountered on the morrow. Can any plant owner or manager imagine a man going home in such a condition and spending much time in mental development, reading up on engineering matters, or figuring on problems pertaining to his plant? Furthermore it is not reasonable to expect that an engineer will subject his energies to any extra taxation in order to keep his plant in the best condition when his regular working hours cover almost the entire period out of bed.

In the fireroom, a fireman who knows he will have to shovel coal for twelve hours, besides attending to other duties such as blowing tubes, cleaning fires, oiling the feed pumps and keeping the boiler room clean, is not going to exert himself in seeing how little coal he can burn. His greatest aim will be to get through the day's work as easily as possible, without a care as to the money he throws away because of inattention to his legitimate duties. Can he be greatly blamed?

The net result of this sort of policy is that the economy of the plant falls far below what it should be and the owner pays the bill, meanwhile laboring under the silly delusion that he is saving the expense of the third set of men which would be required to operate the plant on eight-hour shifts.

Heat Loss of a Steam Engine Cylinder

As Watt has been credited with inventing everything connected with the steam engine, and saying about all the epigrammatic things that have been said about the steam engine and its management, it is possible that he said: "Keep the cylinder as hot as the steam which enters it," and it is also possible that he invented the steam jacket in order to carry out this injunction. But, as the steam jacket only transfers condensation from the inside to the outside of the cylinder, its use, in a great many cases, is at least of doubtful economy.

If a perfect nonconducting cylinder covering could be found, most of the losses from radiation could be prevented, and whether used on the outside of a steam jacket or in place of it it would, if not too expensive, be rapidly adopted. "Dead air" has long been regarded as a most efficient insulating substance, but no air at all is generally thought, whether rightly or otherwise, to be the best insulation. Whether the Thermos bottle jacket is lined with dead air or with more or less of a vacuum, the question arises: Why would not the insulation used on the Thermos bottle be just as efficient if applied to the steam-engine cylinder?

From data obtained in a rather crude sort of way, the operating engineer in a large pumping station estimated that a gain of four per cent. in the amount of water delivered per pound of coal burned was realized by substituting a vacuum jacket for a steam jacket on one of the engines. In this case the jacket was connected directly to the condenser of the engine and the cost of maintaining the vacuum was slight.

With a higher vacuum and special means of guarding against slight leaks of air into the system the gain might be greater. Who knows? Engineers would like to know. Designers should know. Who will find out and tell?

Priming and Foaming

Everybody has seen the pot boil over. That is what happens when a boiler foams or primes. The term "to prime" is usually applied to the mechanical entrainment of moisture in greater or less quantities, while "foaming" implies the formation of suds.

The lifting and carrying over of water are favored by rapid ebullition, by tortuous and constricted passages for the steam to follow before being liberated, by the liberation of a large quantity of steam from a small amount of water surface and by a tendency to form small bubbles or suds, which is produced by the presence of soapy substances or by the concentration of salts in the water.

In the old days, when boilermakers used to strive to get as many square feet of heating surface as possible into a given shell, it was found that the tendency to raise the water was much reduced by leaving out the central vertical row of tubes, a practice which is now quite generally followed. Steadiness in steaming will be favored by a large and free disengaging surface for the steam, and the avoidance of constricted passages for the steam to pass through beneath the water line. Of course, the more steam bubbles there are beneath the water line the higher will the water line be, with a given amount of water in the boiler, and the more rapid the rate of steaming the more violent the ebullition, and the greater the volume in which the steam escapes into the steam space the greater the tendency to carry the water along with it.

The likelihood that priming will result from the use of any given feed water should be taken into consideration in the design of the plant. The boilers selected should be of such type and capacity that there will not be a great inherent tendency to priming. It has been stated, for instance, that the locomotive type of boiler is three or four times more prone to priming than the ordinary horizontal return-tubular boiler. Aside from the type of boiler and the rate at which it is driven, however, there are many things in the operation of a plant that have an influence on the tendency to priming. One of these is whether the boilers are washed out regularly and kept clean. Mud, precipitate, or other matter in suspension will increase the tendency to foam. Another agency is the water level that is carried. In many boilers a change of water level results in considerable variation in disengaging surface and also in steam-storage space. The greater the disengaging surface and the greater the steam-storage space, the less likelihood there will be of particles of water being carried into the steam pipe.

Another point is the extent to which impurities are removed from the water before it enters the boiler. Mud and other impurities in suspension can be kept out by a filter, but impurities in solution must be removed by suitable chemical treatment. Carbonates, it is true, can be precipitated by an external heat treatment, but sulphates, chlorides, etc., require the addition of some suitable reagent which, in nearly all cases, whether the purifying process be of the hot or cold type, or whether a boiler compound be used, is some salt of sodium. This sodium combines with the sulphate radicles of calcium sulphate to form sodium sulphate. Sodium sulphate is very soluble and will not precipitate even though the water be boiled down to the consistency of a syrup. Any great concentration of this sodium salt in the boiler has a tendency to produce foaming, which should be prevented by frequent and regular blowing down. It has been found in many cases that where the blowing down is faithfully attended to the boilers can be driven far above their normal rating without trouble from priming.

The presence of oil in the boiler also has a tendency to produce foaming, even where some compound containing soda or other alkali is employed to prevent its baking onto the plates. Alkalies combine with the organic part of the oil to form soap. The remedy is, as before, to blow down frequently.

Mention was made in the foregoing of the fact that solid impurities in the water are conducive to foaming, and this applies not only to solids brought in with the water, but also to those precipitated from the water in the boiler, either by heat or by compounds, and even to old scale loosened from the shell or tubes of the boiler as a result of the use of scale preventatives. These particles are sometimes very fine, especially where magnesia is present in the water, and they do not settle readily while the water is in rapid motion from boiling. They have a tendency to collect on the surface, which can to some extent be removed by the use of the surface blowoff. Another factor in producing priming not mentioned is the intermittent action of the engine in withdrawing steam. Inasmuch as the carrying power of gaseous currents increases more rapidly than the increase in speed, it will be seen that if a given amount of steam is supplied intermittently there will be much more likelihood of water being carried away with it than if the same amount of steam were drawn out in a steady current. This can be remedied to a large extent by the use of receiver-separators on the steam lines. The better to effect the latter purpose, the separator should have a large volume, should be a separator-receiver and be located near the engine, while from the point of view of preventing water hammer and unsightly and annoying leaks at joints, etc., and a quick and easy return of the water, a separator with less receiver capacity should be used at the boiler. When a superheater is used the use of a separator between the boiler and the superheater will relieve the superheating surface of the work of evaporating the moisture and leave it free to do the work for which it was designed. The heat required to dry out ten per cent. of moisture from 120-pound steam would superheat it some one hundred and fifty degrees.

Initiative

In an orderly power plant, where all the proper tools and appliances are at hand and set rules are followed in the performance of daily tasks, initiative is not of vital importance. Any man ordinarily skilled in his trade or profession should find no serious difficulty in superintending or working in such a plant. There is usually little or no call for inventive ability and no adaptation of means or materials necessary, so that a lack in this quality would not be a serious handicap. An enviable record may even be made. But take the same man and put him in a plant where the initiative of another has not left it in such excellent shape and the materials and tools are not at hand to do every job in a hurry, then observe the result. His ingenuity and ability will be taxed to the limit and he will find it necessary to exercise his brain to a much greater extent than was ever necessary in the model plant.

An inventive mind making it possible to take the initiative in every instance is not a case of inheritance. It comes from broad experience in the various lines of work pertaining to power-plant operation, and is acquired in no other way. To show a man how to scatter coal or spray and properly to handle the slice bar requires previous experience in this line. Knowing how to use a hammer and chisel, to file a piece of metal flat or round, to turn off a commutator, or even handle a pick and shovel are small things in themselves, but all go to make the thoroughly competent and all-round man. A chief engineer may never have to do such work, but it is to his advantage to have practical knowledge of all these things gained by experience, so that, when occasion demands, he may take the initiative and train the unskilled hands. Without these qualifications and the ability to devise ways and adapt means, the job is apt to get muddled and sooner or later the "boss" will find himself in a sorry plight. As a minor example, if a bolt three inches long is needed for a repair or replacement, and the nearest ones on hand are two-inch and four-inch bolts, the man of initiative would promptly cut an inch off the four-inch bolt, smooth up the end and use it. The other sort of man would let the job wait a week or a month, until some three-inch bolts could be got in stock.

New York N. A. S. E. Convention

The fourteenth annual convention of the New York State Association of the National Association of Stationary Engineers was held at Syracuse, June 11 and 12, with headquarters at the St. Cloud hotel. The executive sessions of the delegation were held in the New Onondaga courthouse.

Promptly at half-past 9 o'clock on Friday morning, the convention was called to order by the chairman of the local committee, Harry Bache, and after the Rev. E. L. Waldorf offered prayer, Mayor Alan C. Forbes made a pleasing address of welcome. President J. C. Roberts responded for the engineers. Past National President Herbert E. Stone's witty and interesting speech was well received. The convention then went into executive session and the several necessary committees were appointed.

During the progress of the meetings resolutions were adopted concerning the death of the late Ira Watts, secretary of the Life and Accident Association. A special fund was voted for the use of the legislative committee to help in the efforts to secure a State license law. An invitation was extended to the State association by the secretary of the Chamber of Commerce to make Syracuse its permanent convention city, and Superintendent Fischer, of the Onondaga county courthouse, extended to the delegates the use of the courthouse for exhibition purposes at any time. Mr Fischer will be made an honorary member of Syracuse Association No. 34 at its next meeting.

The following State officers were elected, and were installed by Past National President Herbert E. Stone: Grover H. Worden, president; Charles Schabecker, vice-president; E. E. Pruyn, secretary; Winfield C. Graham, treasurer; Harry Bache, conductor; Joseph M. Gregory, doorkeeper; Stewart Warner, chaplain. Either Albany or Buffalo will be the next meeting place.

The manufacturers' exhibit was the largest ever held in connection with the State convention. The exhibit hall was in the basement of the courthouse, convenient to the convention hall, and was very tastefully decorated with the national colors. The following occupied booths: Home Rubber Company, Garlock Packing Company, Edward Joy Company, V. D. Anderson Company, Syracuse Supply Company, Jenkins Bros., Mechanical Rubber Company, Syracuse Rubber Company, Peerless Rubber Manufacturing Company, Eureka Fire Hose Manufacturing Company, Carbohydride Company, C. H. Trumble, Chapman Valve Manufacturing Company, Stewart Heater Company, Penberthy Injector Company, Winegar Boiler Compound Company, C. E. Mills Oil Company, Geo. S. Herrick, McLeod & Henry Company, Direct Separator Company, Albany Steam Trap Company, Dearborn Drug and Chemical Works, Underfeed Stoker Company, Greene, Tweed & Co., Syracuse Gas Engine Company, *Practical Engineer*, W. B. McVicker Company, Neemes Bros., Keystone Lubricating Company, *National Engineer*, Fairbanks Company, Strong, Carlisle & Hammond Company, S. H. North, Fulton Company, POWER.

On Saturday evening a banquet was served at the Hub café, at which fully 300 attended. At the close of a splendid menu, Herbert Self, of the Peerless Rubber Company; William Murray, of Jenkins Bros., and John W. Armour, of POWER, entertained. During the evening Harry Bache, the toastmaster, introduced the following speakers, who made short, snappy and interesting addresses: Rev. E. L. Waldorf, J. E. Reagan, Prof. John E. Sweet, J. C. Roberts, Giles Stillwell, H. E. Stone, T. W. Meachem, Joseph Griffin and E. E. Pruyn.

There were trolley rides to places of interest in the city, a visit to the Syracuse University and an excursion to Long Branch park.

Kentucky N. A. S. E. State Convention

With eleven delegates seated and a total of sixty members and friends present, the sixth annual convention of the Kentucky State Association convened in Liederkranz hall, Henderson, Ky., June 4. Vice-President Draper presiding. After preliminary remarks, Mr. Draper introduced Hon. S. D. Harris, mayor of the city, who paid high tribute to the National Association of Stationary Engineers. The

DELEGATES AND VISITORS AT NEW YORK N. A. S. E. CONVENTION, AT SYRACUSE, JUNE 11 AND 12, 1909

DELEGATES AND VISITORS AT KENTUCKY N. A. S. E. CONVENTION AT HENDERSON, JUNE 4 AND 5, 1909

objects of the order are well known to Mayor Harris, as this was the second time the State body had been entertained at Henderson.

Mayor O'Brien, of Owensboro, an honorary member of the association, was the next speaker. He referred to the occasion of last year's meeting at Owensboro, when Mayor Harris was in attendance. This year he was returning the compliment, and hoped that each of the cities would be further favored with the State meetings.

F. W. Raven, national secretary, then addressed the convention. He took a strong position in favor of a State license law for engineers, not only for the benefit of the organization itself, but also for humanity in general, and deplored the fact that political pull is so often able to defeat the best of measures. He also showed how the N. A. S. E. was working for education and for the public in getting only competent men in charge of power plants. J. H. Van Arsdale, national trustee, of St. Louis, was then introduced, and in a talk on the welfare of the association outlined several plans whereby individual members could help in its advancement.

Following this talk, a paper on "The Aims and Objects of the N. A. S. E." was read by State Deputy R. Baumgarten, of Ashland, Ky., who covered completely the grounds upon which the association was founded and on which its affairs are conducted. This paper was greatly appreciated and a rising vote of thanks was tendered to its author. State President August Pohl, of Louisville, then took the chair, resuming the regular order of business. Among other matters it was decided to furnish a streamer representing Kentucky, to supplement the American flag owned by the National body. After the business session, F. V. Gantt, of Cincinnati, delivered an interesting talk on steam turbines. He brought out their advantages as compared with reciprocating engines and went into considerable detail with regard to low-pressure turbines which, he predicted, would have a large application in the near future. Details of construction were also taken up, with special reference to the Curtis type of machine.

Hopkinsville was chosen as the next place of meeting.

J. N. Draper, of Henderson, was elected State president; F. L. Roy, of Louisville, vice-president; A. S. Smith, of Henderson, secretary; J. H. Cobe, of Owensboro, treasurer; C. Carroll, of Louisville, conductor, and R. Baumgarten, of Ashland, doorkeeper.

Installation of officers was by F. W. Raven, assisted by J. H. Van Arsdale. Immediately following adjournment a trolley ride was taken to Henderson's beautiful park overlooking the Ohio river. Here refreshments were served and a group photograph was taken. The social events wound up in the evening with a banquet in Backerkamp hall. This was served by the ladies of the local committee and was a grand success. Several members from Evansville, Ind., came over with their wives and joined in the festivities. F. W. Raven was toastmaster and the speakers were Mayor Harris, of Henderson; J. H. Van Arsdale, J. N. Draper, James Yeaman, Emil Hoegel, Edward Krampwirth, Isaac Dunn, B. S. Morris, C. O. Harris, Paul Marin, Dr. Graham and Joseph Wanrath.

American Order of Steam Engineers

The twenty-third annual convention of the American Order of Steam Engineers was held at Reading, Penn., during the week beginning Monday, June 7, the headquarters being at the Penn hotel. The sessions were held at Rajah Temple, there being about 50 delegates in attendance.

On Monday morning the assemblage was called to order by Past Supreme Chief Hiram M. Trout, chairman of the local committee, who introduced Mayor Rick, who gave the delegates and guests a hearty welcome to Reading. He spoke approvingly of the principles which govern the American Order of Steam Engineers, and wished the organization continued success. He also complimented the American Supplymen's Association on its splendid display. Supreme Chief Frederick Markee responded for the engineers.

During the several sessions of the convention considerable business was transacted, various committees were appointed and the following supreme officers were elected:

Frederick Markee, chief engineer; John Rost, 1st assistant chief engineer; T. J. Armbruster, recording engineer; W. S. Wetzley, corresponding engineer; T. J. Dunnam, treasurer; W. J. Courtney, senior master mechanic; Walter Lord, junior master mechanic; W. Rush, inside sentinel; W. J. Keller, outside sentinel; James Lightfoot, chaplain; H. Dubson, trustee.

The association was reported to be in a flourishing condition. Philadelphia was

OFFICERS OF PENNSYLVANIA STATE ASSOCIATION, N. A. S. E.

selected for the next convention, in June, 1910.

The American Supplymen's Association held its exhibit on the second floor of the Rajah Temple. The exhibition was the most successful ever held by the association and the arrangement of the hall and booths, under the supervision of H. G. McConnaughy, was the best we have ever seen at a convention exhibit, and the committee in charge is to be congratulated on the results attained. The following exhibited: Garlock Packing Company, McLeod & Henry Company, *Practical Engineer*, Jenkins Bros., Dearborn Drug and Chemical Works, Scully Steel and Iron Company, *American Journal of Steam and Electrical Engineering*, Keystone Lubricating Company, Griscom-Spencer Company, Berry Engineering Company, H. B. Underwood & Co., Peerless Rubber Manufacturing Company, John R. Livezey, Home Rubber Company, Corbett Supply Company, H. W. Johns-Manville Company, Philip Carey Company, Engineering Equipment Company, Watson & McDaniel Company, American Steam Gauge and Valve Manufacturing Company, Allentown Rolling Mills, Birdsboro Steel Foundry and Machine Company, William H. Taylor & Co., Scranton Steam Pump Company, Wilkirk Electric Company, W. B. McVicker Company, *Southern Engineer*, Anchor Packing Company, H. Belfield Company, Hutchinson-McCandlish Coal Company, McArdle & Cooney, George W. Lord Company, Cancos Manufacturing Company, L. J. Wing Manufacturing Company, France Packing Company, Quaker City Rubber Company, O. F. Zurn Company, Crandall Packing Company, Cyrus Borgner Company, POWER.

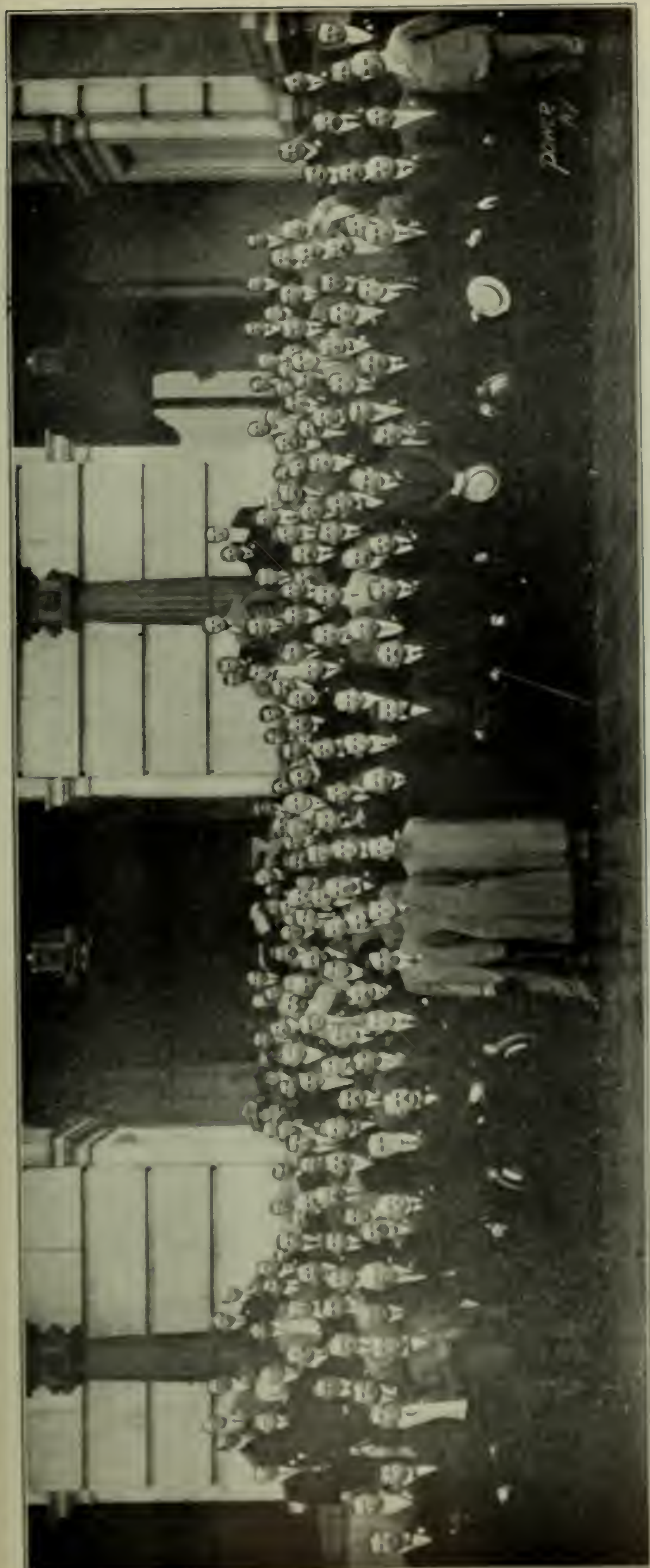
On Tuesday evening, at the Rajah Temple, a banquet was given to which the ladies were invited, and about 500 were seated at the tables. After the covers were removed, Past Supreme Chief Hiram M. Trout, toastmaster, introduced the following speakers: Frederick Markoe, the reëlected supreme chief; Charles E. Leippe, Judge H. Willis Bland, Noah R. Pierson, past supreme chief, and "Jack" Armour. Claude Miller entertained with a humorous monologue.

On Wednesday evening an entertainment was given in the exhibition hall by the New York "bunch." Every number was generously applauded, and the occasion was thoroughly enjoyed. During the evening Supreme Chief Frederick Markoe presented to each of the following gentlemen a handsome bouquet of American Beauty roses: William Le Compte, Charles Hopper, H. G. McConnaughy and Hiram Trout.

The other features of entertainment included trolley rides to Neversink and places of interest about the city, and a trip to Mount Penn.

At a meeting held by the American Supplymen's Association the following officers were elected: Charles Hopper, president; Nathaniel Kenny, vice-president; John W. Armour, treasurer; Frederick Jahn, secretary. "Bert" Williams was appointed director of exhibits.

DELEGATES TO THE PENNSYLVANIA N. A. S. E. CONVENTION, ERIE, JUNE 4-5, 1909



CONVENTION OF PENNSYLVANIA ENGINEERS' SOCIETY AT HARRISBURG, JUNE 9, 10 AND 11, 1909

Convention of Pennsylvania Engineers' Society

The Engineers' Society of Pennsylvania met at Harrisburg on June 9, 10 and 11. The sessions were held in the State Capitol. Mayor Ezra S. Meals welcomed the visitors and E. Herbert Snow responded for the society, of which he is president. The organization is composed largely of members of the Engineers' Clubs of Philadelphia, Harrisburg and Scranton and the Engineering Society of Western Pennsylvania, and the object of this union meeting was to take some action toward perfecting a State organization of all branches of the profession and the consideration of a code and draft of laws to support it. The call states that a bill providing for the examination and licensing of engineers and providing fees and penalties almost passed the general assembly at the last session, and it is thought well to see what better proposition the engineer has to offer. Some protection to the public is demanded.

A committee was appointed to draft a code and laws, and numerous papers upon general engineering topics were presented. Most of these dealt with civil and municipal engineering, but two were of especial interest to POWER readers: The first of these was a talk, illustrated by lantern slides, upon "Gas Engines," by E. T. Adams, of the Allis-Chalmers Company. He said that engines of 5000 horsepower are here and engines of twenty thousand horsepower are no farther off, looking forward, than engines of 1000 horsepower are looking backward. A station of one hundred thousand kilowatts capacity can be put into the same space with producers and gas engines as with boilers and steam engines, and in large capacities the prices are on comparable terms. The engines are of course much more bulky than turbines, but the saving comes in reduced coal storage and less room for producers, while the cleaning and scrubbing apparatus require very little more space than the turbine condensers. In gas engines directly connected to compressors, the greater masses involved result by their inertia the greater initial pressure and go far toward equalizing the effective pressure. Steel pistons can be used without trouble in cast-iron cylinders, because the piston is supported by tail rods outside of the cylinder and not allowed to bear. A station on railroad work near Milwaukee (probably Port Washington) [illegible] burned 2½ pounds of Pocahontas coal per kilowatt-hour. It is got down to a 50 per cent. load factor and a little over [illegible] pounds per effective kilowatt-hour on the line.

The other paper was that of J. G. Callan, on "Low Pressure Steam Turbines."

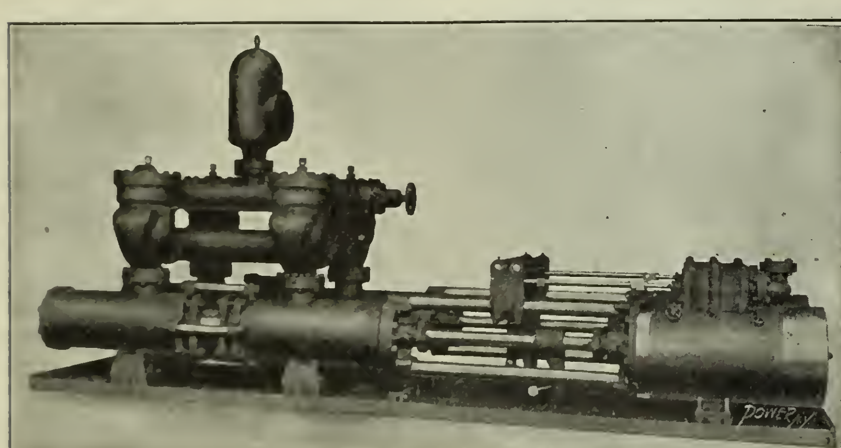
Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

Duplex Pot Valve Pump

The pump shown herewith has outside end-packed plungers and is designed for feeding boilers, pumping water containing sediment or grit, working on oil lines, or hydraulic presses, and for mining purposes. The only wearing part in the pump end is the packing of the plunger stuffing boxes. No leak can occur there without being observed, and it is easily stopped by setting up the packing. As the plunger does not touch the pump castings, there is no cutting or wear, consequently they require no reboring or refitting when working on gritty or sandy water. The piston rods do not enter the pump cylinders and are not exposed to the action of the water. Rods support the plunger slide in babbitted bearings.



DUPLEX POT-VALVE PUMP

The water-end valves are in pots and are quickly accessible by taking off the plates over them. The steam cylinders are of a new type, the steam ports being arranged on a novel plan. The method of steam cushioning is new, and the valves are of an original form. The pump will not short-stroke, it is claimed, which overcomes the most serious objection to duplex pumps. The valve gear is extremely simple and not liable to injury or wear, and can be replaced at very little expense or trouble. Rock shafts are abandoned and one-piece levers substituted. The levers swing on steel studs having extra long bearings. Both levers are alike and are easily removed and replaced. This pump is manufactured by the Dean Brothers Steam Pump Works, Indianapolis, Ind.

The Erie City Vertical Water-tube Boiler

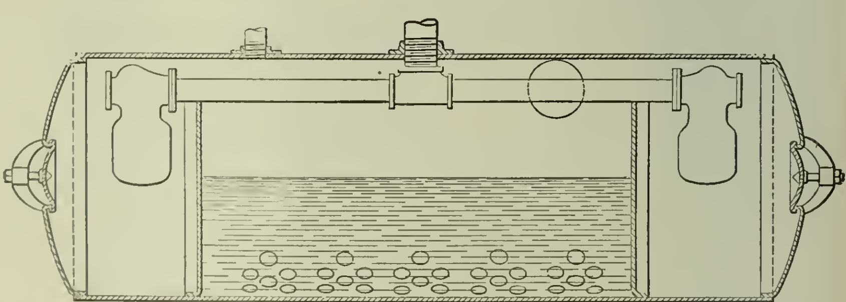
The Erie City Iron Works, of Erie, Penn., has added to its line of products the boiler shown in the accompanying illustrations, the reproduced photographs shown being from the experimental boiler at the Erie shops. It is not claimed that the type is novel, but that the Erie iron works will bring to its manufacture and exploitation refinements and improvement in detail and experience and facilities which should soon make a place for it among the standard types.

Unite the three banks of tubes of a Stirling boiler in a single upper drum, placed with its center directly over the center of the lower one, and you have the type. The furnace is an extension on the dutch-oven plan, allowing great flexibility in the adjustment of grate to heating surface and introducing the improved furnace conditions of the reverberatory arch. Additional capacity is gained by increasing the length of the drums and the number of tubes sidewise, carrying with it increased width of furnace and proportionate increase of grate surface, while the length of the grate may be made such as to give the desired ratio of grate to heating surface.

The tubes are so spaced that any one of them may be cut out, removed and replaced without interfering with any other. The entire boiler is suspended, as the engravings show, from the upper drum, giving perfect flexibility and freedom to adjust itself to varying conditions of temperature and stress. The sufficiency of the expanded tube joints in the upper drum to sustain the weight thus brought upon them has not only been tested out thoroughly in former boilers of this construction, but has been tried in the boiler illustrated by means of hydraulic jacks and found to be entirely adequate.

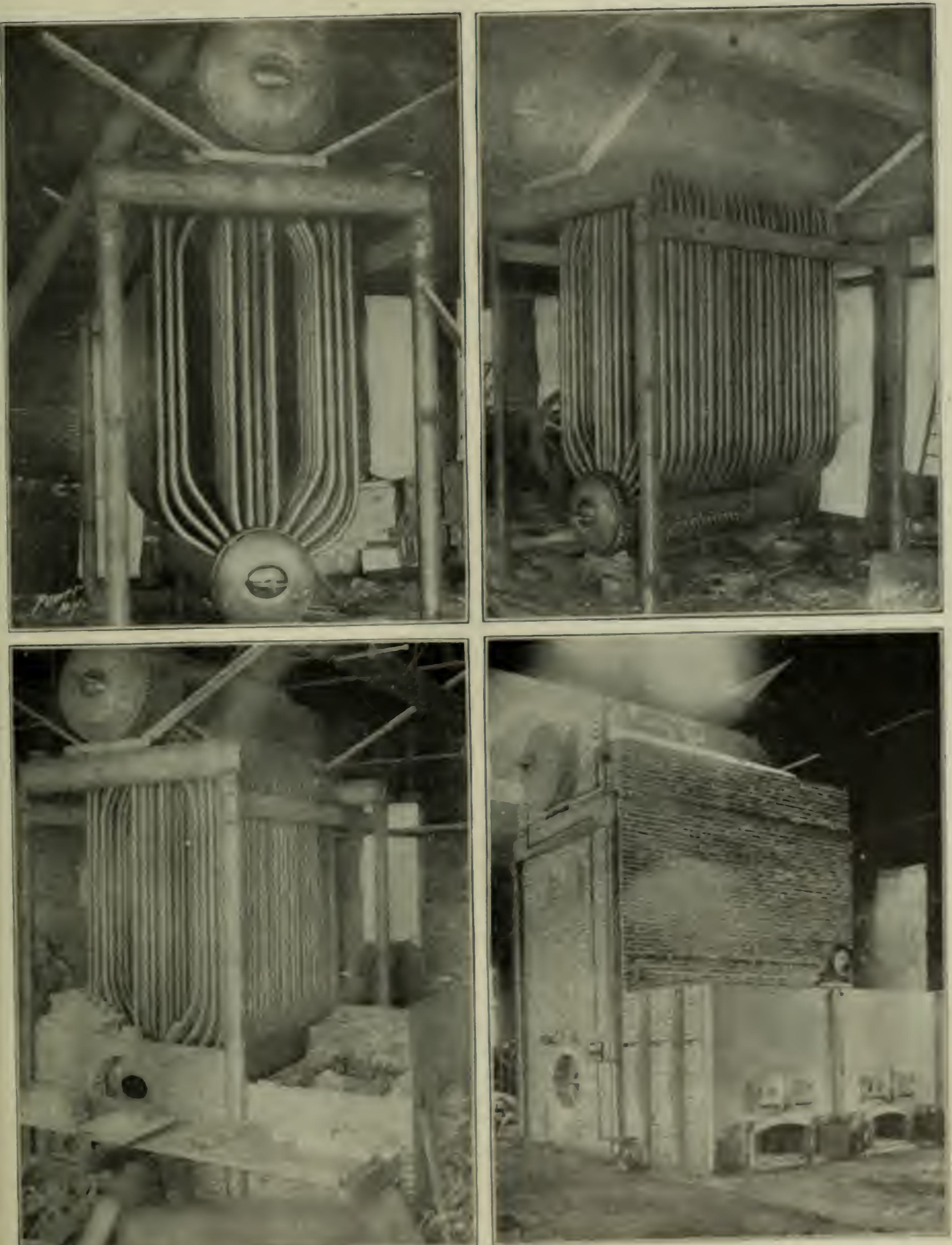
In this particular boiler the upper drum is 48 and the lower 40 inches in diameter, with 11 rows of connecting 3-inch tubes and, with 22 tubes in each row, furnishing 2377 square feet of water-heating surface. The front and rear groups contain 4 rows each, the central group, 3 rows.

The baffling is arranged to give three passes as shown, the gases passing longitudinally through each group of tubes. This gives a travel of the gas of something like 40 feet in contact with the heating surface, yet with such freedom of passage that there was little drop in draft pressure between the stack and the furnace when the boiler, nominally rated at 238 horsepower was developing over 500, and burning 36.7 pounds of coal per square foot of grate.

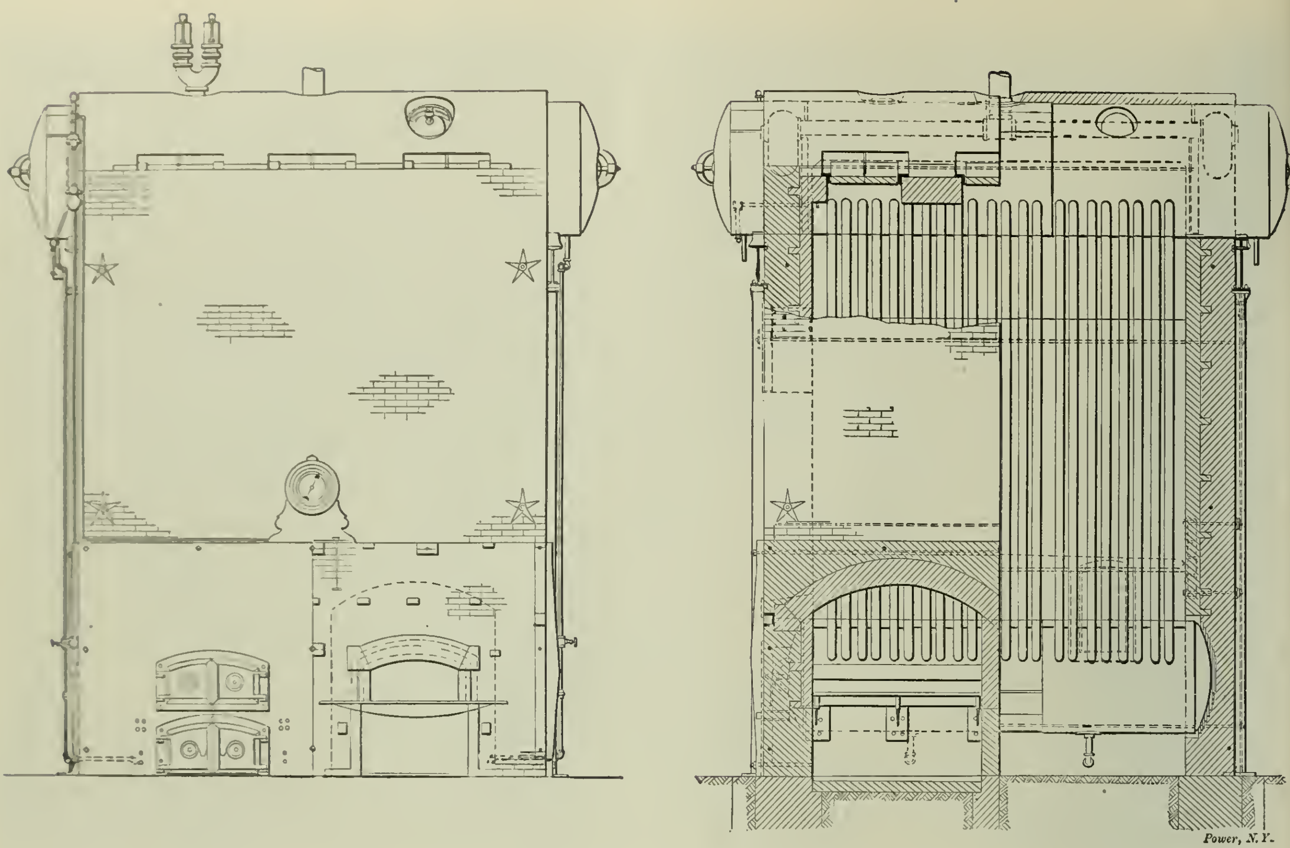


ENLARGED VIEW SHOWING SEPARATOR IN DRUM OF ERIE CITY BOILER

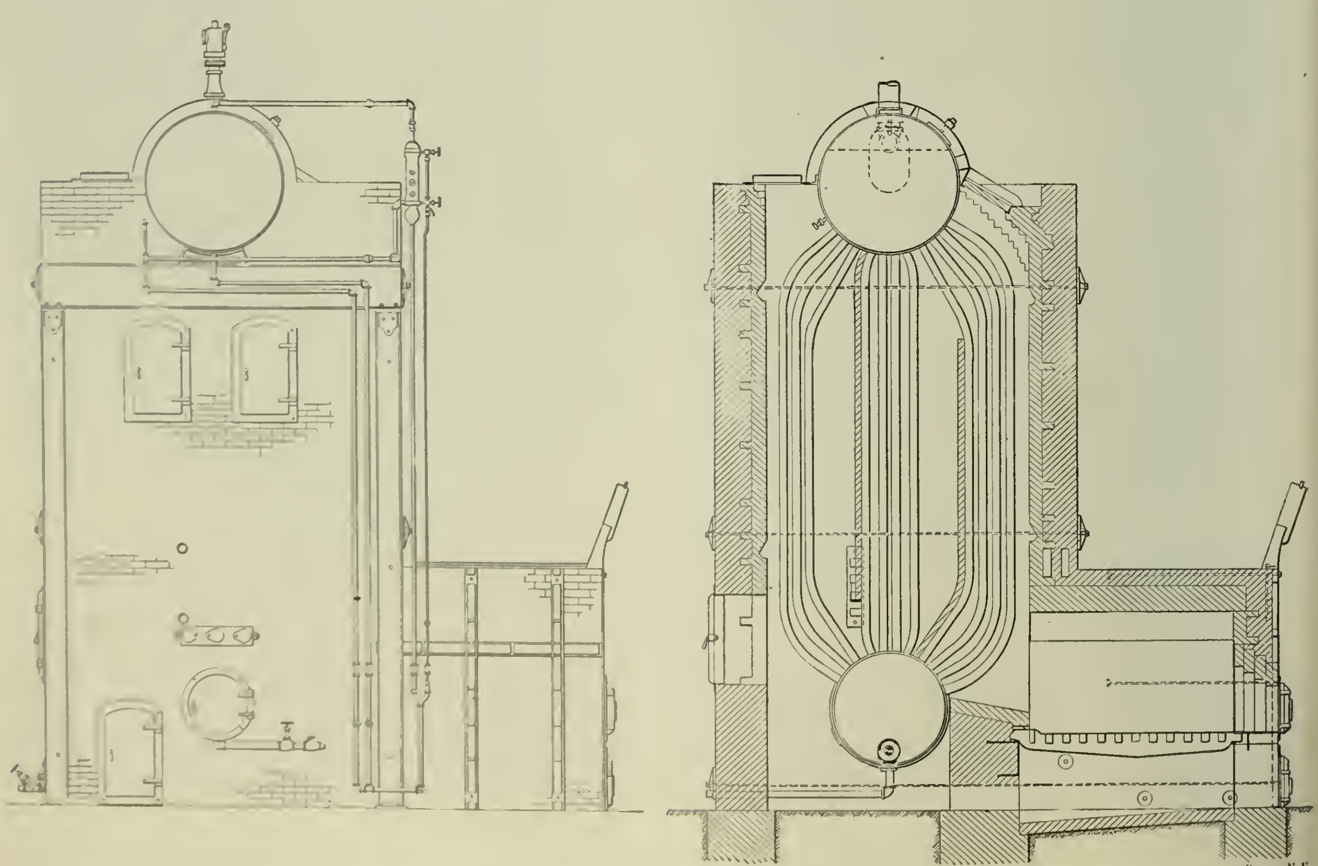
At each end of the upper drum is a dry chamber, as shown in the longitudinal section, in which is placed a separator upon each end of the steam-outlet pipe,



VIEWS OF ERIE CITY VERTICAL WATER-TUBE BOILER IN PROCESS OF ERECTION



FRONT ELEVATIONS OF ERIE CITY VERTICAL WATER-TUBE BOILER



SIDE ELEVATIONS OF ERIE CITY VERTICAL WATER-TUBE BOILER with the inlet facing toward the end of the drum and away from the steam-liberating surface. The boiler appears to be one which will be well adapted to the large units and intensive service demanded by the modern power plant, especially those in which large amounts of power are required for peak periods and where the ability to stand forcing is particularly desirable.

Feed Water Grease Extractor

The principal points in connection with this device are as follows: Two valves forming the inlet and discharge from the extractor, when seated as shown in the illustration, force the water into the shell of the extractor through the cartridges, and in this manner the grease is extracted. Where the valves are seated on the lower seat they form a bypass so that the shell of the extractor can be opened, the cartridges taken out and either replaced with an extra set or cleaned and put back.

The covering on the cartridges and form of applying are plainly shown at A, which is a somewhat reduced reproduction as to length when compared to the extraction shell. The ratio of the openings in the cartridges to the inlet of the extractor is as 48 to 1, and the cartridges are held firmly in place by resting on the lower seat by plate and spring washers at the top.

The pressure gages are applied to both the main chamber and base so as to note the difference in pressure and tell when the pressure in the main casing is increased due to the restricted flow of the water by the covering of the cartridges becoming filled with grease.

Provision is also made in the base, as shown at B, to connect a ½-inch steam pipe, driving steam into the inside of the cartridges and in this manner cleaning them so as not to necessitate taking the cartridges out as often as would otherwise be necessary. The shell of the extractor is small and compact. The shape of the cartridges, which are triangular, as shown at C, enables them to be placed in a comparatively smaller space.

The device is intended for stationary or marine practice and can be connected, as shown, directly to operating valves or to the valves in the pipe line. This extractor is manufactured by the American Steam Gauge and Valve Manufacturing Company, 208 Camden street, Boston, Mass.

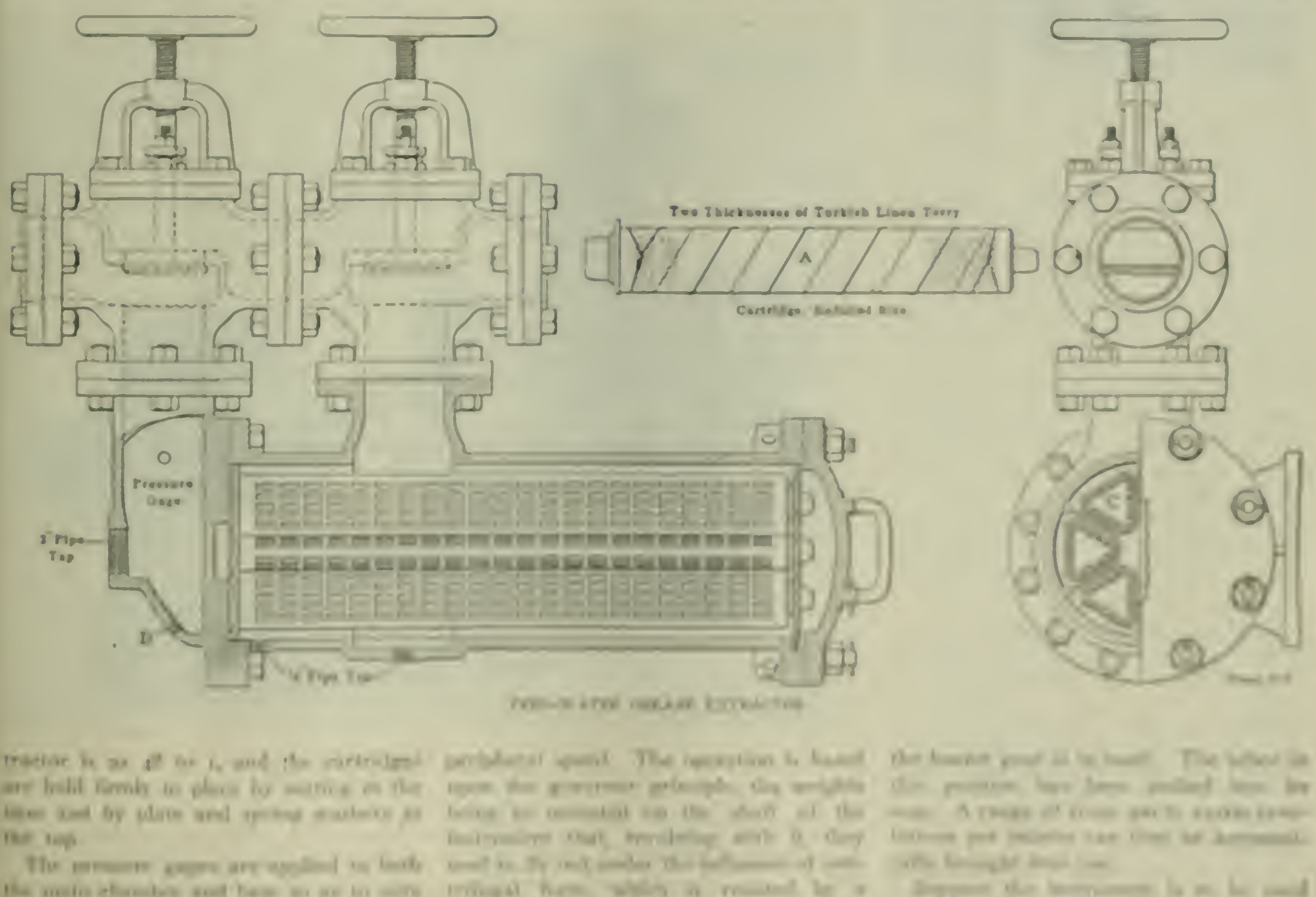
A Portable Tachometer

A portable single-spindle-type tachometer is herewith illustrated. It is manufactured by the Industrial Instrument Company, Foxboro, Mass. This instrument is designed for hand application to engines or any shaft or pulley, and shows at a glance the rate of rotation or peripheral speed. The operation is based upon the governor principle, the weights being so mounted on the shaft of the instrument that, revolving with it, they tend to fly out under the influence of centrifugal force, which is resisted by a spring. The resultant action of the weights relating to the shaft depends upon the rate of revolution and is indicated on a properly graduated dial by means of a suitable link and pointer.

The arbor is carried on a slide so that in this extreme position the highest speed is in gear. By pushing in on the arbor against the pressure of a spring, the next lower gear is brought in, and so on, until the lowest gear is in mesh. The arbor in this position has been pushed home by hand. A range of from 30 to 12,000 revolutions per minute can thus be automatically brought into use.

Suppose the instrument is to be used and the correct speed is not known. The operator pushes against the shaft until the

FIG. 1. PORTABLE TACHOMETER IN CASE



PRESSURE-TYPE GREASE EXTRACTOR

tachometer begins to register. The figures appearing on the sight aperture indicate the range in gear. If desirable, this arbor can be clamped in this or any other range position by means of the lock stud shown on the side of the case.

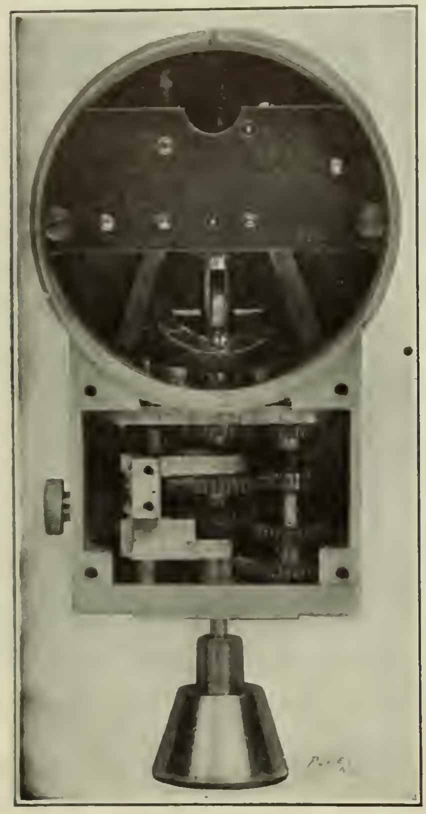


FIG. 2. MECHANISM OF THE TACHOMETER

If the speed of the shaft or pulley is within the range of the lowest number shown on the range register, which is from 300 to 1200 revolutions per minute, the instrument will register on the inner graduation of the dial, which figures read from 3 to 12. If the speed range is from 900 to 3600, the registration will be on the outside figures of the dial, which show from 10 to 35, the numbers indicating speeds of 1000, 1500, 2000, etc. If a still higher speed of from 3000 to 12,000 is to be registered, the readings are taken from the inner readings of the dial, but are read in thousands instead of hundreds, as in the first instance.

Each instrument is furnished with a leather case as shown in Fig. 1, in which is mounted one extension piece for the arbor, one steel and one india-rubber point for coupling to the shaft, one rubber-lined cone for coupling to a spindle and one disk for band drive if the shaft is inaccessible. Fig. 2 shows the interior mechanism.

Stationary tachometers are made in horizontal and vertical types for belt drive or direct connection to shafts.

Trenton "Type A" Gas Engine

A new type of gas engine known as "Type A" is now built by the Trenton Malleable Iron Company, Trenton, N. J., the illustration in Fig. 1 showing this type of engine direct-connected to a direct-current generator.

As to construction, all the surfaces within the combustion chamber are machined so that the heat losses from radiation and the tendency to accumulate carbon are reduced to a minimum. All valves are removable without interfering with any piping, it being merely necessary to remove one cotter pin, and slip out the stud, when by removing the cap screws the valve and valve seat can be removed without interfering with any other adjustment on the engine. By taking out the valve case, the interior of the combustion chamber can be cleaned and inspected at will. The cam shaft, main bearing and connecting-rod boxes are readily accessible through doors in the housing. One lever shifts all auxiliary cams and the engine is controlled from one position.

As indicated in Fig. 1, the bedplate is of box construction and supports the crankshaft bearings, shown at either side. The bearings are made of malleable iron and lined with Parsons white brass. As a means of lubrication to the bearings, oil

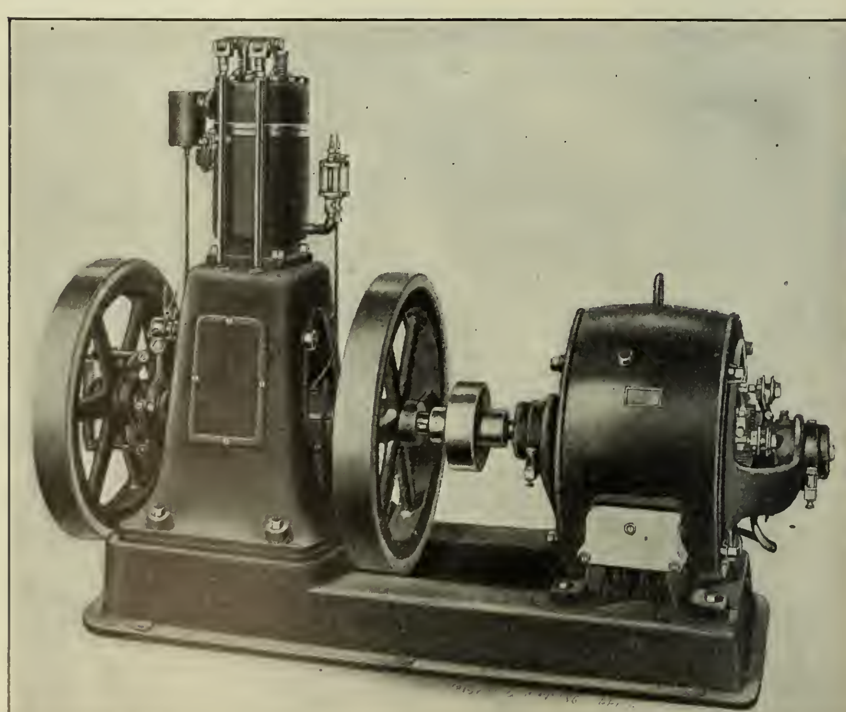


FIG. 1. TRENTON "TYPE A" GAS ENGINE

is delivered through an oil pump driven by a spur gear inside the housing. By removing the cap of the boxes and lifting the weight of the crank shaft, the lower halves of the boxes can be taken out by giving them one-half revolution on the shaft.

In Fig. 2 is shown the piston, which is of the trunk pattern, of ample length and packed with cast-iron rings. It carries a wristpin which is steeled, hardened and

FIG. 2. PISTON, SHOWING OILWAYS

ground. The sides of the piston are fitted with oilways which are filled with lubrication from the oil pocket, being fed from the inside through a suitable hole.

Both the inlet and exhaust valves are

of the poppet type, mounted in cases bolted to the cylinder head. They are operated from the cam shaft by means of push rods and valve levers.

The governor is of the centrifugal ball type mounted on the end of the housing and is so driven that the torsional disturbance of the cam shaft, due to the operation of the valves is not affected. It is simple and extremely sensitive which enables a very close regulation to be obtained. A simple mixing chamber and valve are fitted to the engine. At the center of the inlet manifold are the gas and air inlet valves and mixing chamber. The make-and-break type of ignition is used, being at all times under governor control. This engine is built in sizes up to 8½ horsepower and makes a compact, neat generating set where a limited amount of power is required.

Ladies' Night at Pawtucket

Saturday evening, June 5, was the annual ladies' night of Pawtucket Association No. 2, N. A. S. E., and in spite of the pouring rain a large number gathered at the association rooms in Cottrell block. Shortly after 8 o'clock the exercises were opened with a piano duet by Miss Marion Cooper and Ralph Daniels.

President Keene, in a racy preliminary address introduced F. L. Johnson as the "religious" editor of Power and also as the first speaker of the evening and toastmaster. Mr. Johnson gave a short description of his "missionary" life in New York and his domestic troubles in Lynn. He took advantage of his position as toastmaster to bring his remarks to an early close, and soon introduced Past National President P. H. Hogan, who spoke of the educational advantages enjoyed by members of the National Association of Stationary Engineers. He was followed by a character duet by the Misses Bessie Donohue and Bessie Ryan.

"Ed" Kearney, Massachusetts State deputy, told how the average engineer, instead of telling his troubles to a policeman, usually took them home with him. Alvin Martin, in a few apt remarks, presented to the winner, "Ed" L. Cheney, the prize which is given every year to the member furnishing the best question for discussion during the educational season.

Next on the program was a presentation of the balcony scene from "Romeo and Juliet," by the Misses Donohue and Ryan. This was followed by a few remarks by Columbus Hill, of America. W. M. Childers expressed his opinion that a woman's place was at home, not attending auxiliary meetings or ladies' nights.

Mrs. Canfield, past president of Rhode Island No. 1, Ladies' Auxiliary, in a few well chosen remarks gave Mr. Childers all that was "coming to him." Then the toastmaster remarked that had the committee of arrangements possessed more paper the program would have been longer.

The remainder of the session was given over to the refreshment committee, who served ice cream, cake, coffee and cigars.

As the last car left the square, in the wee sma' hours, the guests reluctantly took their homeward way, the out-of-town visitors going to Hotel Burke in Pawtucket.

Next day the visiting guests were taken on an automobile excursion to the various points of historical interest in and around Providence and Pawtucket.

The occasion will long be remembered by all who participated in it.

Personal

Karl M. Way and Perry Barker, formerly assistant engineers of the United States Geological Survey, have joined the fuel engineering department of the Arthur D. Little Laboratory of Engineering Chemistry, Boston, Mass.

Business Items

Herbert S. Crocker and Milo S. Ketchum have formed a partnership under the firm name of Crocker & Ketchum, consulting engineers, with offices at Suite 438, 811 Seventh street, Denver, Colo.

J. Proudfield Simpson has opened an office as consulting mechanical engineer at 541 Calvert Building, Baltimore, Md. Mr. Simpson would like to receive catalogs and hear from concerns wishing a representative in that section.

The Jacobson Machine Manufacturing Company, of Warren, Penn., builder of gas and gasolene engines, announces that it has engaged as foreman of its machine department John [illegible], who was for several years mechanical inspector at the Franklin works of the Chicago Pneumatic Tool Company.

The Stone and Webster Engineering Corporation, of Boston, recently placed an order with the American Ship Windlass Company, Providence, R. I., for three Taylor mechanical stokers for installation at the Dallas, Tex., electric light and power plant, for which six similar stokers were previously purchased.

An engineer's handbook has been published by the Erie Engine Works, Erie, Penn. It contains upward of eighty pages of useful information for operating engineers. It also, of course, illustrates the product of the Erie Engine Works and will be sent free to any engineer sending his name and address.

The Jackson Manufacturing Company, Nashua, N. H., awarded a contract to the [illegible] Construction Company, Boston, Mass., for the construction of a reinforced concrete trestle through its coal pocket. The track is to be supported by beams running under the rails. Large concrete columns with Y tops poured in place by concrete beams are to form the main supports. The whole construction is to be heavy enough to take the largest coal cars.

The American Blower Company, Detroit, Mich., has just issued a [illegible]-page booklet, 7x[illegible] inches, treating of "Sirocco" fans and other "A B C" specialties. The greatest interest, of course, attaches to the portion of the booklet which deals with "Sirocco" fans, several important installations being shown, and valuable engineering data given by emphasizing the claims for these fans, including increased efficiency and capacity, decreased space required and slower speed.

The Interborough Rapid Transit Company, of New York City, has adopted Keystone grease, manufactured by the Keystone Lubricating Company, Philadelphia, for all the escalators at its elevated-railroad stations. These machines are motor-driven and the largest escalators have several motors for the different parts. As these installations are a public-service proposition it is absolutely essential that they be kept running without fail, and therefore proper lubrication is all-important.

The Detroit United Railways recently placed a contract with the Westinghouse Machine Company for another turbine unit. This company already operates Westinghouse turbines in three of its power stations. The new turbine, which is of 1000 kilowatts capacity and is to operate at 150 pounds steam, 28 inches vacuum and saturated steam, will be installed at the Rochester station on the Detroit & Flint division. This station already contains engine-type units, but extensions of traffic have necessitated the installation of this new turbine unit.

The American Steam Gauge and Valve Manufacturing Company, Boston, recently furnished the following equipment for the three new colliers built by the Maryland Steel Company: Eighteen American-Thompson improved indicators, three 10-inch chime whistles, three 6-inch steam whistles, twelve 2½-inch duplex pop safety valves, three 2-inch single pop safety valves, 18 steam and water relief valves, 12 cylinder relief valves, 12 gages, 3 clocks, 6 counters. The company also furnished the following for the "North Dakota," built by the Fore River Shipbuilding Company: Six clocks, 108 steam and vacuum gages, 2 counters, 48 valves.

The Wisconsin Engine Company, of Corliss, Wis., reports increasing orders for both its Corliss engines and its complete-expansion gas engines. A recent gas-engine contract was received from the Bartlesville Electric Light and Power Company, of Bartlesville, Okla., and covers two engines of the horizontal tandem double-acting type, each to develop 800 b.h.p. and to be direct-connected to a 60-cycle alternating-current generator. These generators are to operate in parallel and very close regulation has been guaranteed. The complete-expansion principle, they say, embodies the expansion of the burning charge to a very low terminal temperature and pressure with the consequent balancing of the working conditions, simplifying the lubrication problem and decreasing the gas consumption by about 20 per cent.

The Industrial Instrument Company supplies data on its instruments in the form of engineering bulletins, each bulletin being devoted to a certain line or class of industry, or to those instruments of different classes that group themselves conveniently for a certain industry. This method saves much of the handling of loose-leaf catalogs without involving the trouble of their classification. It furthermore eliminates the formidable general catalog, only a small part of the contents of which is of interest to the average customer. The accompanying bulletins treat upon types or lines of instruments extensively, without including irrelevant matter. The various bulletins published by this company are kept on file and provided for binding together as convenience requires. These covers, or binders, and any bulletins will be sent to prospective purchasers for instruments upon application to the Industrial Instrument Company, Foxboro, Mass.

Much has been written and said concerning the [illegible] of lubrication and how much it is [illegible] efficient operation of any form of mechanism. Elaborate formulas have been given for testing different lubricants and literature has been prepared with a view of exploiting all kinds of products of this nature. It is not, however, essential that one should acquire an education of oils and greases, but it is imperative that a good article be used, for should this not be done the engineer is gaining very expensive experience. Then the primary object should be to select a product that has a reputation which has been gained because of satisfaction. Adam Cook's Sons, 313 West street, New York, state that Albany grease was the first lubricant in the field, being in practical use on all kinds of machinery for over 40 years, and that good results have been obtained under the most adverse conditions. Its use has been extended to every portion of the power plant where a solid lubricant may be employed. Albany grease is made in seven densities and is packed in one-, five-, ten-, twenty-five -and fifty-pound cans and kegs, half barrels and barrels.

New Equipment

A new power house will be erected at the Butler Hospital, Providence, R. I.

The Martin Dyeing and Finishing Company, Bridgeton, N. J., will enlarge power plant.

The American Silver Company, Bristol, Conn., is having plans prepared for the installation of a new steam plant.

The Great Western Electric Power Company has let contract for the construction of a substation at Oakland, Cal.

A new power house is being erected at the Hudson River State Hospital, Poughkeepsie, N. Y., to cost $125,000.

The Le Mars (Iowa) Water and Light Company is planning to install new generator, changing from 120-cycle to 60-cycle direct belted.

The corporation of Basic City, Va., will erect a hydroelectric light and power plant. Plans can be had of W. M. Page, city treasurer.

The Calvert (Tex.) Water, Ice and Electric Company has awarded contract for rebuilding and improvements to plant to cost $40,000.

Proposals will be received until 10 a.m., June 21, by Constructing Quartermaster, Fort Sill, Okla., for the installation of a central heating plant.

The Geneva, Waterloo, Seneca Falls & Cayuga Lake Traction Company, Seneca Falls, N. Y., will erect an auxiliary power plant at Cayuga Lake Park.

The Bettendorf Improvement Company, Bettendorf, Iowa, has applied for franchise for waterworks system, sewer system and electric light plant.

The Tulia Light and Ice Company, Tulia, Tex., has been incorporated with $10,000 capital. Incorporators, J. W. Schwarz, J. E. McCune, L. D. Smith.

R. P. Arnold and M. W. Gresson, of Prescott, Ark., and others are organizing a company to establish a ten ton ice plant, cold-storage plant, grist mill and cotton gin.

The Mound City Electric Light and Ice Company, Mound City, Mo., has been incorporated with $25,000 capital by F. M. Miller, R. W. Neill, T. W. McCoy, J. A. Crowell.

City of Gulfport, Miss., is having plans prepared for waterworks improvement to include the installation of an additional 1,000,000 gallon pump. M. F. Sullivan, city engineer.

The Commissioners of Waterworks, Newport, Ky., will arrange for improvements to cost $85,000. These will include two pumps of 5,000,000 gallons daily capacity. W. L. Glazier, superintendent.

The North Rose Cold Storage Company, North Rose, N. Y., has been incorporated to establish cold storage plant and warehouse. Capital, $20,000. Incorporators, John Hill, Frank Hill, Thos. B. Welch, Addison Weed.

A. M. Powell, candy manufacturer, Sullivan and Canal streets, New York, will erect a new ten-story building. Three Erie Ball engines, three Scotch boilers will be installed. Seventy-five ton ice machine, several pumps and elevators will be needed.

The Isthmian Canal Commission, Washington, D. C., will receive bids up to 10:30 a.m., June 21, for surface condenser, pumps, hose, rubber valves, packing, pipe covering, leather belting, pipe fittings, valves, ejectors, lubricators, etc., as per Circular No. 514.

Bids will be received by W. T. Kelly, Borough Clerk, Bellefonte, Penn., until June 1 for construction of complete electric power-plant, as per plans and specifications on file in clerk's office and at the office of D. C. & W. B. Jackson, 84 State street, Boston, Mass.

The Bureau of Yards and Docks, Navy Department, Washington, D. C., will receive bids until 11 a.m., June 26, for one 1000 and two 1500-kilowatt turbo alternators for New York, Philadelphia and Boston navy yards. Specifications can be had at the bureau or navy yards.

New Catalogs

Templeton Manufacturing Company, 22 Randolph street, Boston, Mass. Catalog. Sterling steam trap. Illustrated, 5x9 inches,

Greene, Tweed & Co., 109 Duane street, New York. Catalog. Rochester automatic lubricators. Illustrated, 48 pages, 6x9 inches.

Alberger Condenser Company, 95 Liberty street, New York. Catalog No. 13. Wainwright water heaters. Illustrated, 16 pages, 6x9 inches.

Woven Steel Hose and Rubber Company, Trenton, N. J. Catalog. Rubber hose, belting, packing, etc. Illustrated, 28 pages, 6x9 inches.

Ingersoll-Rand Company, 11 Broadway, New York. Bulletin Form No. 300L. Air and gas compressors. Illustrated, 16 pages, 6x9 inches.

Du Bois Iron Works, Du Bois, Penn. Bulletin, "EP"-No. 3. Motor, gasolene, engine and belt-driven pumps. Illustrated, 8 pages, 6x9 inches.

The Westinghouse Air Brake Company, Pittsburg, Penn. Instruction Pamphlet No. 5030. Type K Triple Valve. Illustrated, 30 pages, 4½x7 inches.

The Bristol Company, Waterbury, Conn. Bulletin No. 102. Partial lists of recording pressure and vacuum gages. Illustrated, 24 pages, 8x10½ inches.

Hill Clutch Company, Cleveland, Ohio. Pamphlet, "Tests of Friction Clutches for Power Transmission," by Prof. R. G. Dukes. Illustrated, 16 pages, 6x9 inches.

The Jeffrey Manufacturing Company, Columbus, Ohio. Catalog 32-A. Coal and ashes handling machinery in power plants. Illustrated, 72 pages, 6x9 inches.

Westinghouse Electric and Manufacturing Company, Pittsburg, Penn. Circular No. 1160. Multiple tungsten lamps. Illustrated, 12 pages, 7x10 inches. Circular No. 1164. Type MS mill motors. Illustrated, 24 pages, 7x10 inches.

Westinghouse Electric and Manufacturing Company, Pittsburg, Penn. Circular No. 1165. Electric fans. Illustrated, 36 pages, 7x10 inches. Circular No. 1148. Mercury rectifier battery charging outfits. Illustrated, 18 pages, 7x10 inches. Circular No. 1158. Electric motor friction brakes. Illustrated, 14 pages, 7x10 inches.

Remarkable Plant of the St. Clair Tunnel

Turbine Plant Enabled to Carry a Load Varying Instantly from Zero to 100 Per Cent. Overload by Novel Method of Controlling Combustion

BY OSBORN MONNETT

A study of the power problems involved in the recent electrification of the St. Clair tunnel at Port Huron, Mich., and their method of solution, serves to show to what extent a modern steam plant may be designed to meet special conditions. It is safe to say that there is no other electric power plant in the country where the load conditions are so extremely unusual. Large variations in load are, of course, no novelty, but in this case the fluctuations represent the entire range of generating capacity, with no-load periods of indefinite duration, the load coming on without the slightest warning and dropping off with equal rapidity.

Consisting of a single-track iron-lined bore 19 feet in diameter, the tunnel proper, which was built in 1890 and operated with steam locomotives of special design up to 1908, extends a distance of 6032 feet, in addition to the two approaches of 2500 feet on the American side and 3300 feet on the Canadian side, connecting the Port Huron and Sarnia terminal yards of the Grand Trunk railway.

Operated as a single-track division of the railway system, there is offered no opportunity for "recuperative working." The heavy Westinghouse single-phase locomotives pull direct on the power house through their pantograph trolleys for the full amount of power necessary for the movement of the trains. In Fig. 1 the grades and distances involved are given. Assuming that a train is passing from the American to the Canadian side, the load factor may be said to follow approximately the profile of the tunnel; there will be no power used on the down grade, and owing to the momentum little or none on the 1700-foot stretch at the bottom of the tunnel, which is practically level, having a grade of only 1 foot in 1000 for drainage purposes, but at the end of this level stretch sufficient power must be instantly supplied to pull a 1000-ton train up a 2 per cent. grade for a distance of 1 mile at a minimum speed of 10 miles an hour, and be able to start from a standstill on this grade if necessary. It can be seen, therefore, that quick steaming capacity was of the utmost importance, and, on the other hand, of no less importance was the ability to take care of the no-load periods without distress, these periods coming on instantly after carrying for a short time loads varying anywhere from full load to 100 per cent. overload.

FIG. 2. POWER HOUSE OF THE ST. CLAIR TUNNEL COMPANY

FIG. 1. MAP AND PROFILE OF YARDS AND TUNNEL

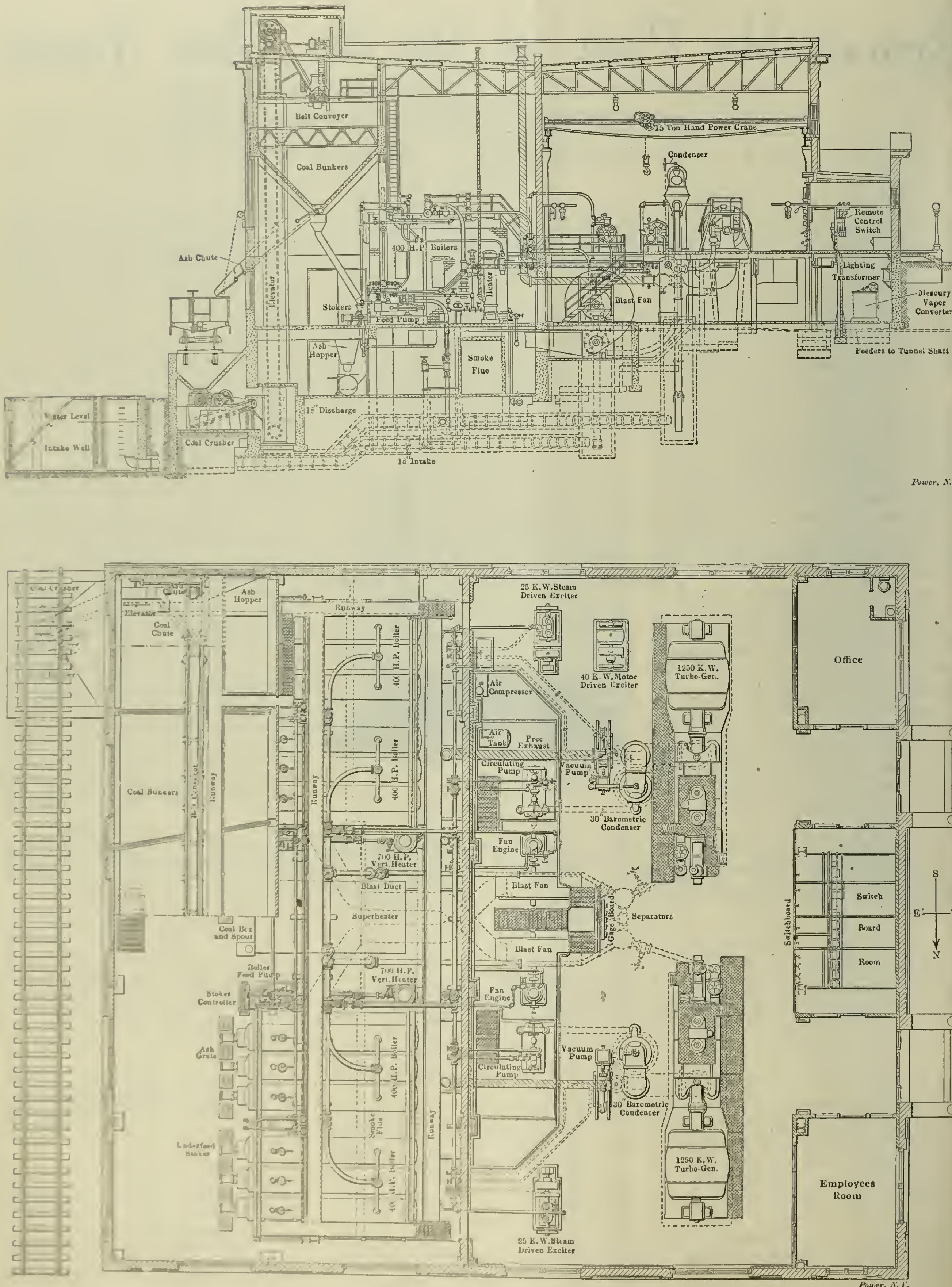
Located on the American side on the bank of the St. Clair river and slightly to the north of the center line of the tunnel, the power house, which together with the remainder of the system was installed under the direction of the Bion J. Arnold Company, of Chicago, consists of a substantial building with concrete foundation up to the grade line, and above this dark brown brick paving blocks, the trimmings being of stone and concrete. The stack, which is of Weber steel-concrete construction, rises 105 feet above the basement and is faced up to the roof of the building with paving brick to correspond with the general architecture. Fig. 2 shows the power-plant building and Fig. 3 the arrangement of the plant in plan and elevation. Owing to the slope of the river bank at this point there is considerable difference in level between the boiler and turbine rooms.

Coaling Facilities

Plenty of light and room are provided on the firing floor which overlooks the river, and there is sufficient space between the building and the water's edge to provide for a switch track by which coal may be delivered and ashes taken away. If desired, coal may also be unloaded directly from boats. After being dumped into the receiving hopper, the coal is passed through a crusher driven by a 20-horsepower three-phase induction motor, and delivered to a bucket elevator, from which it is distributed to reinforced concrete hoppers by a Robins belt conveyer and automatic tripper. Bunker capacity of 750 tons is provided. A desirable feature in connection with the coal bunkers is that metal lath concrete partitions extending to the ceiling completely close off the bunker space, thereby excluding the dust from the boiler room.

Boiler Installation

As the character of the load on this station imposes severe requirements on the steam-generating equipment, it is to be expected that some departure from standard sizes and dimensions will be found here. There are four Babcock & Wilcox water-tube boilers installed, having



Power, N. Y.

FIG. 3. PLAN AND ELEVATION OF POWER PLANT

ing wrought-steel inclined headers, and while rated at only 400 horsepower each, they have three horizontal steam drums 42 inches in diameter and 23 feet 4 inches long. This provides a considerable excess of water capacity which becomes available for steam making on lowering the steam pressure, and also enables the feed pumps to be used freely in reducing the steam pressure on no-load, should occasion require it.

Two boilers are set in a battery, and each boiler is equipped with three Jones underfeed stokers. In consideration of the load requirements it was desired to avoid any furnace construction calling for a large amount of firebrick walls or arches, which would have a retarding effect on the quick steaming action in case the brickwork should become cooled down during a no-load period, and which would also tend to give up a large amount of heat after the demand for steam had passed. Therefore, nothing has been interposed between the bank of tubes and the bare fires, and the boilers being constructed nine tubes high and as wide give a large amount of heating surface directly over the radiant heat of the furnaces, so that quick response is obtained to all conditions of the load.

As shown in Fig. 4, coal is conveyed to the stoker hoppers. Ashes are raked out onto the floor and passed through gratings into hoppers in the basement, from which they are loaded into push cars, dumped into the bucket conveyer and elevated to an ash hopper which can be unloaded into cars on the side track.

FIG. 4. BOILER ROOM

Novel Method of Controlling Combustion

The stokers operate with closed ashpits and forced draft, the draft being automatically controlled by the steam pressure and the speed of fuel feed being also regulated according to load conditions. Two forced-draft fans with galvanized-iron ducts leading to each ashpit are installed. By means of a special blast gate either fan may be used on the boilers. There is also a hand damper at each stoker to shut off the draft entirely if desired. As indicated in Fig. 1, the fans are located in the pit of the turbine room. They are of the American Blower Company's steel-plate construction, 11 feet in diameter by 3 feet 4 inches wide and are driven by its type B vertical center-crank engines.

Steam for these engines is taken from a 6-inch auxiliary header and the supply is controlled by Kitts regulating valves located in the boiler room. These valves have pressure lines tapping the main steam header just before reaching the turbines, and an increased load coming on the machines, the pressure will be reduced here before affecting the boiler pressure. Immediately the fan in use will be speeded up in direct proportion to the drop in pressure. At the same time fuel will be fed to the furnaces at a proportionately increased speed by a Cole automatic regulator, Figs. 5 and 6 giving the details of its construction. Belted to each fan engine is a line shaft running in self-oiling bearings and extending to the front of the boilers in the basement, where each shaft is connected through bevel gears with another shaft running at right angles, and by which the Cole automatic regulating valves are operated by belts. Either shaft may be cut out by a friction clutch when its corresponding fan is not in use. Situated on the boiler-room floor at each battery of boilers are the regulating valves, each of which controls six stokers. As is well known, the Jones stoker operates by forcing the charges of coal upward into the fire by means of a ram plunger operated by a steam piston, the return stroke of the piston allowing fresh coal to drop into the charging tube from the hopper above. In operation the function of the Cole regulating valves is to control the number of charging strokes of the stoker by turning steam alternately into each end of the stoker cylinders.

The Cole valves themselves, which are shown in detail in Fig. 7, consist of a rotating stem with a flat end, held to a valve seat by the steam pressure. The stem is turned by a ratchet attachment driven by a connecting rod receiving motion through a lay shaft and worm gear direct from the fan engine, as previously described. At each revolution, a steam port A, Fig. 7, is uncovered, causing a charging stroke of the stoker. At other times during the revolution the steam port is connected to the longer passage B, which causes the stoker piston to remain in the outward position ready to make a charging stroke. It can be seen then that the rate of feed will be proportioned to the number of revolutions of the controlling steam valves, which in turn are entirely dependent on the speed of the fan engines. In addition there is a further adjustment provided at the ratchet, as shown, whereby more or less notches on the driving mechanism may be engaged or disengaged, the more notches being taken up by the ratchet, the faster the steam valves will revolve. By means of the equipment described it is possible to provide a fuel feed which meets the peculiar load conditions in a most satisfactory manner.

Boiler Feed and Pumps

There are two Worthington tandem-tank pot-valve feed pumps provided and these are located between the two batteries of boilers. They take water from a sump tank which takes the overflow from the hotwell. Other connections are arranged so that water may be taken from the cold-water main of the condensers or from the city mains, giving three sources of supply. Each pump is connected to a Worthington-Cochrane open B vertical closed heater which utilizes the

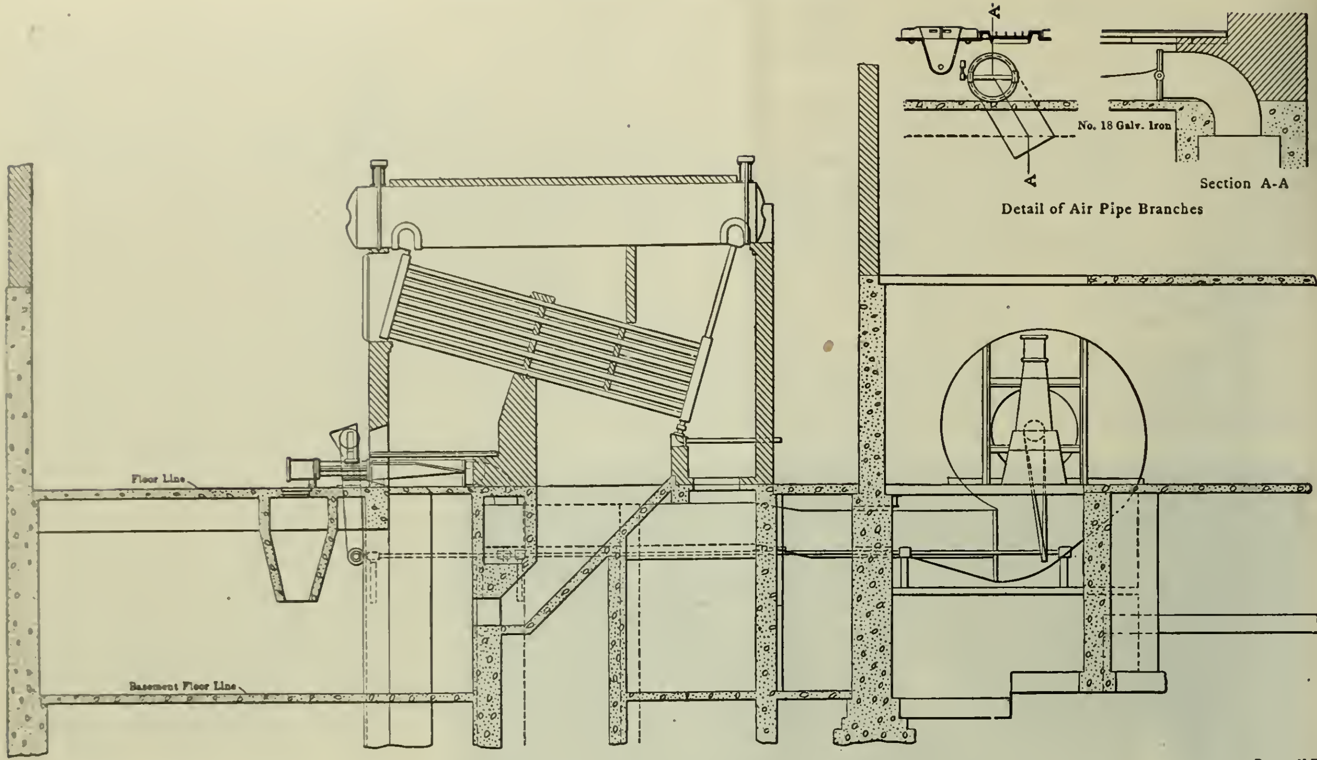


FIG. 5. BOILER SETTING AND DETAILS OF AIR BLAST

auxiliary exhaust. From the feed pumps the water passes through 3-inch Worthington water meters before going to the heaters. A thermometer is inserted in the feed lines both at the entrance and at the outlet to the heater. The average feed temperature is 200 degrees.

Referring to the sectional view of the boiler setting, Fig. 5, it is desired to call attention to the arrangement for cleaning the combustion chambers, the bottoms of which are really hoppers opening through doors into the basement, allowing the contents of the combustion chambers to be raked out into the small push cars. Anyone who has had to do with the cleaning of ordinary combustion chambers will certainly appreciate this arrangement. Vertical gas passes are used, finally leading to a flue under the boiler-room floor and passing to the stack.

Steam is taken from the boilers through 6-inch long-sweep bends and discharged into an 8-inch header leading down to a separately fired Foster superheater, located between the batteries of boilers. All high-pressure piping is of mild steel with welded flanges. Seven-inch lines connect the superheater with the turbine throttles, a bypass being arranged so as to run on saturated steam if necessary. Separators are installed at the turbines to take care of entrained moisture in this event.

Separately Fired Superheater

The superheater, a close view of which is shown in Fig. 8, is designed to superheat 36,000 pounds of steam per hour at 200 pounds per square inch to a final temperature of 587 degrees Fahrenheit, corresponding to a superheat of 200 degrees. It is of Foster construction, the

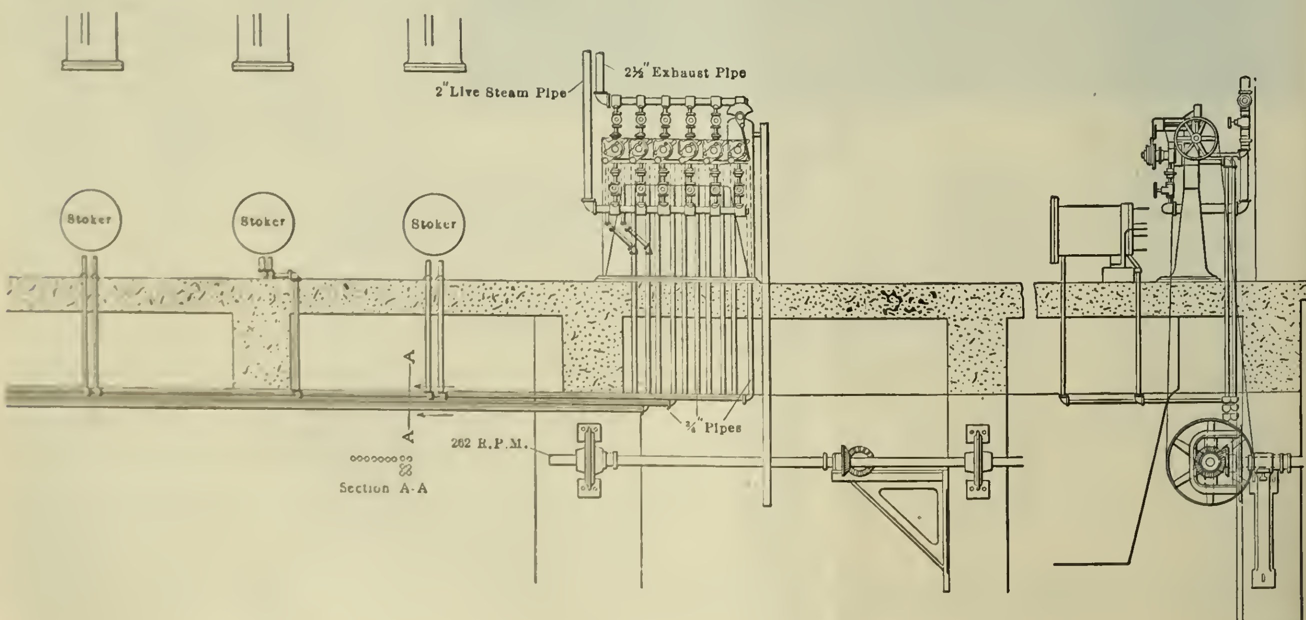


FIG. 6. SIDE VIEW AND END ELEVATION OF COLE REGULATING MECHANISM

lements consisting of cold-drawn seamless steel tubing upon which are shrunk ast-iron rings of special form, making a ibe of practically one metal, being steel n the inside for containing the pressure nd exposing only cast iron of special rade to the destructive action of the

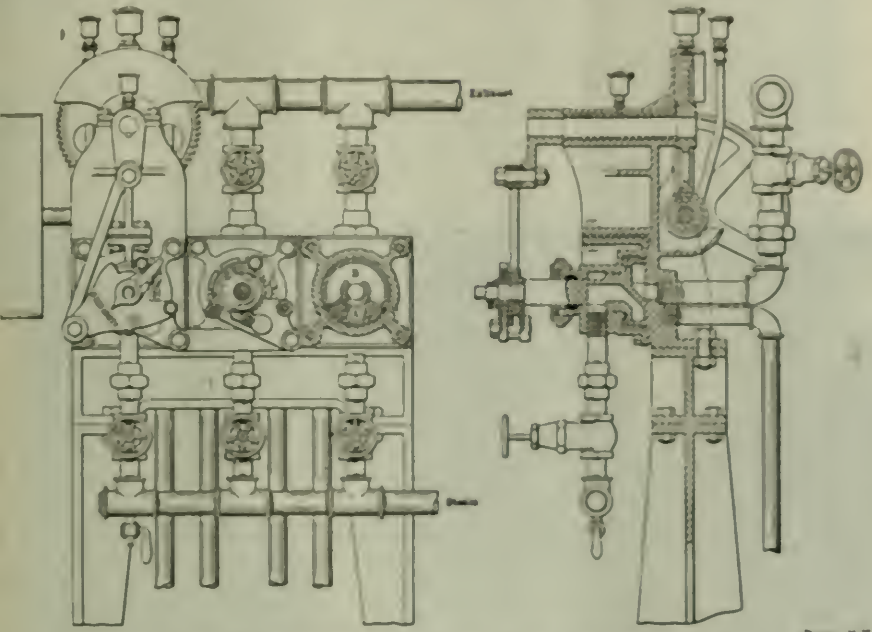


FIG. 7. DETAILS OF COLE AUTOMATIC VALVES FOR STOKER CONTROL

ot gases. The cast-iron rings, aside from rotecting the steel tube, give increased eating surface due to the corrugated ffect. The heating surface is so arranged that the entering steam is brought n contact with the cooler gases as they eave the superheater, the direction of the low of the steam being contrary to the irection of flow of the gases. The supereater is supported on a complete selfontained structural-steel framing, indeendent of the brickwork, which was fterward built into the frame.

In operation a fire is maintained on he grates by hand, and the temperature s controlled automatically by means of thermocouple in the steam outlet to he superheater, which is connected to a elay by which a large solenoid is operted. The solenoid opens or closes valves o a hydraulic piston, which in turn acts irectly on the dampers. A separate coal hute is provided for the superheater, and atural draft is depended on entirely, the ases passing into the main flue under he boiler room floor.

Turbine Room

The turbine room, which occupies about ne-half the power-house building, is ined with light colored pressed brick and urnished with an 8-foot wainscoting of hite enameled brick. Great pains have een taken with the painting and finishing f the machines, so that the plant presents n exceptionally neat appearance. A 15-on Northern hand-operated crane is installed here. About one-half the floor is cut away, forming the pit shown in Fig. 9, in which are located the fan engines and circulating pumps.

The Westinghouse Parsons turbo-units constitute the generating equipment. They deliver three-phase current at 3300 volts, 25 cycles, and are rated at 1250 kilowatts, with the further ability to deliver their full rated load on one phase. The steam ends have the standard bypass arrangement for overloads, and a speed-limiting device to shut off the steam in case of an excess of speed. The generators are completely enclosed and are ventilated by air drawn through the coils by vanes installed on the rotor.

While the requirement to deliver full load from a single phase results in a larger and more expensive generator, it also carries with it a number of advantages. There are a considerable number of shop motors and pumping outfits connected to the system, all of which may be operated advantageously on three-phase current. Again, there is always the possibility of wanting to use power at some greater distance, in which case three-phase transmission would be desirable. Finally, in case of general electrification of the road at any future time, the machines would be in shape to operate in parallel with the rest of the system without any change in equipment, and in this event considerably more than the present rating of the generators would be available on the three-phase circuits.

Barometric jet condensers are installed in connection with the turbines. They are of the Worthington type and have 30-inch exhaust connections, with 14-inch automatic relief valves leading to the atmosphere through spiral-riveted pipe of the same size. Condensing water is supplied by two 10-inch volute pumps, driven by 7x9-inch vertical engines taking the water supply from wells connecting with the St. Clair river through 18-inch tile lines which terminate in a concrete intake protected by a structural-steel grid and screen-wire screen at the dock line.

Another 18-inch tile pipe line carries the overflow from the hotwells to the sump under the feed pumps, the excess

FIG. 8. SEPARATELY FIRED FOSTER SUPERHEATER

water flowing to the river. On the main floor near the condensers are located the straight-line rotative dry-vacuum pumps, with 8x0x12-inch cylinders. One motor-driven exciter of 40 kilowatts capacity is installed for ordinary service, with a squirrel-cage 3300-volt induction motor taking current from the busbars. In addition each unit has a Westinghouse steam-driven exciter in reserve.

Switchboard

Ten switchboard panels, all of standard Westinghouse construction, are required to distribute the electrical output. The may be thrown on either the alternating-current busbars or on the 110-volt direct-current exciter circuits. All of these panels are equipped with ammeters, voltmeters and indicating wattmeters. In addition recording wattmeters are installed to measure the output on locomotive service, pumping service and lighting service.

A Tirrill regulator controls the voltage of the generator carrying the locomotive load, and this is mounted on a special instrument panel at the left end of the board. All lighting, including the mercury-arc circuit for illuminating the terminal cover of which is seen in Fig. 2, and conduits are laid in the tunnel on each side of the track.

Aside from the power and lighting load in the roundhouses and buildings at the Port Huron and Sarnia terminals, the greatest load outside of the traction service is for emergency pumping in the tunnel. It will be understood that the long open inclined approaches previously mentioned, occupy in the aggregate, considerable territory; in fact on the American side this amounts to approximately 11 acres, and on the Canadian side 13 acres. It is important to take care of

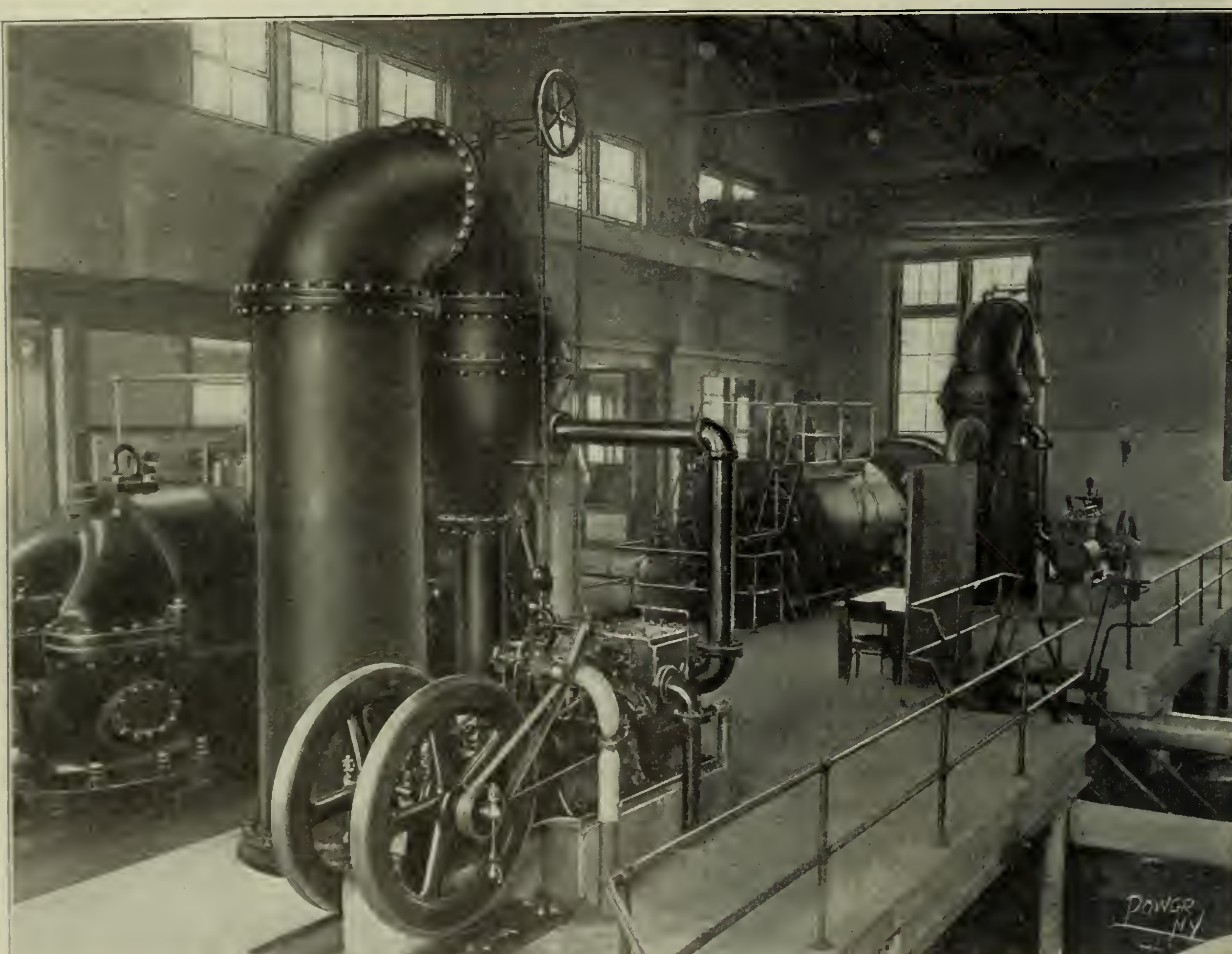


FIG. 9. GENERAL VIEW IN TURBINE ROOM

high-tension oil switches are located in an inclosed switchboard directly behind the board. There are two main generator panels located in the center of the board, as evident in Fig. 10; one for the locomotive power circuit, one each for three-phase power and pumping, and an arc-light panel. The output from the two steam-driven exciters is concentrated on one panel and that of the motor-driven exciter occupies another. One power-house panel takes care of the power and light in the engine and turbine rooms. Connections are so arranged that the lighting here, which is by Nernst lamps, yards, is carried by this machine to take advantage of the closer regulation. The station voltmeters, frequency indicator and synchroscope are also mounted on the same panel.

Facing the switchboard on the opposite side of the operating floor is a gage board carrying all necessary indicating and recording instruments for the boiler plant, so that in connection with the corresponding electrical data on the switchboard, everything is conveniently at hand for the operating engineer. Feeders from the switchboard enter the tunnel through a shaft in the power-house yard, the the rainfall on this area to prevent the tunnel from being flooded, and for this purpose centrifugal motor-driven pumps have been installed, operating at 3300 volts, 25 cycles and displacing the steam pumps formerly used. Fig. 11 shows the interior of one of these pumping stations.

At the Port Huron portal there are two pumps with a capacity of 4000 gallons per minute driven by 100-horsepower induction motors, and at Sarnia there are two of 5500 gallons capacity connected to 200-horsepower motors. In addition, each pump house has a small 150-gallon outfit for pumping out surface water which

FIG. 10. SWITCHBOARD

dinarily finds its way into the approach. Two similar pumps are located at the foot of the Sarnia grade to take care of condensation and seepage water in the tunnel. It is arranged so that water falling on the sides of the incline can be impounded in reservoirs, leaving only that falling on the central portion of the grade to be immediately handled by the pumps during a rainstorm. The reservoirs may then be emptied at leisure.

Operating Features

Fig. 12 gives in graphical form the operating data during a train movement, the total weight of which, including locomotive, was 1020.5 tons. A study of the chart will show the power required at any instant and the variation of temperature, pressures, etc., occurring simultaneously. It will be noted that there is really a remarkable ability on the part of the plant as a whole to maintain normal conditions regardless of load.

As the load comes on absolutely without warning, the first indication given to the firemen is usually the speeding up of the pulleys driving the Cole regulating valves. When this takes place about

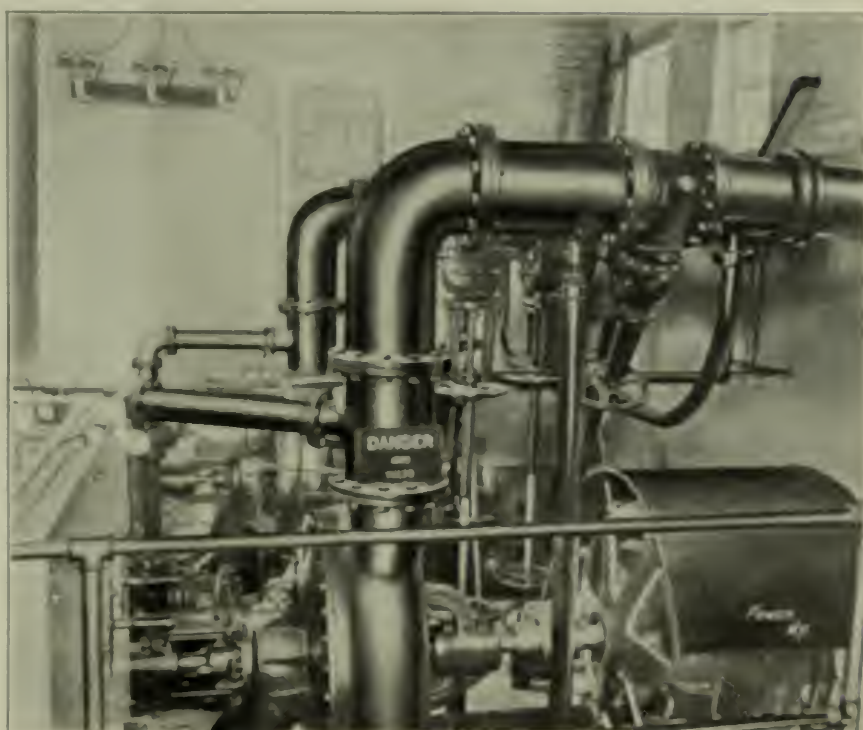


FIG. 11. INTERIOR OF ONE OF THE PUMPING STATIONS

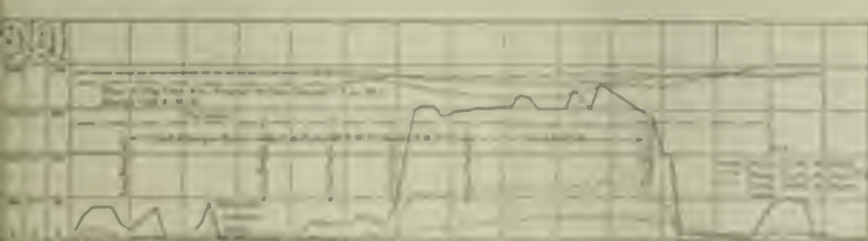


FIG. 12. GRAPHIC LOG OF OPERATING DURING ONE TRAIN CYCLE THROUGH TUNNEL

six shovelfuls of coal are thrown on the superheater fire. At the time of the writer's visit to the plant a load came on with the steam at 195 pounds. It fell very quite rapidly to 180 pounds, immediately starting to come back, and when it had reached 200 pounds the load dropped off. Meantime the superheater temperature dropped from 455 degrees to 420 degrees at a rate corresponding approximately to the drop in steam pressure. The temperature then gradually returned to 455 degrees, at which point it registered when the load went off, as indicated by the slowing down of the Cole automatic mechanism. When the load had completely subsided neither the steam pressure nor superheat rose appreciably above the figures given.

By consulting the recording gages in the turbine room it was afterward found that the peak load at this time was 1200 kilowatts, an overload of 65 per cent. The forced draft before the load was 0.3 inch of water and during load 2.5 inches.

The recording-gage charts at this plant are changed at midnight, and by a careful inspection of the variations for this particular day, it was found that the fluctuations had all kept within the limits given above, so that they may be considered as fairly representative of what the plant does under ordinary conditions. The largest momentary load ever carried up to the present writing is stated as 2045 kilowatts—more than 150 per cent. overload.

The forty-first annual commencement of Cornell University was held Thursday, June 17. Two hundred and twenty-five graduates received the degree of mechanical engineer, including seventy-five who have specialized in electrical engineering. Two years ago the electrical course was improved by the addition of a junior laboratory course, and the present class is the first to graduate with this complete course.

Manganese, the hardest of the common metals, is half as hard as the diamond.

Blowers as Breakdown Insurance

By C. M. Ripley

One difficulty the engineer meets with in dealing with "the boss" is due to the frequent inability to state a proposition of an engineering nature so that it will be fully understood by the commercial or financial mind of his employer. Many an engine room would contain much-needed improvements, for which the engineer could not obtain an appropriation, if he had pleaded his cause properly.

The president or treasurer of a company must not be dazzled by technicalities, nor must he be confused in a maze of engineering facts. He must be made to see the *commercial* side of the proposition. He must be made to realize that if a certain sum of money is *invested*, the improvement so purchased will yield him an annual return in reduced operating expenses. His mind always has been and always will be best appealed to by talking in dollars and cents and annual percentage income, rather than in pounds of coal, gallons of water, B.t.u., etc.

A Blower, for Example

Let us take, for instance, a blower. The engineer knows that if a blower were installed for, say, a plant with two boilers, the following results not only would be expected, but could be positively guaranteed:

A cheaper fuel could be burned, furnishing, say, 9,000,000 B.t.u. for a dollar instead of 6,000,000.

Any defects in the draft would probably be remedied.

When one boiler needed cleaning, the other could be forced to carry the load.

A breakdown in one boiler could be immediately repaired by forcing the other boiler to carry the load.

But the president of the company never heard of a B.t.u., and as for draft, little does he realize how the draft up the chimney vitally affects his bank account. The cleaning of the boiler means to him probably nothing more than does the cleaning of the marble wainscoting in the main hall.

What the Boss Wants to Know

The engineer would more frequently have his recommendations O. K.'d and new improvements put under way if he were to talk to the president or general manager in the following manner:

"If we were to spend a little money in a blower, I figure—and I am ready to back it up at the cost of my position—that it will bring a return to us of 200 per cent. per annum, if not more. I consider this to be a very wise move for the following reasons: (1) We burn 2000 tons of coal a year, costing $8200. (2) With blowers we could get along with coal costing $2.80 per ton instead of $4.10 per ton. (3) The difference is $1.30 on every ton that is delivered and will amount to over $1800 per year. (4) The cost of making such changes is less than $500. (5) Therefore this investment will annually save us over three times the first cost, i. e., return 300 per cent. per annum. (6) I have personally investigated in odd hours other plants (naming them) where this change has been made and conditions in our plant are almost identical with these. (7) Besides this great saving every year, a blower will almost serve as an extra boiler, and will be as good in case of a breakdown of either boiler as would a third boiler held in reserve. (8) Our fuel bills will be bound to increase unless I am able to close down each of the boilers every few months and remove the scale from the tubes. This I can do, if a blower is installed, with the least possible danger, and without the need of outside help, since the other boiler can do almost double work by merely starting the blower. (9) I hold the position of chief engineer for you and receive more salary than a mere engine man, because I am expected to keep the plant operating as cheaply as possible; because I am expected to furnish absolute reliability of service, and I am expected to keep the machinery modernized and with the least amount of depreciation. (10) It is my judgment that this change is necessary from my standpoint and will prove a splendid investment on the books of the company."

The blower is but one example of a great many valuable improvements. As soon as the engineer is better able to explain the financial side of the operating questions with which he has to deal, and present them as *investments*, not as expenses, then the efficiency of isolated plants will increase and there will be fewer men thrown out of employment by the central-station service.

Killed and Injured in Boiler Explosion

One man was killed, another probably fatally hurt and two others severely injured when the boiler of a portable sawmill in the woods near Parker's mountain, about 14 miles from the city of Rochester, N. H., exploded June 14.

The largest piece of the boiler was blown over 500 feet and sections were picked up at much greater distances. The fireman was blown into the air and died within a few moments. Another man was terribly scalded and was so near the boiler that part of the contents of the furnace were scattered over him, burning most of his clothes. His condition was considered serious and it was not thought he could recover.

The exact cause of the explosion is not known, but the boiler is believed to have burst under a high steam pressure.

Sizes of Fuses for Three-Phase Motors

By N. A. Carle

In selecting the sizes of fuses for three-phase alternating-current motors it is necessary to make some assumption as to the probable power factor of the motor in operation and, knowing the efficiency of the motor from the manufacturer's guarantee, calculate the amperes required to operate the motor at full load.

It is customary to install fuses with a capacity from two to three times the calculated amperes at full load to provide for the excess current demanded to start the load.

The formulas covering the various operations to be performed in calculating the amperes at full load are as follows:

$$\frac{\textit{Horsepower} \times 746}{1000} = \textit{Kilowatts Output}$$

$$\frac{\textit{KW. Output}}{\textit{Motor Efficiency}} = \textit{Kilowatts Input}$$

$$\frac{\textit{KW. Input}}{\textit{Volts} \times \textit{Power Factor} \times 1.732} = \textit{Amperes.}$$

Combined into one formula:

$$\frac{\textit{Horsepower} \times 746}{\textit{Motor Efficiency} \times \textit{Power Factor} \times 1.732 \times \textit{Volts}} = \textit{Amperes.}$$

The chart on page 1143 is designed to show the sizes of fuses to use for three-phase alternating-current motors up to 200 horsepower for the usual limits of the variable factors entering into the calculations in the foregoing formula. This chart is so designed that for motors above 100 horsepower, 400-440 volts must be used. Either 200-220 or 400-440 voltage circuits can be used in calculations for motors of less than 100 horsepower.

Examples

(1) If the efficiency and power factor of a 50-horsepower three-phase motor operating at 200 volts is 85 per cent., what size of fuse, with a factor of safety of 2.5, should be installed in each wire?

Starting with 50 horsepower read up to 85 per cent. motor efficiency, then across to 85 per cent. power factor, then down to 200 volts, then across to 2.5 factor of safety, and then down to 375 amperes as the capacity of fuses to be installed in each wire.

(2) If a 100-kilowatt motor operating at 440 volts has a power factor of 90 per cent. and an efficiency of 85 per cent., what size fuses should be installed in each wire, if the starting current is assumed to be equal to three times the operating current at full load?

Starting with 100 kilowatts read up to 85 per cent. motor efficiency, then across to 90 per cent. power factor, then down to 440 volts, then across to 3.0 factor of safety, and then down to 515 amperes as the capacity of fuses to be installed in each wire.

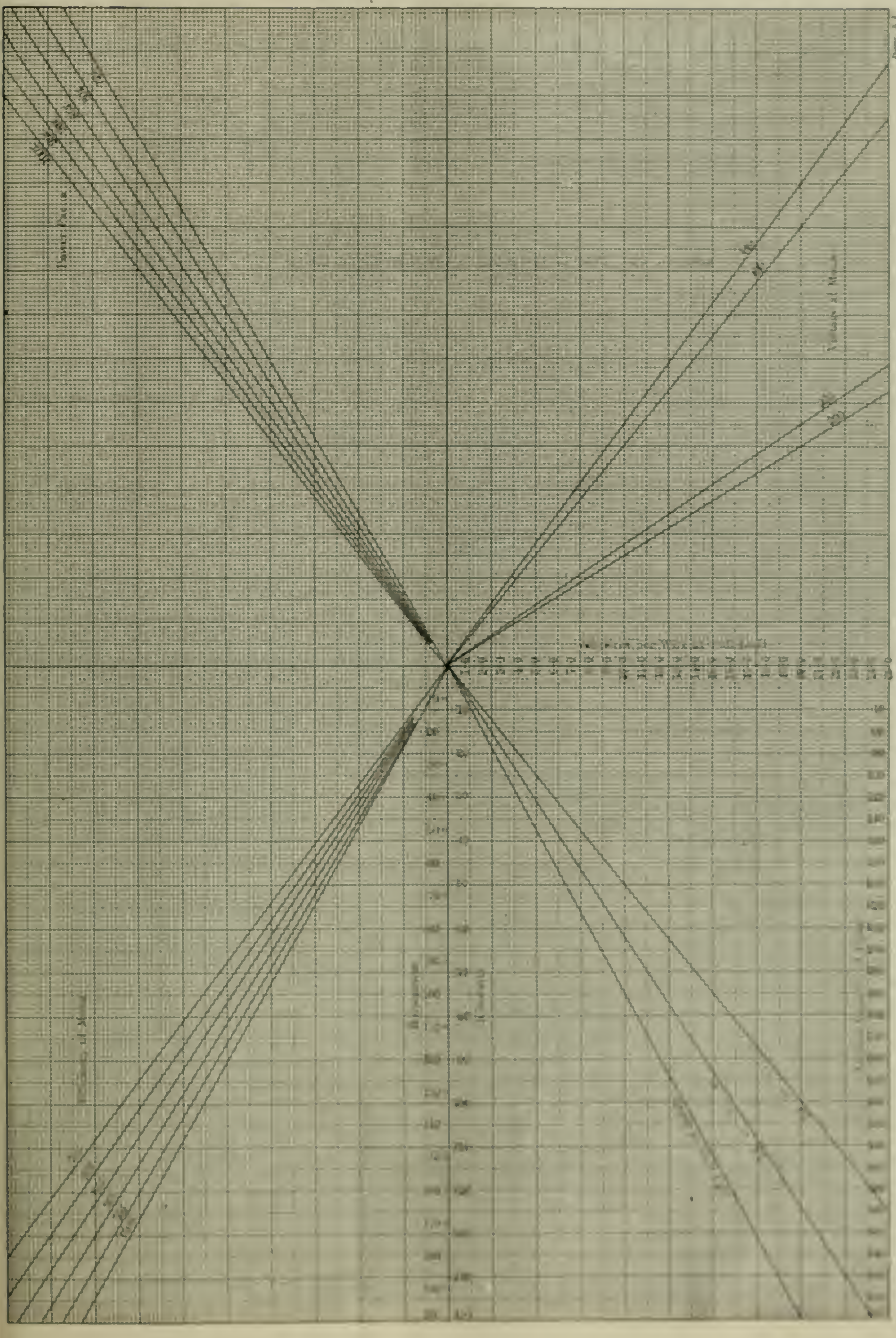


CHART FOR CALCULATING THE SIZE OF PLANT FOR THREE-PHASE ALTERNATING-CURRENT MOTORS

Heat Transmission into Boilers

Possible Ways of Utilizing More Fully the Heat Absorbing Ability of Steam Boilers to Obtain Better Economy and Higher Capacities

HENRY KREISINGER AND WALTER F. RAY

The investigations which are detailed in this article are the result of the study of one of the many problems growing out of the general plan of the United States Geological Survey to increase the efficiency with which the coals of the country are being used. Greater efficiency requires better boiler and furnace design and means the conservation of the fuel resources of the country. These special investigations have been undertaken by the Technologic Branch of the Survey, of which Dr. J. A. Holmes is the expert in charge, and H. M. Wilson, chief engineer. J. C. Roberts, engineer locally in charge of the Pittsburg plant, has given the work every possible encouragement. These experiments are directly under the charge of L. P. Breckenridge, consulting engineer, and D. T. Randall engineer-in-charge of tests, and are part of a carefully prepared plan of general investigations into fuels. The experiments are now being continued at the Geological Survey testing station at Pittsburg, Penn.

The object of this article is to treat of the heat-absorbing ability of steam boilers, and to point out possible ways of more fully utilizing this ability in getting both better economy and higher capacities from steam boilers. By a steam boiler is meant only the metallic vessel which holds water and steam and which absorbs heat, aside from the furnace whose function it is to liberate the heat from the fuel.

True Boiler Efficiency

The amount of heat a boiler will absorb per unit of time depends almost entirely on the amount of heat available for absorption. Not all of the heat which is liberated in the furnace nor all the heat which is delivered to the boiler is available for absorption. Heat flows of its own accord only from bodies at higher temperatures to bodies at lower temperatures, so that only that part of the heat which is above the temperature of the boiler will flow into the latter and therefore is available for absorption; heat below the temperature of the boiler will not flow into it and is not available for absorption.

For example, supposing 4 pounds of furnace gases at 2500 degrees Fahrenheit are delivered to a boiler operating under a pressure of 100 pounds by gage. The temperature of the water in the boiler is 337 degrees Fahrenheit. Assume that the specific heat of the gases is 0.25 and that it does not vary with temperature. The heat in the gases which is available for the boiler is then,

$$4 \times 0.25 \times (2500 - 337) = 2163 \ B.t.u.$$

Heat below 337 degrees Fahrenheit is below the temperature of the boiler and cannot be absorbed by it.

In practice no boiler absorbs all the available heat and the gases leave the boiler from one to several hundred degrees higher than the boiler water, according to how good or how poor a heat absorber the boiler is. The heat which the boiler does absorb, expressed in percentage of the heat available for absorption, is the true measure of the boiler's ability to absorb heat and has been given the name *True Boiler Efficiency* by the United States Geological Survey. The true boiler efficiency is then the ratio,

$$\frac{\textit{Heat absorbed by the boiler}}{\textit{Heat available for absorption by the boiler}}.$$

Thus, supposing that in the previously given illustration the 4 pounds of gases are cooled by the boiler from 2500 degrees Fahrenheit to 550 degrees Fahrenheit, we have then as the heat available to the boiler.

$$4 \times 0.25 \ (2500 - 337) = 2163 \ B.t.u.$$

The heat absorbed by the boiler is,

$$4 \times 0.25 \ (2500 - 550) = 1950 \ B.t.u.,$$

and the true boiler efficiency is,

$$\frac{1950}{2163} = 90.1 \ \textit{per cent.}$$

If the atmospheric temperature is 50 degrees Fahrenheit, then in the above case the heat in the gases above atmospheric temperature, delivered to the boiler, is

$$4 \times 0.25 \ (2500 - 50) = 2450 \ B.t.u.,$$

and the ordinarily used boiler efficiency is,

$$\frac{1950}{2450} = 79.6 \ \textit{per cent.}$$

The difference between the two efficiencies occurs in the denominators. In the true boiler efficiency the denominator is the heat available to the boiler, which heat has for its base line the temperature of the boiler water or steam, while in the ordinarily used boiler efficiency the denominator is the heat above atmospheric temperature delivered to the boiler, which, of course, has for its base line the temperature of the atmosphere. True boiler efficiency has the advantage over the ordinarily used boiler efficiency that it takes care of the variation of the temperature of the furnace gases as well as the temperature of the boiler due to different steam pressures. In other words, true boiler efficiency does not blame the boiler for lessened useful effect caused by low temperature of furnace gases, which is really the fault of the furnace, nor does it blame the boiler for absorbing less heat when the temperature of the boiler water is raised by raising the steam pressure.

Thus, for an example, supposing two boilers A and B are exactly similar in size, construction and setting and both are operated under a pressure of 100 pounds by gage. Suppose boiler A is supplied with 4 pounds of furnace gases per second at 3050 degrees Fahrenheit, while 8 pounds of gases are supplied at 1550 degrees Fahrenheit to boiler B; and also suppose that the temperature of the atmosphere is 50 degrees Fahrenheit. It is evident that the boiler getting gases at the higher temperature will absorb much more heat than the boiler getting them at the lower temperature, even if the gases supplied to each boiler contain the same quantity of heat above atmospheric temperature. Substituting these values, the heat above atmospheric temperature supplied to boiler A per second =

$$4 \times 0.25 \times (3050 - 50) = 3000 \ B.t.u.;$$

the heat above atmospheric temperature supplied to boiler B per second =

$$8 \times 0.25 \times (1550 - 50) = 3000 \ B.t.u.;$$

the heat available to boiler A =

$$4 \times 0.25 \times (3050 - 337) = 2613 \ B.t.u.;$$

and the heat available to boiler B =

$$8 \times 0.25 \ (1550 - 337) = 2426 \ B.t.u.,$$

Supposing further that the temperature of the gases leaving boiler A is 700 degrees Fahrenheit and that of the gases leaving boiler B is 470 degrees Fahrenheit. Many experiments made by the Geological Survey on large boilers and also on small models show that the temperature of the leaving gases would be about as assumed above. The heat absorbed by boiler A is

$$4 \times 0.25 \times (3050 - 700) = 2350 \ B.t.u.$$

and the heat absorbed by boiler B is,

$$8 \times 0.25 \times (1550 - 470) = 2160 \ B.t.u.$$

The true boiler efficiency of boiler A is

$$\frac{2350}{2613} = 90 \text{ per cent.},$$

and of boiler B,

$$\frac{2160}{2426} = 89 \text{ per cent.}$$

or very nearly the same as of boiler A. The ordinarily used efficiency would give boiler A credit for

$$\frac{2350}{3000} = 78.4 \text{ per cent.},$$

and boiler B credit for

$$\frac{2160}{3000} = 72 \text{ per cent.}$$

On comparing the efficiency in the two cases, it is seen that the true boiler efficiencies are very nearly the same, while the ordinarily used efficiency is over 6 per cent. lower for boiler B than for boiler A. It is apparent that the drop in useful effect of boiler B is caused by some defect of the furnace construction or its operation, and, therefore, should not be charged against the boiler, but rather against the furnace.

A moment's reflection will show that if the steam pressure is kept nearly constant and if the same quantity of heat is put into twice the weight of gases at half the temperature, twice the quantity of heat is below the temperature of the steam and, therefore, not available for absorption. It may be asked why the true boiler efficiency has been devised. The answer is, to study the heat-absorbing ability of a boiler independently of the operation of the furnace. In studying any complicated problem such as a steam-generating apparatus presents, it is necessary, if any general deductions are to be drawn, for as many of the variable factors to be eliminated, or fixed, as possible, leaving only the ones (preferably two in number) which it is desired to study. In studying the function of the steam boiler proper, the first step was to eliminate the furnace and devise the measure of the boiler's ability. This latter has been done by devising the true boiler efficiency, and it now remains to study the ways in which heat gets from the hot furnace solids and gases into the boiler water.

Modes of Heat Travel

Fig. 1 shows diagrammatically a section through a boiler heating plate and the modes of heat travel. It is shown that the metal of the plate is covered on the gas side with a layer of soot, and on the water side with a layer of scale. Next to the soot layer and entangled in its recesses is a layer or film of gas. This film of gas under ordinary conditions adheres so tightly to the soot or metal that it may almost be considered a part of the plate. It is, therefore, reasonable to assume that the dry surface of the plate is located somewhere within this film of gas. The wet surface of the heating plate is perhaps in a similar film of water and steam adhering on the inside of the boiler to the layer of scale or metal plate if the boiler is clean. Through the metal plate and its coatings the heat is transferred from the dry surface purely by conduction. For constant physical conditions of the coatings the rate of heat flow depends only on the *difference of temperatures* between the dry and the wet surfaces of the plate.

The heat is imparted to the dry surface of the plate mainly in two ways: (a) By radiation from the hot fuel bed and furnace walls, and (b) by convection from the moving hot furnace gases. The convection of heat is the process of the particles of the moving gas coming in contact with the dry surface of the plate and giving their heat to it. In a large majority of the boilers of the water-tube type the heat imparted to the dry surface

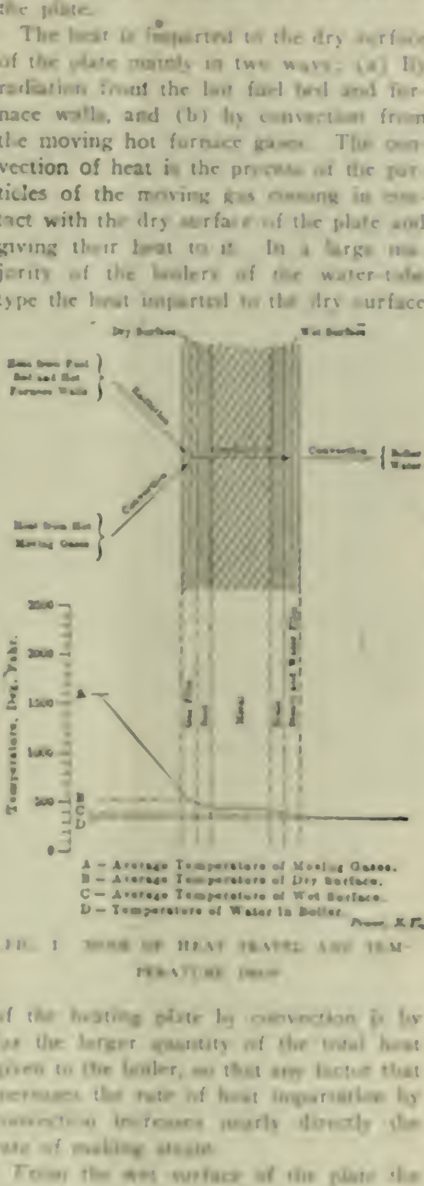


FIG. 1. MODE OF HEAT TRAVEL AND TEMPERATURE DROP

of the heating plate by convection is by far the larger quantity of the total heat given to the boiler, so that any factor that increases the rate of heat importation by convection increases nearly directly the rate of making steam.

From the wet surface of the plate the heat is carried into the boiler water mainly by convection. Here the conveying body is the circulating water which scrubs the bubbles of steam from the wet surface and puts more water in contact with it. It is reasonable, then, to say that the faster the circulation of water the faster the rate of heat transfer from the wet surface into the boiler water.

The heat which is communicated by radiation to the dry surface of the heating plate is approximately proportional to the difference between the fourth powers of the absolute temperatures of the fuel bed and furnace walls on one side and the temperature of the dry surface of the heating plate on the other.

According to this law the heat which the boiler receives by radiation increases rapidly with the temperature of the furnace. However, in modern water-tube boilers the heating plate exposed to radiation is so small a portion of the total heating plate that the rise in temperature affects the rate of making steam but little. Furthermore in well operated boiler furnaces the temperature cannot be raised much higher, so that there is very little hope of increasing the capacity of a boiler by raising the temperature of the furnace. The absorption of heat by radiation is aside from the aim of this article and will not be further discussed.

There is much more to be expected from convection. The quantity of heat imparted to the boiler in a unit of time can be increased by bringing more particles of gas into contact with the dry surface of the heating plate, thereby increasing the rate of making them. In fact, this is what has been done for years in locomotive and marine practice. In these types of boiler the capacity is increased by passing more gases over the heating plates, thereby bringing more particles of gas into contact with the dry surfaces of the plates.

Heat Imparted by Convection

Today it is a fairly well established law that the amount of heat imparted to a boiler plate by convection is very nearly directly proportional to the difference of the temperatures of the gases and the dry surface of the heating plate, times the velocity of gas passing over the plate, times the density of the gas. This law can be expressed by the equation,

$$H = C\,(T - t)\,v\,w$$

where

H = Heat imparted to a unit surface of heating plate per unit time,
C = Constant,
T = Temperature of moving gases,
t = Temperature of the dry surface,
v = Velocity of gases moving over the surface,
w = Density of the gas.

This law, originally proposed by Prof. Osborne Reynolds, was lately derived by Prof. John Perry of England. It is not hard to see why this law should be such as it is. If more gas is passed over the heating plate, more particles come in contact with the dry surface and, therefore, more heat is given to the surface in a unit of time.* Again, if these particles are at

*Strictly, this statement that the number of particles of gas striking the dry surface of the heating plate increases nearly directly with the velocity of gas passing over the [illegible] higher temperature, the heat will flow faster from these particles of gases into the surface and more heat will be given to the plate by each contact of each gas particle; also if the gases are denser, that is, if these particles of gases are closer together, more of them will come into contact with a unit of dry surface in a unit of time and, therefore, more heat is given to the plate. Unfortunately, when the temperature rises, the gases expand and the density drops, so that at high temperatures what is gained by the rise in temperature is nearly lost in the reduction of the density. This is the reason why in the two given examples the boiler receiving the gases at 1500 degrees Fahrenheit absorbs almost the same percentage of the heat available as the boiler receiving heat at 3030 degrees Fahrenheit.

By extending this law still farther, it can be seen why fire-tube boilers with small tubes are more efficient than those having large tubes, or water-tube boilers having small tubes close together are better heat absorbers than those having large tubes farther apart. For an example, take one fire tube 2 inches in diameter, and one 4 inches in diameter; in the 2-inch tube the particles of hot gas near the center of the tube are twice as near to the dry surface of the tube as the gas particles in the center of the 4-inch tube and, therefore, in the first tube the gas particles in the center can come in contact with the surface about twice as easily as in the second tube. Similar reasoning will show the same advantage for small air passages against large ones in water-tube boilers. If the 2-inch tube is of the same length as the 4-inch one and the same weight of hot gas is passed through both, the 2-inch tube will actually absorb more heat than the 4-inch, although the latter has twice as much heating surface. This explains why boilers of locomotives are more efficient than multitubular boilers used for stationary purposes.

In the locomotive boiler in the attempt to get larger amounts of heating surface, the tubes ordinarily used are much smaller (about 2 inches) than in stationary multitubular boilers. Within certain limits a 2-inch tube 10 feet long will absorb about the same amount of heat as a 4-inch tube 20 feet long, although the latter has four times as much heating surface as the former, provided the same weight of gases at the same temperature is put through both tubes. In fact, any tube whose ratio of diameter to length is (10 × 12) ÷ 2, will absorb approximately the same amount of heat under the above conditions. By making this ratio larger more heat in percentage of the total heat available for absorption can be absorbed by the tubes.

The quantity of heat imparted to a tube depends upon the number of contacts the particles of gas make with the dry surface of the tube.

In a small tube the particles of gas being closer to the surface make contact with it quicker and, therefore, the same number of contacts is made in a shorter length of the tube than would be the case in a tube of a larger diameter. Giving this law a full consideration, if all other factors were known, a boiler designer can design a boiler for any true boiler efficiency. It is not so much the amount of heating surface which determines the efficiency of a boiler, but the arrangement of it.

This law has been derived by Prof. John Perry, of England, from purely theoretical considerations and has been found to be very nearly true by laboratory experiments made by the United States Geological Survey.

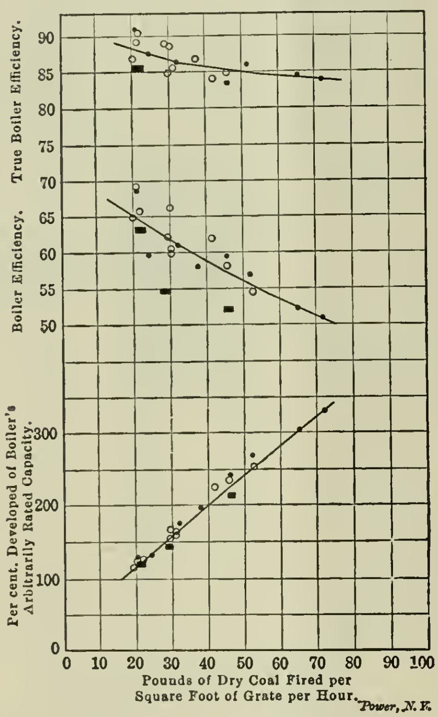


FIG. 2. RELATION OF CAPACITY AND EFFICIENCY TO RATE OF COMBUSTION

Rate of Heat Travel

It will be asked, can the heating plate of a boiler transfer any quantity of heat? The answer is, that it can transfer several times more heat than it does at present, especially in stationary-boiler practice. This answer, however, provides that the scale and soot are not unreasonably thick. The heat conductivity of iron at 400 degrees Fahrenheit given in the Smithsonian physical tables is about 0.0005. This means that if the two surfaces of a steel plate 1 inch thick are kept at a temperature difference of 1 degree Fahrenheit, every square inch of the plate will transmit 0.0005 B.t.u. per second; if the temperature difference is 10 degrees Fahrenheit, 0.005 B.t.u. will be transmitted, or if the thickness of the plate is 0.1 inch, the temperature difference of the surfaces being 10 degrees Fahrenheit, 0.05 B.t.u. are transmitted for every square inch per second.

The walls of the tubes of water-tube boilers are about 0.1 inch thick; the tubes of a locomotive are probably thinner. Let us figure what the temperature difference of the two surfaces of a tube 0.1 inch thick is at various rates of making steam. At the rate of 10 square feet of heating plate per boiler horsepower the heat transmitted per square inch per hour is,

$$\frac{34.5 \times 965}{10 \times 144} = 23.1 \textit{ B.t.u.},$$

or

$$\frac{23.1}{60 \times 60} = 0.0064 \textit{ B.t.u. per second.}$$

To transmit this quantity of heat requires a temperature difference between the two surfaces of

$$\frac{0.0064}{0.005} = 1.3 \textit{ degrees Fahrenheit.}$$

If only 1 square foot is taken to do the same work, the temperature difference would be 13 degrees Fahrenheit; if the same amount of work is required from 0.1 square foot, the temperature difference would be 130 degrees Fahrenheit.

These figures show that the resistance of the metal to heat transfer is very small, and that there is something else which is to be blamed for the low rate of steam production in steam boilers. Undoubtedly the soot and scale coatings are to be blamed for part of the resistance. However, even if the temperature drop through the soot and scale is assumed to be 10 times as much as the temperature drop through the metal alone, it will be found that the combined temperature drop through the soot, metal and scale is only a small fraction of the total drop between the moving gases and the water in the boiler. Thus, referring to Fig. 1, the lower portion shows the temperature drop or gradient through a portion of a heating plate and the coating. It is shown that the drop through the soot and scale is 10 times that through the metal.*

For the normal rate of making steam the temperature drop through the metal is 1.3 degrees Fahrenheit, and through the soot and scale 13 degrees, making the total drop 14.3 degrees. Now, as heat is transmitted through the plate only by conduction and as the conditions and the conduction of the plate and coating generally cannot be changed, the temperature drop through the plate must be increased if more heat is to be transmitted through the plate. Thus if the rate of making steam is to be twice the normal, the temperature drop must be increased from 14.3 to 28.6 degrees Fahrenheit, or if the rate is to be 10 times the normal the temperature drop would have to be 143 degrees Fahrenheit, and so on. It is ap-

*The authors have assumed "10 times" simply as a matter of convenience.

arent that even at 10 times the normal ate of making steam the temperature rop through the plate and its coatings is erhaps about one-tenth of the total temerature difference between the boiler ater and the gases.

In well-operated boiler furnaces the emperatures are 2500 degrees Fahrenheit, r higher; if the boiler works under a ressure of 150 pounds, the boiler-water emperature is about 365 degrees Fahrenheit. Assuming that the gases leave the eating plates of the boiler at 600 degrees ahrenheit, the total temperature drop etween the boiler water and the gases is t the furnace end of boiler,

$$2500 - 365 = 2135;$$

nd at the uptake end of boiler,

$$600 - 365 = 235.$$

he approximate average is 1180 degrees ahrenheit. If the boiler generates steam t a rate averaging one boiler horsepower er square foot of heating plate, which is

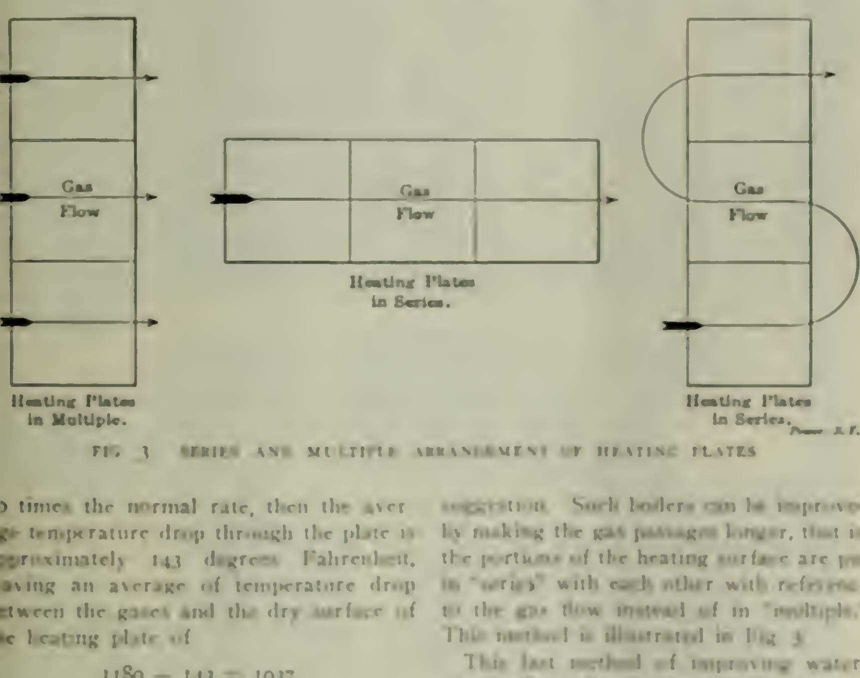


FIG. 3. SERIES AND MULTIPLE ARRANGEMENT OF HEATING PLATES

0 times the normal rate, then the average temperature drop through the plate is pproximately 143 degrees Fahrenheit, aving an average of temperature drop etween the gases and the dry surface of he heating plate of

$$1180 - 143 = 1037$$

Although these figures are only roughly pproximate, they serve to illustrate that *he slow rate of heat travel is not through he heating plate itself but rather from he hot gases to the dry surface of the eating plate.*

Temperature vs. Velocity of Gases

The logical conclusion, then, is that the late will take care of all the heat that eaches its dry surface, and this is where knowledge of Perry's law of heat imartation will be of service. It has been ointed out that according to this law he heat imparted to a unit of dry surace of heating plate varies directly as he difference between the hot gas and he dry surface, approximately directly as he velocity of gases flowing over the plate, and directly as the density of the gas. It has also been pointed out that when the temperature rises the density of the gas drops; that increasing the temperature beyond certain limits does not help much the rate of heat impartation; besides high furnace temperature is destructive to the materials used in furnace construction. It is the utilization of the velocity factor which offers a possibility of increasing both the efficiency and capacity of a boiler.

Improving Economy

As previously stated, the economy can be improved by making the gas passages smaller as compared to the length, that is, arranging the heating plates in such a way that the distance of the gas particles to the dry surface is the shortest possible. In some cases this arrangement is not practicable on account of difficulty in construction; water-tube as well as fire-tube boilers already installed cannot have the gas passages changed according to this suggestion. Such boilers can be improved by making the gas passages longer, that is, the portions of the heating surface are put in "series" with each other with reference to the gas flow instead of in "multiple." This method is illustrated in Fig. 3.

This last method of improving water-tube boilers already installed is successfully used by W. L. Abbott and A. Bement, of the Chicago Commonwealth Edison Company. A few years ago they rebaffled some of the Heine boilers at the Harrison street plant in such a way that the gases pass through the tubes three times instead of once, as they do in boilers with the usual standard baffling. Later, by the insertion of only one baffle, they made the gases flow twice through the tube chamber; with almost the same total draft they have obtained about the same capacity and from 6 to 15 per cent. higher efficiency.*

Increasing Capacity

The capacity of any boiler can be increased by forcing through the boiler larger weights of gases. If the weight of gases passed through the boiler per second is doubled, the velocity of the gas is doubled, with the result that the quantity of heat absorbed by the boiler per second is nearly doubled. It has been already mentioned that this method of increasing the capacity is used in locomotive and marine practice. In stationary boiler practice a good example can be quoted in the work of H. G. Stott and W. S. Finlay, Jr., of the Interborough Rapid Transit Company, New York City. They have added a stoker under the rear end of each of several Babcock & Wilcox boilers. This addition enabled them to burn nearly twice as much coal, resulting in twice the weight of gases of combustion being put through the boiler at nearly twice the velocity, and making the boiler absorb nearly twice as much heat as with a single stoker.**

It is true that when boilers are forced to make two or three times the usual amount of steam, the over-all efficiency drops somewhat. By using the methods for increasing the efficiency in connection with those for increasing the capacity, the latter could be increased without decreasing the efficiency, or even higher efficiency could be obtained.

Generally, when in locomotive or marine boilers the capacity is doubled or tripled, the over-all efficiency of the whole steam-generating apparatus drops several per cent., and it is said that the "boiler" is less efficient at higher rating. But when close examination is made of such results, it is found that at least two-thirds of the drop is due to incomplete combustion or other causes of low furnace efficiency. The true boiler efficiency, the true measure of the boiler's ability to absorb heat, changes but little. Fig. 2 shows results of 20 tests made by the United States Geological Survey on a torpedo-boat boiler. The true boiler efficiency is figured from the temperature drop of the gases while passing through the boiler. The method of computation was made as shown by the ratio:

[illegible]

The furnace temperature was taken with a Wanner optical pyrometer which was calibrated before each test. The flue-gas temperature was taken with a thermocouple.† The curves show that the com-

*For more detailed description of their work see United States Geological Survey's bulletin on "Heat Transmission in Steam Boilers." See also paper by present authors on "The Nature of True Boiler Efficiency," Journal Western Society of Engineers, Vol. XII, page [illegible].

**For a more complete description of this work see United States Geological Survey's bulletin on "Heat Transmission in Steam Boilers." See also paper by W. S. Finlay, Jr., read before the American Institute of Electrical Engineers, [illegible]

†For a complete description of the tests see United States Geological Survey's bulletin, [illegible] on a [illegible] Water-tube Boiler," by the present authors.

ery increases nearly directly with the rate of combustion; and that while the over-all efficiency drops 15 per cent., the true boiler efficiency drops only about 4 per cent. The true-boiler-efficiency curve indicates that the boiler keeps absorbing heat as fast as it is supplied. This fact agrees with the statement made previously that the faster the gases pass over the heating surface the faster the latter absorbs the heat.

In Fig. 2 the rectangles represent tests made on large square briquets, the solid circles represent tests made on small round briquets and the white circles represent tests made on run-of-mine coal.

New York's First Corliss Engine

By Thomas Wilson

One of the old vertical walking-beam type of engines made by Corliss & Nightingale in 1851 was the first Corliss engine to be installed in New York City. This engine is still in service and after its 58 years of almost continuous operation is practically as good as ever, and the probability is that it will be maintained in service for many years to come. The old engine, which bore the name "Enterprise," was exhibited at the World's Fair held in the Crystal Palace in New York in 1853, and was used to turn the shafting supplying power to other exhibits. The engine cylinder has a diameter of 20 inches and a stroke of 5 feet, standing 6 feet above the floor, and outside of the lagging has a cross-section 2 feet 1 inch by 3 feet. The top of the beam is approximately 15 feet above the floor, and from the center of the piston-rod pin to the center of the crank-arm pin measures roughly 14 feet. The crankshaft is 9½ inches in diameter, the crankpin 3¾ inches and the flywheel with a 2-foot space has a diameter of 18 feet.

In Fig. 2 it will be noted that the governor is hung from a bracket bolted to the frame of the engine, and from its lower end operates a bell crank, which in turn controls the movement of the steam valves. The dashpot for one of the valves is suspended from the cylinder, and the other rests on the floor. The valve gear itself is of the old familiar type used on early Corliss engines. It will be more apparent in Fig. 1 that the governor is driven by belt from the main shaft, with a gear connection interposed at the cylinder end. The beam is partially shown in Fig. 3, it being impossible to obtain good photographs of the engine in its present location on account of the limited space and the loft running immediately below the beam. The journal or pin projecting from the beam at the left in the photograph, was originally intended for connection to the air pump, but the condenser was never used with the engine.

In 1856 the engine was bought by Hall, Cornell & Co., afterward known as Hall, Bradley & Co., manufacturers of paints. It was used to supply power to their factory, and also some power to manufacturers in the immediate vicinity. Some time in the sixties G. F. Hall was engaged as chief engineer and remained a number of years with the firm until they moved to Brooklyn, their change of location being due to widening Elm street, now known as Lafayette. The additional width of the street cut off a portion of the engine room and made it necessary to seek other quarters. The engine was then sold to the chief engineer, G. F. Hall, who moved it to a basement in the immediate vicinity and continued to manufacture power for sale, only on a more extensive scale. The manufacturers in the entire block on both sides of the street were supplied from the one engine by means of long lines of shafting. The hardest work required of the old-timer was the rolling of lead block into thin lead sheets. This duty taxed it to the utmost and had to be performed at noon hours and after 5:30 when the other power was off. The engine continued in this service until 1897, and during all this time the only repair of any note required was a new cylinder, the original cylinder having been smashed by the beam, which had accidentally been allowed to fall on it.

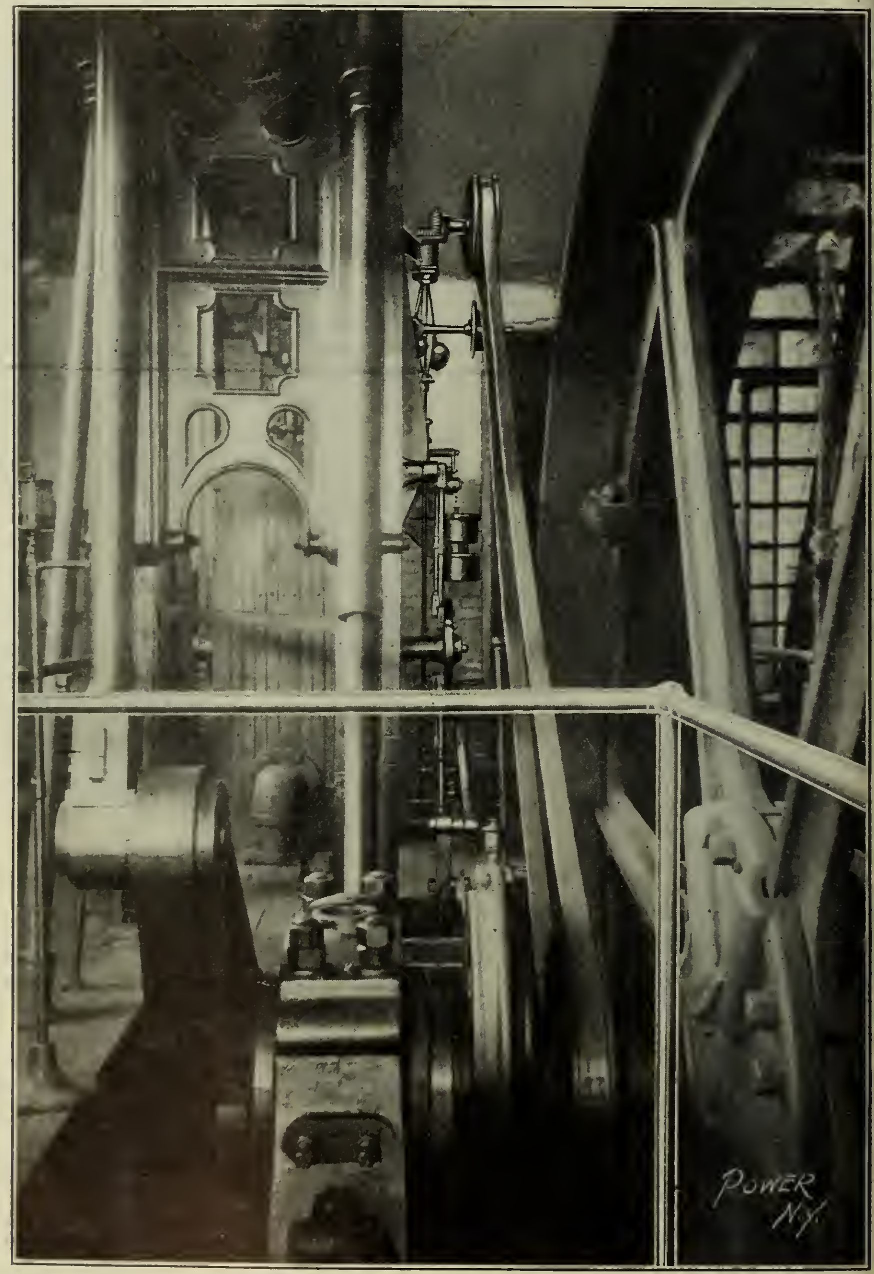


FIG. 1. THE "ENTERPRISE" AS SHE APPEARS AFTER 58 YEARS OF SERVICE

At the latter date the engine was sold by G. E. Hall, son and successor to G. F. Hall, to Wilson & Roake, of New York.

City, who had it in their possession for a few months. During this interval it was offered to the Stevens Institute and also to Cornell University as a relic of the early days of the steam engine, but as neither institution had space to store it, the engine was eventually sold in October of the year noted to the Raymond Rubber Company, of Titusville, N. J. This

FIG. 2 VALVE GEAR AND GOVERNOR

FIG. 3 THE BEAM

firm is a manufacturer of rubber goods from reclaimed rubber, and the engine is required to do the heavy work of the mill on 120 pounds steam pressure and at 35 revolutions per minute. It has been run almost continuously since its purchase, and frequently 22 hours a day. Nevertheless, it has given first-class satisfaction.

In 1905 the anchor bolts holding the main bearing to its foundation gave a good deal of trouble, and it was decided to put in new pillow blocks and an entirely new and heavier bearing of the same design. In the following year a new piston rod and cylinder head were required, as the former broke, due to imperfect alinement, and smashed the top of the cylinder to some extent. These are the sum total of the repairs made in 58 years. The engine now appears to be in good condition, and the present owner, who perhaps may be a little optimistic on the subject, claims that the "Enterprise" is good for 20 or 30 years more.

There are no data on the steam consumption of the engine, but a test performed by J. E. Holmes, director of machinery at the Crystal Palace, immediately after the fair may be of interest, although it is not nearly so elaborate as the tests of present-day practice. It appears that tests were conducted on December 17, 1853, on three engines, all of which were belted to the shafting and used for general power purposes in the Palace. The first was the engine under description, which was rated at 60 horsepower under a steam pressure of 70 pounds gage; the second

FRICTION AND REGULATION TEST

Time.	Steam Pressure	R. P. M.
7:00	12	37
7:10	32	37
7:20	27	37
7:30	22	37
7:40	18	37
7:50	19.2	37
8:00	7	37
8:10	4.5	36
8:15	3	34
8:20	2	28
8:25	1.5	18
8:30	1	14
8:45	0.75	7
8:50	0	stopped

was a double horizontal engine, 15x32 inches, with the two cranks set at right angles to each other and working a single-belt flywheel. This engine was rated at 60 horsepower under 60 pounds steam pressure and was built by the Lawrence Machine Shop under the agency of Gordon McKay. The third was a horizontal engine, 13x60 inches, known as the "Southern Belle," and was designed and constructed by J. S. Winter of the Winter Iron Works, Montgomery, Ala. The tests were conducted to show the regulation and friction of the engines, but the data relating to the "Enterprise" will be given only.

At 7 o'clock of the day of test the engine was started under load, with a pressure of 12 pounds gage; the number of revolutions made per minute were 37. At 7:20 the pumps were uncoupled from the Corliss-engine shafting without making any visible increase in its speed. One minute afterward the pumps were coupled again to the shafting, and with a pressure of only 27 pounds gage the speed of the engine was not retarded more than one-quarter of a revolution. At 8 o'clock the pumping machinery was detached, and with a steam pressure of 7 pounds gage the engine turned the long line of shafting, belts, loose pulleys, etc., 14 revolutions per minute. At 8:45 the engine made 7 revolutions per minute under 3/4 pound steam pressure, and four minutes later stopped. The complete data of the test of the "Enterprise" are given in the accompanying table, from which it will be noted that the friction of the engine and shafting apparently had but little effect, and the regulation under the existing conditions was exceptionally good.

Government Publications Relating to Water Power Development

By H. H. Clingerman

The extent to which publications by the Government assist in the preliminary investigations for the development of a water power is hardly anticipated by anyone about to enter this field for the first time. In many cases a good general idea of the amount of power available can be secured from Government publications.

From the "List of Publications of the United States Geological Survey Relating to Water Resources" can be selected various water-supply papers which may have a direct bearing upon the stream under consideration. These papers are available through application to the director of the United States Geological Survey. If the free supply has been exhausted, they can usually be secured at a nominal price from the superintendent of documents, Government printing office, Washington, D. C. The papers giving the stream measurements for each year are of particular importance since these records frequently cover long periods of time.

The relative stages of a stream are observed either from a rod or gage extending into the water at the lowest stage or a chain suspended from a fixed support on a bridge and lowered until it touches the surface of the water. That part of the chain extending above the point of support is measured by laying it out horizontally on a fixed scale. The chain is of known length and will reach from the point of support to a point in the stream below the low-water level. Gage heights determined by a chain are subject to a slight error in a high wind or a stream having a high velocity. At times of different river stages, the flow of the stream is determined by a current meter and from these data the discharge curve for the stream is determined. Reference to the curve or its equivalent in the form of a table will disclose the flow of the stream for any gage height and these gage readings are usually reported daily.

Such data furnish the basis for tables showing the maximum, minimum and average flow of a stream in cubic feet per second for each month, the rate of flow per square mile of the drainage area and the runoff in inches. There are various ways for arriving at the amount of power available from these figures. In a report of the Government engineers on "The Relation of the Southern Appalachian Mountains to the Development of Water Power," it is stated that it pays to develop water power up to the minimum during the four high months of the year. Another rough approximation in use is to take the average monthly minimum for an average year. In the New England States, it is said, the rule is to take the minimum for the third driest month starting with the driest month for an average year.

The flow of streams as determined from these publications on "stream measurements," is subject to inaccuracies due to error in the gage reading and incorrect data for the discharge tables owing to a possible variation in the contour of the river bed at the point of measurement after the rate of flow has been determined. The results, however, are valuable for preliminary investigations.

In cases where such data are not available a general idea of the real conditions of flow can be arrived at by a careful study of the relation of rainfall to runoff. The section director of the United States weather bureau can supply statistics on the rainfall in the drainage area of the stream to be investigated which, together with the ratio of runoff to rainfall as determined for streams subject to similar climatic and topographic conditions, will give the average rate of flow for the year. The minimum and maximum, similarly, can be estimated.

Each section of the weather bureau publishes an annual climatological report giving the precipitation per month for the year at various stations and its departure from the normal as deduced from records covering a considerable length of time. By plotting in the form of a curve the normal precipitation, the average time and duration of dry and flood periods are evident.

In some cases the Government has made surveys of rivers and these show the amount of fall available. The contour of the watershed is shown on topographic maps for certain sections of the country. The United States Geological Survey has been engaged since its organization in making a topographic map of the United States and the parts covered from time to time are noted on index maps. The topographic maps or "Atlas Sheets" are of uniform size and drawn on a scale of one or two miles per inch. The contour intervals may be as low as five feet.

The amount of information secured by the Government and available to the public should be sufficient to define to a limited extent the possibilities of a proposed hydroelectric development.

Boiler Explosion at Copperhill, Tennessee

By George L. Fales

The right-hand drum of one of the four National water-tube boilers at the plant of the Tennessee Copper Company exploded on the morning of June 1, at 12:50 o'clock, causing a property damage of some $5000, but there were no personal injuries. The boiler on which the drum exploded was insured with the Maryland Casualty Company, of Baltimore, which allowed a pressure of 175 pounds per square inch. The boilers are about ten years old, and have seen constant service all that time, but are in excellent condition, being clean and free from scale, although the tubes are getting thin. Each boiler has two drums 36 inches in diameter by 17 feet long and 120 four-inch tubes; the headers are of the box type holding six tubes each.

As shown in Fig. 1 the rupture occurred in the solid sheet along side of the longitudinal seam of the middle course on the right-hand drum of No. 2 boiler. An examination of the rupture immediately after the explosion disclosed the fact that the sheet had been developing a crack for some time, as the metal part way through the sheet was old and rusty, and the remainder showed a clean fracture; the crack in places extended nearly through the sheet, and other places had from 1/8 to 1/4 inch of good metal. The only part of the sheet that appears to have been sound clear through is the part showed in Fig. 3, at the hight-hand corner. The crack was a little under the overlapping part of the seam, and it would have been almost impossible to detect it by internal or external inspecetion.

The drums were constructed of 3/8-inch steel plate, with 7/8-inch rivets 15/16 inch when driven, pitched 2 3/4 inches on the longitudinal seam and 2 inches on the girth seam. The rivets in the longitudinal seam were not disturbed at all, being tight, and the seam in good condition; the rivets in the girth seams were sheared off, as shown in Fig. 1, in some places, and the sheet gave way in others. The explosion carried away all the wooden part of the boiler-room roof and blew all the windows, sashes and all, out of the building. Practically all the piping over the National boilers was blown off, flanges and valves breaking off and letting the pipe free. No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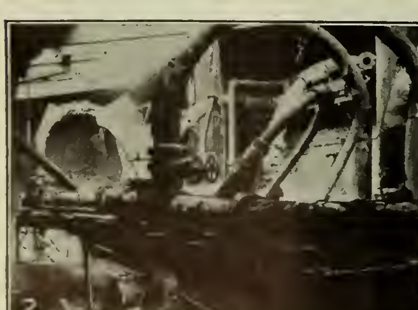
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VIEWS OF DAMAGE DONE BY BOILER EXPLOSION AT COPPERHILL, TENN.

FIG. 302. LARGE DIRECT-CONNECTED GENERATOR BUILT BY THE CROCKER-WHEELER COMPANY

ersonal injuries resulted, as the firemen nd other employees happened to be at the ther end of the boiler room near the Aultman & Taylor boilers, which were lso in service when the explosion occurred.

As soon as possible after the explosion he boilers which were not damaged were ut apart from the damaged section and ut on what good steam lines were left. The plant was in normal operation again ten hours from the time the explosion occurred, and measures were taken to ontinue its operation by repairing such amage as was immediately necessary.

Fig. 1 shows the exploded drum and sheet; Fig. 2 the damage above the boilers to the piping and roof, etc.; Fig. 3 hows a closer view of the ruptured sheet, lso the piece of sheet at the right hand hat had good metal all the way through it; Figs. 4 and 5 show views taken from bove the roof looking down on the oilers and piping from two different directions; Fig. 6 is a view taken from in ront of the boilers looking up, but does ot show much of the damage owing to the ight streaming through the roof.

At the time of the explosion the boilers were carrying steam at 160 pounds gage, and had 1½ gages of water in them. The oilers are inspected internally by the Maryland Casualty Company's inspectors very six months. The accident illustrates once more that the lap-riveted seam is dangerous, and emphasizes the fact that the butt-strap seam is none too good for joints of this character.

Catechism of Electricity

1071. *Illustrate and describe a large-size direct-current generator built for direct connection with the prime mover.*

Fig. 302 shows a generator of this kind built to give 600 kilowatts at 250 volts when run at a speed of 80 revolutions per minute.

The magnet frame *a* is of cast iron and is split horizontally, the two halves being aligned by dowel pins and held together by bolts *j*, *j*, etc. The lower half of the field-magnet frame is provided with feet drilled to receive the holding-down bolts and provided with leveling screws for adjusting the position of the magnet frame. The poles are of steel cast welded into the frame. Each pole is fitted with a cast-iron removable shoe *t*, which distributes the magnetic flux over the armature surface and serves also to retain the magnet coils in position. The air gap or clearance between the armature and pole faces is relatively large to reduce the bad effects resulting from a slight displacement of the armature from its true center.

The machine is compound wound and the magnet coils are separated from each other and the frame by spacers *n*, to provide free circulation of air between and around the coils. The series coils are wound of copper strip, connections between them being made by interleaving the multiple strips.

The arms *d*, attached to the hub *k*, support the toothed laminations of steel which form the armature core, and there are ventilating ducts in the core and end flanges. The armature conductors consist of flat copper ribbon, heavily insulated and retained in the slots by means of wedges. The commutator spider *h* is mounted on an extension of the armature spider and is therefore independent of the shaft *l*. A sectional clamping ring *r* permits removing a few bars of the commutator without disturbing the others.

The cast-iron rocker *s* is rigidly supported at *w*, *w*, from the magnet frame and has a tangential screw and hand wheel *w* for shifting simultaneously the position of all brushes. Each set of brushholders is supported on a bracket *o* clamped to the rocker ring and insulated from it. All the positive brush holders are connected to a copper bus-ring *u* mounted on one side of the rocker ring, and all the negative brush holders are similarly connected to a similar ring *v* on the other side of the rocker ring.

The Absorption Refrigerating Machine

The Different Parts and Their Functions Explained in a Simple Manner, with Practical Advice as to Its Care and Operation

BY W. E. CRANE

The absorption refrigerating machine is thought by many to be complicated and, therefore, it does not get the credit its merits deserve. When run by steam from the boiler it is simply a condenser, the heat being taken up by the machine and the resulting condensation going back into the boiler at the temperature it leaves the machine; while with the compression machine there is the loss of the exhaust steam, as with any engine.

About ten years ago a hotel proprietor wanted to put in a refrigeration plant and the writer introduced him to a refrigerating engineer. The hotel man had high-speed engines and lots of exhaust steam, but no excess boiler power nor room for more, and he wanted to do his refrigeration with exhaust steam. The engineer explained the relations of the temperatures to each other and showed by figures that it would never be possible to do the work with less than 65 pounds steam pressure. On our way home the hotel man said:

"I believe I can do it with exhaust steam."

Taking the proposition to absorption-machine builders they told him the same story the engineer did, and but one of them would consider the proposition, and then only on condition that the purchaser should be responsible for any failure. The machine was built and worked all right, at atmospheric pressure, on the exhaust, and since then many machines have been built along that line.

The action of the absorption machine is that of a double cycle (and more) and is apt to make a novice, or even a man skilled on a compression machine, nervous.

How It Is Done

Refrigeration is caused by the heat absorbed by expansion. If air is compressed it is heated. Cooling it under pressure and then expanding, or relieving the pressure, the air will absorb, or take up heat, either from surrounding objects or itself, and thus grow intensely cold, as can be seen in winter when using compressed air in drills, etc., the moisture in the air freezing. It is not of sufficient density to take up enough heat to be commercially useful and recourse is had to elements that liquefy under pressure.

Carbonic acid is one of these, but it requires a pressure of from 1200 to 1500 pounds, at which pressure, and cooled, it becomes a liquid. When expanded to 200 pounds it again becomes a gas and the heat expended in changing it from a liquid to a gas will change anything near it to a very low temperature.

Carbonic acid is odorless and is used in many places where odors are objectionable, as on shipboard. The objection to it is the exceeding high pressure necessary to liquefy it. It being odorless and no test being able to detect leaks, it is necessary to perfume it when looking for leaks. Wintergreen is one odor used and camphor is another. To use camphor dilute it with alcohol, put it into the system and the odor will be detected readily and at the leak there will appear a whitish substance.

Ammonia is the most-used medium in refrigerating systems. It will liquefy at 70 pounds, and at atmospheric pressure will boil at 29 degrees below zero. In a refrigerating system the ammonia under pressure is conveyed through the condenser, in which it comes in contact with coils of running water, is cooled and be-

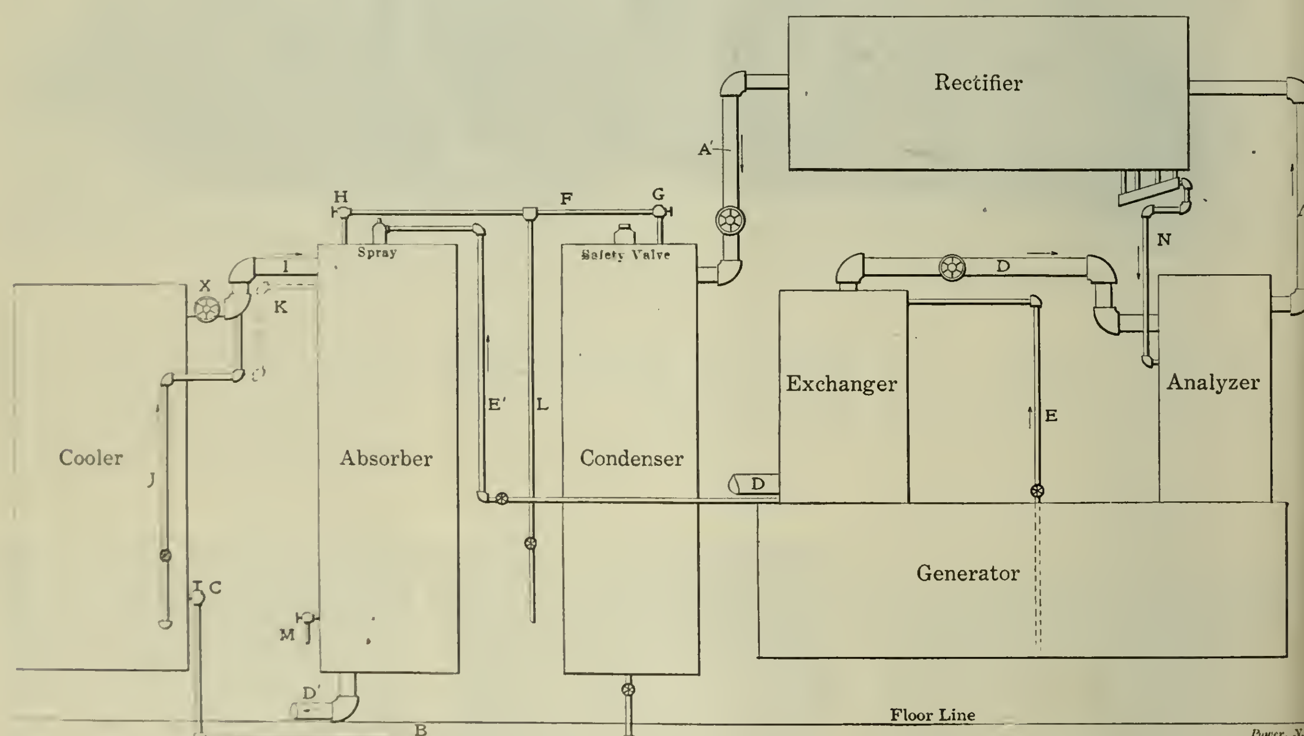


FIG. I. LAYOUT OF ABSORPTION SYSTEM

comes liquid and then passes to the cooler which contains the brine coils. It here passes through an expansion valve. This is a needle valve capable of very fine adjustment.

This valve being opened slightly, a fine stream of the liquid ammonia is injected into the cooler and, being at such pressure that it boils, it is soon turned into gas. This requires heat, and the changing to the gaseous state means that it becomes a valuable refrigerant.

In the compression machine the gas from the cooler must be kept at a sufficient pressure to cause it to fill the compression cylinder quickly, and it does not liquefy as quickly as in the absorption machine, where the cooler can be kept at atmospheric pressure and lower temperatures are obtained. For very low temperatures the absorption machine is the better.

The Machine Itself

In the compression machine only anhydrous, or pure, ammonia is used. In the absorption machine aqua ammonia is used and the anhydrous ammonia is distilled in a generator, a vessel containing steam coils.

Let us call the anhydrous ammonia "gas," and the aqua ammonia "liquor;" there being rich liquor and poor liquor. The gas, as it is distilled, goes up through the analyzer, a vessel filled with pans, through the pipe *A*, Fig. 1, to the rectifier. This is a vessel similar to a separator in a steam line; it dries out the moisture, or separates it, so that the gas goes to the condenser in a dry state, the moisture returning to the generator through the pipe *N*. (The water pipes and connections are not shown, in order to render the ammonia pipes clearer.)

For cooling, the water goes through the condenser, then the absorber and, last, the rectifier. From the rectifier the gas goes to the condenser, having been partially cooled in the rectifier. Here it is liquefied and passes through the small pipe *B* to the cooler, where it is changed back into gas.

Water has a great affinity for ammonia, and the colder it is the greater its attraction; cold water cannot be used, however, but a poor liquor will still have attraction for more ammonia if it is cool.

When the gas in the generator has been distilled it leaves the aqua weak, especially at the bottom, and this weak liquor is forced up through the pipe *E*, through the exchanger and through the pipe *E'* to the top of the absorber, where it is thrown over the incoming gas and the water coils in a spray, by means of a valve for that purpose at the top.

The gas in the cooler, passing up through the brine coils, is drawn into the absorber through the pipe *I*. This pipe should reach the center of the absorber and turn down, as if zero brine is carried the gas will be considerably below zero, and should it strike forcibly against the water coils, it might freeze them.

In the absorber the weak liquor absorbs the gas and it then becomes rich liquor and passes out at the bottom through the pipe *D'* to the ammonia pump, and from there to the exchanger through pipe *D*, whence it goes to the analyzer on its way to the generator.

The exchanger is the same as a heater for a boiler. The cold, rich liquor going to the generator meets the hot, poor liquor coming from it on its way to the absorber and they exchange heat, one being in the shell and the other in a coil. The hot, rich liquor, in passing over the pans in the analyzer, gives up any gas that may be found and this passes out through the gas pipe *A*.

On the generator, condenser, absorber and cooler are glass gages. It is a good idea to keep that on the generator closed except when the level of the ammonia is to be read. The gage on the cooler has to be kept closed, or it would become covered with frost; when used the valves have to be opened very slightly and even then not much can be told, as the ammonia in the cooler is pretty lively stuff. The gages on the condenser and absorber may be left open.

On top of the condenser and absorber is a crossover pipe *F*. The valve *G* is left closed and the valve *H* open. The pressure gage from the absorber is taken from this pipe. The vertical pipe *L* is for purging.

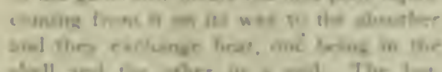


Fig. 2

The important features of the absorption machine are the expansion valve, the absorber and the strength of the liquor. The expansion valve should be handled very carefully, as it is delicate and will not bear rough usage. A monkey wrench should never be put on it. For small ammonia valves a wrench like that shown in Fig. 2 may be used judiciously, the handles to be not more than 4 inches long.

The expansion valve may be likened to a throttle valve on a full-stroke engine. If opened wide or more than is necessary to operate the machine a little above its capacity, it will draw on the generator as a wide-open pipe will draw on a boiler and it will take from the generator more liquor than can be separated in the rectifier; and when it passes the rectifier it must go through into the cooler. As this liquor cannot evaporate at that temperature, it will plug up the cooler. This is termed a "foul-over."

To get rid of this liquor, in the machine shown, it will be necessary to take it out from the bottom of the cooler through the purge pipe *J*.

The usual practice is to shut the gas valve *K* at the top of the cooler and, there being slightly more pressure in the cooler than in the absorber, the liquor will be forced over and can then be pumped back into the generator, afterward using greater care. With good care, even, dead liquor will collect in the bottom of the cooler after a time and must be taken out in the same way.

Now, shutting off the gas valve also necessitates shutting off the expansion valve and the machine stops working, with the consequent raising of temperatures. Also, when the machine is purged and the gas and expansion valves are opened, 10 or 12 degrees in temperature will be lost, as it will be an hour or more before the machine gets to work reducing temperatures again, and if there is still bad liquor in the condenser to come over, the machine will want purging again soon, with another rise in temperature.

Should the cooler need purging, leave the gas valve *K* open, and in some cases the expansion valve, and open the purge valve. Usually purging will start right away but, after a time, stop. Should this happen, close the purge valve for a few minutes and then open it.

It will take longer to purge by this method, but the machine will not lose the temperature, and after part of the cleaning is done the temperature will go down, and sometimes 1 or 2 degrees is gained during the purging. Refrigerating men will tell you not to do purging this way, but the engineer is interested in keeping his temperature down.

The condition of the frost on the purge pipe will indicate the stuff going over. If it is a sort of black frost and a wet finger does not freeze to the pipe, it is dead liquor. If the frost turns white and a wet finger freezes to the pipe, it is good liquid ammonia or gas and can be shut off.

When the liquid ammonia flows through the expansion valve it does not all vaporize at once, but some of it falls to the bottom of the cooler as a liquid and evaporates later. There should be an amount of this in the cooler all the time for the cooler to work on, the amount being indicated by the frost on the glass gage fittings; some coolers work best with only the bottom fitting frosted and others require both top and bottom to be frosted. Some require the bottom frosted in winter and both in summer. Only a trial on the particular machine can determine this point.

For purging, I have put in a pipe from the ell on the purge pipe *J* and connected it to the pipe *D'* between the absorber and the pump, and if there is a large amount of liquor in the cooler, I should open the valve in this pipe. It should be a globe valve so as to be readily regulated, and take the stuff direct to the pump. From one-quarter to one-half turn is sufficient, for if much ammonia goes through it will render the pump gas-bound and stop its pumping, as the ammonia pump will not work if the liquor gets too rich.

Instead of connecting the purge pipe *J* to the gas pipe *I*, as shown, and as is the custom, I should connect it as shown by the dotted line *K*, being careful to carry it inside and turn it downward in the center, as was done with the pipe *I*. Connected in this way the purging would be faster with the gas valve open.

Should the ammonia pump stop working from gas accumulation, place one man to watch the absorber pressure gage and slowly open the valve *G* at the top of the condenser until the pressure in the absorber gets up to 50 or 60 pounds, where it should be held until the pump starts working. Before doing this it would be necessary to close the gas valve *X*, opening it again after the pump starts. The expansion valve should never be opened above one-quarter of a turn, and then only to put extra ammonia into the cooler. With low pressure it will usually run with a turn of the rim of from 1/4 to 1/2 inch; at high pressure it will frequently leak enough to keep the cooler all right when apparently closed tight.

Never try to force an absorption machine, as it only results in partial or severe "boil-overs" and other trouble. For a short time I had a man who claimed that a machine has to be forced to keep up its work, and he would run with the expansion valve open a half turn and for a short time run the temperature down to 2 to 3 degrees per hour; then his cooler would be filled up and the shutdown for purging would follow, with the rise in temperature; and while he was supposed to keep the brine at zero, it would fluctuate from zero to 15 degrees above, he keeping at work ,all the time.

One should not expect the temperature to go down more than 1 to 2 degrees per hour. With the expansion valve opened just enough to maintain the temperature and the speed of the ammonia-pump set, the machine may not have to be touched for two or three days, and there is nothing to do but keep the log.

The Absorber

The efficiency of the machine depends upon the condition of the absorber. If the absorber is cool and free from air or poor gas, the cooler will give off its gas with ease. As long as the water and absorber are cool it is difficult to tell about the spray at the top.

This spray device is simply a valve with three oblique holes. If one side of the absorber gets warmer than the other, turn the valve slightly down, say one-eighth of a turn, and by a little manipulation the all-over temperature of the absorber can be maintained even. Sometimes a little scale or dirt will get over a hole and close so much of the valve.

This valve does not regulate the flow of the poor liquor, simply its distribution over the coils. The flow of the poor liquor is regulated by the valve near the exchanger, that at the generator being used only to shut off the poor liquor altogether. There should be only enough poor liquor thrown over to absorb the gas. More than this puts an extra load on the ammonia pump, exchanger and absorber. It is at this point that the expense of the absorption machine comes to be considered, as regards water, and also the capacity of the machine, all being limited by the amount of gas the absorber will take over from the cooler.

There is a great deal said about the relative temperatures, due to that of the water, and the pressure that should be carried on the generator. These points should be known when laying out and building the machine and determining the size of the condensing and generating coils; but when the engineer has a machine on his hands he wants to know why.

The practical point is just here: When the absorber is cold the poor liquor within it will have a large absorbing power and take gas from the cooler all right, even if it is gas of medium high percentage; if it grows warmer, it will have less absorbing power and do less work.

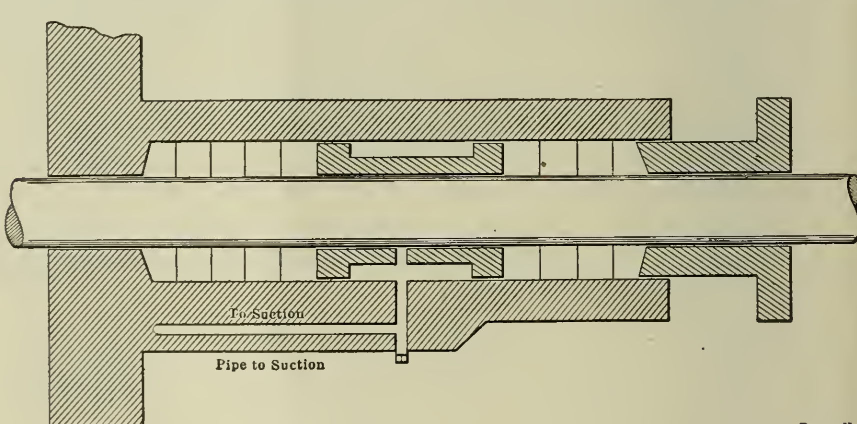


FIG. 3

If the temperature cannot be improved because of insufficient water or because of the high cost of the water, the liquor coming over must be made weaker, by turning more heat on the generator and distilling more of the gas over into the condenser, which will carry a large amount in storage. It will also be found that the cooler will need a little more gas under this condition. This weakens the whole charge in the generator, requiring higher heat in the coils and a higher pressure to distill the necessary gas from the weakened charge, and this is the reason a higher pressure has to be carried with a warm absorber.

With cooling water at or below 60 degrees, a low-pressure machine will run at atmospheric pressure; with water at 70 degrees, the steam pressure may have to be raised two or three pounds; and at 75 degrees it may have to be raised to 10 pounds. Some machines will require higher pressures, depending on the heating surface in the generator. With 60-degree temperature water the pressure in the generator may be from 90 to 100 pounds and at 75 degrees it will be necessary to carry it to 150 to 160 pounds. All these pressures are determined by the temperature of the absorber and whether coal or water costs the more.

If water can be obtained from driven or bored wells, an absorption machine can be run the year through with exhaust steam, and it will not act as a brake on the engine. Where there is lots of brine pumping by steam pumps it is possible to run a machine with the exhaust from the pumps.

It can be noticed at any time whether the absorber is taking hold well by the frost on the gas pipe *I*. If the frost continues white and keeps accumulating, the absorber is working uniformly; if the pipe begins to thaw, either the absorber has "let go," or the cooler has become foul.

At the bottom of the absorber is a valve *M*. The pipe from this should have a swivel joint so it may be swung into or out of a bucket. If there is air in the system it will usually be found at the bottom of the absorber and is to be drawn out through this valve. The valve should be opened occasionally to test the system for air. A clean machine ought to run from one to two months without trouble of this kind. To test it, get a bucket of cold water, and set it under the outlet to the pipe and open the valve from one-eighth to one-fourth turn. If air is present, bubbles will rise to the top of the water, nearly noiselessly. Should there be few bubbles, accompanied by a crackling sound, like water being heated with steam it indicates the presence of gas, showing that that part of the machine is all right.

When air bubbles are rising, if a match is held over the pail and a pale yellow flame results, it shows that there is some foul gas mixed with the air.

Half way up the absorber there is another purge pipe for drawing off foul gas. If this valve is slightly opened and the gas issuing therefrom is lighted and continues to burn of itself, it shows foul gas and the pipe should be turned into a pail of water until good gas comes, which can be told by the crackling sound. Do not make the mistake of holding a light under it only to light it. Ammonia gas will burn if a light is kept under it with a very similar flame. The pail of water tells the story.

The pipe *L* on the crossover pipe *F* can also be tested: The absorber should be pumped as low as possible without allowing gas to get in the pump, and the pressure should be kept as near a vacuum as possible. The pump should be kept at a uniform speed. The pressure in the cooler will be nearly the same as that in the absorber, as it is the absorber that governs the pressure. The makers' instructions will give the proper pressures to carry with relation to brine temperatures, but the poor fellow who has followed them and run up against the packing of a rich liquor rod under pressure will keep just as near a vacuum as possible and save packing, ammonia and the nervous system.

Every ammonia-liquor pump has, or should have, a long stuffing box and a thimble at the center of the box (see Fig. 3), with packing on both sides. This thimble should be central, as there is a recess in the thimble connecting, by a port, to the suction side of the pump and all leakage past the first packing goes back into the suction, the packing outside the thimble having to resist only the pressure on the absorber; but do not imagine that 5 pounds pressure on the rod of a rich-liquor pump is a simple thing, for it is the worst proposition in the packing line a man ever ran up against. Keep the pressure in the absorber as near vacuum as possible. The richness of the ammonia charge is determined by what the absorber will take care of.

There is no telling what the composition is after the machine starts, except by the operation of the machine. If you are running with exhaust and the absorber works all right, the rich liquor at the pump will show 26 degrees, but that only tells what it is at that point.

There should be sufficient anhydrous ammonia in the system for the cooler to have all it wants and allow the generator to keep a few inches in the condenser gage all the time, with the steam pressure down to the low point. This is with a cool absorber, and it is sometimes possible to have the liquor in a cool absorber so rich that the pump will not take it, the gas separating out in the pump, a condition which will be shown in the glass gage of the absorber, as when the pump lets go, the absorber fills up and the liquor in the glass will effervesce like soda water. The remedy is to weaken the charge by throwing more of the gas over into the condenser, as a reservoir, and start the pump by pressure from the condenser.

It will be necessary to have a little pressure on the absorber when purging at the valves *M*, etc.; just above atmosphere is all that is necessary. Never open these valves when there is a vacuum, as it would draw air in.

The Condenser

The gage on the condenser shows its condition. There should always be two or more inches in the glass. As the condensing water first passes through the condenser, and as the gas is cooled in the rectifier, there is not much trouble with the condenser. The liquid ammonia, if all right, will continue to effervesce. If it is quiet, like water, there is foul gas, which will collect at the top. In this case, shut the valve *H* at the top of the absorber and open the valve *G* at the top of the condenser. Then get a bucket of water and blow the pipe *L* into it. It will be impossible to do this without wasting some ammonia, and when the water is impregnated with ammonia, so as to be offensive, change it for more water. This may have to be done once or twice a day for two or three days.

When through purging each time, change the valves back again, as the absorber gage is on this line and during the time the pressure is on it the absorber gage will show condenser pressure. In one case the liquid pipe *E* at the bottom of the condenser became plugged, thus stopping the machine. Connection was made from the bottom of the glass gage to this pipe and the delay was short.

It is a difficult matter to get a safety valve that will be tight, so recourse is had to extending the casing and putting in a blank of sheet lead that will let go at the pressure that the safety valve is set for. When this happens, put in another blank.

The Generator

The coils for steam in the generator go in it about the center and return near the bottom. When starting up a generator cold, do so easily, taking plenty of time. If possible, the better plan is to turn steam on at the bottom and let it work its way upward. If it is a large machine with a flange joint in the center, by turning steam on strong at the top, the top will be heated and expand and spring the joint at the bottom. Should this occur, stop the heat and let it cool. Take off one nut at a time, oil it and put it back and pull it up tight. This may stop it once or twice, only do not hurry the heating of the generator.

As soon as there is sufficient pressure to raise the liquor over through the weak-liquor pipe *D*, open the valve and when the liquor shows in the absorber start the pump. This sets up a circulation in the generator and the danger is over. When the pressure is shown to be sufficient to liquefy the gas, which will be at 70 pounds, and it does not show in the gage in the condenser, open the expansion valve slightly so as to start circulation. The top of the steam coils are about at the center of the generator.

It is a good plan to make a gage from a pine strip marked in inches and half inches and fasten it to the gage fittings, with a mark showing the top of the coils. The charge in the generator should always be kept above the coils and usually near the top of the generator. This level will change, depending on the gas in the condenser and cooler and the liquor in the absorber. Sometimes, purging the cooler will raise the level in the generator 4 or 5 inches. When a lot of the anhydrous ammonia is sent over into the condenser the level will be changed.

If there is no leakage around the ammonia pump, all loss will be of anhydrous ammonia and it must be replenished with the same. Should there be leakage of liquor it can be replenished with aqua ammonia, or with water and anhydrous ammonia. If water is used, it should be pure, distilled water, as impure water would cause foul gases.

The troubles caused by allowing the charge to get below the generating coils are two: If allowed for more than a short time the ammonia will corrode the pipes, and the hot pipes in the gas will decompose the gas. This will be shown up around the cooler, the frost everywhere being excessively heavy, as though everything was frozen up, and the gage on the absorber will show about as good vacuum as a condensing engine. The temperature of the brine will be high, as that is the only thing that does not show any low temperature. The only remedy is a good charge of anhydrous ammonia and purging out the bad gas.

Rectifier

The rectifier is for drying out the gas and should be run cool enough to chill off the moisture but not cool enough to liquefy the gas, or any portion of it, as it would drain back into the generator and have to be distilled again. The last passage of water is through this vessel and there is a bypass around it for the water so that the temperature can be regulated. There are thermometers for the rectifier and water leaving it.

If considerable water is used because of the absorber, a large amount will go through the bypass. If water is economized and the absorber is active, all of it may go through the rectifier. The thermometer should not register above 110 degrees. The drain pipe *N* should feel warm to the hand.

Dirty Coils

The condenser and absorber coils are liable to the same trouble where the water becomes warm and the flow stopped. Corrosion, in the form of "barnacles," sets in and the pipes gradually become filled. [illegible] top and bottom and each coil has a valve at both ends.

There should be an air compressor on the premises capable of maintaining a pressure of 80 pounds through an open 3/4-inch pipe. The headers should be connected to the air line, and also to a water pressure, with 1/2-inch pipe; the feed line will do.

Once a week the ammonia should be shut off, or, rather, the machine should be stopped and the water drawn from the coils, the bottom valves closed and air turned on. There should be a valve for the bottom header, in the bottom of the flange, which should be opened and then the valves on the coils should be opened separately and the air allowed to blow through. The deposit will be soft and will easily clear out. After air has blown through, turn on the water in the same manner and wash the coils out. While the machine is idle, the brine temperature may have gone up one or two degrees, but it will readily come down again.

If the coils are badly coated the machine will have to be stopped for two or three days. The ammonia will have to be drawn from the condenser and absorber, as if warmed up the expansion would cause too much pressure. In drawing off the ammonia be careful not to reduce it too low all at once, or the freezing effect will be so great as to freeze the water coils.

Have prepared a sufficient quantity of a strong potash solution, draw the water from the coils, fill them with potash and let it stand for twenty-four hours, or longer if the machine can be spared. When the potash is drawn off, turn on the water from the small cleaning pipe and fill the coils. Close the valve to within one-half turn and turn on the air. Open one valve at the bottom of the coil header and keep it open until the water runs clear, then close that one and open another. After all have been blown, begin with the first and go over them again. They may require four or five blowings out before they will be clean.

When air and water issue from a pipe together, it will be noticed that it issues with a series of explosions, which appear to take place all through the coil and may be thought to do the cleaning, but this method has little effect without the potash. Water at from 125 to 150 degrees appears to do better work than cold water, as the vapor from the warm water makes the explosions stronger.

The gages should be looked at occasionally to see if pressure is being generated, and it is the better plan to cool the generator than to shut off the condenser, as there is no pressure gage on the condenser unless the valve *H* at the top of the absorber is closed and the valve *G* is opened, thus using the absorber gage for the condenser. Do not forget to change back again, however.

Weak-liquor Pipe

In regard to the weak-liquor pipe, it should be remembered that as the pressure in the generator is carried higher the flow through this line is increased unless throttled.

Brine

For brine, chloride of calcium should be used instead of chloride of sodium, because it cleans the pipes better, prevents corrosion and will carry lower temperatures. Care should be taken to get the purest, but even with this there is a sludge that will stop circulation in small pipes, and sometimes good-sized pipes are bothered. Place a steam pipe in the tank for dissolving purposes and do not fill the tank full of water after the calcium is placed in it. When the mixing tank is charged, turn on steam until tank is boils, then close the steam valve. Skim off the scum that rises. It will be necessary to wait until the brine cools before pumping into the system or it would raise temperatures. The skimming can be done without heating, but not as much of the impurities will rise as by heating, and not much time is gained, as the dissolving is so much slower. Heating saves lots of cleaning later, also.

Danger in Ammonia Fumes

In case of accident, ammonia is a bad thing, as it takes but a small amount to overcome a person. Acetic acid is an antidote and is found in ordinary vinegar. A sponge soaked in vinegar and put over the nose will enable anyone to work in a strongly impregnated atmosphere, as far as breathing is concerned, but the eyes would not be protected. To work under such conditions it is necessary to wear a helmet, which should be kept charged at all times at 125 pounds pressure and regulated so that it will take one-half hour to reduce the pressure to 25 pounds.

Should anyone be in danger of suffocation, breathing the fumes from vinegar will neutralize it. Drinking warm milk will relieve a person partly suffocated from ammonia or any gas.

Workers around ammonia should not forget the strong affinity it has for water and the absorbing power of water. When there is a small leak of even the gas under pressure, a piece of water-soaked waste put over it will remove all trouble until the water is thoroughly saturated with it.

It is a good idea to practice using water for even unimportant leaks so as to be accustomed to it. A 1-inch hose and a 2½-inch hose under water pressure should always be handy, as by their use a big leak could be drowned; and these would be thought of instantly if one were accustomed to the use of water to take care of ammonia fumes.

Detecting Leaks

There are various devices for detecting leaks, but the best is white litmus paper. This can be procured free from the dealer in ammonia. Take a strip ¼ inch wide and about 1½ inches long. With a thread, tie it onto a small stick 15 to 18 inches long. When using it, moisten it in water and hold it to the suspected place. If there is a leak the paper will turn red and the shade of red will show how strong the leak is. Litmus paper will detect leaks that cannot be smelled. Turn it away from the leak into pure air and it again becomes white. It can be used until completely worn out, all that is necessary, when using it, being to moisten it.

Fittings

For putting screwed fittings together, or for material to put on flanges, use litharge and glycerin; for sheet packing, use pure rubber. Do not get fittings intended simply to receive the pipe that is to be screwed into them; get special ammonia extra-heavy fittings, either with a stuffing box at each end of the fitting, in which rubber packing should be used or fittings with a lead ring in each outlet and with provision to put in shot and allow a plug to be screwed in the top to force the shot down on the pipe.

Care and Management of the Water-tube Boiler

By William Kavanagh

Water-tube boilers having straight tubes may be divided in two classes, those that employ ground plugs or caps for closing the holes through which the tubes are inserted and cleaned, and those in which small handhole and circular plates fitted with rubber or asbestos gaskets are used for the same purpose as the ground plugs or caps. The Babcock & Wilcox and Root boilers employ caps with ground joints or surfaces to close the tube openings in the headers, while the Heine and Oil City boilers use handhole and circular plates on which are placed asbestos or rubber gaskets to form a water- and steam-tight joint. Fig. 1 illustrates the method of closing the hole in the tube header of the Babcock & Wilcox boiler. Fig. 2 shows the method adopted by the Heine boiler builders for closing the tube connection in the header or water leg, a gasket being used, as shown at *A*, to insure a water-tight joint.

Fig. 3 is a longitudinal elevation of the Babcock & Wilcox boiler showing doors *D* located in and connecting with the different chambers, the object of the doors being to afford access to these chambers for the purpose of cleaning and blowing the dust off the tubes, for removal of ashes and for repairs to the deflecting arches, walls, etc. Fig. 4 is a view of the Heine boiler and the cleaning doors *D* are for the same purpose as the doors in the Babcock & Wilcox boiler.

When blowing the dust off and from between the water tubes and around the drum two nozzles, shaped as in Figs. 5 and 6, should be used. The straight nozzle may be used in blowing the dust off the tubes in a horizontal and crosswise direction, while the bent nozzle can be used for blowing the dust off the tubes in an upward and downward direction, and also from the bottom of the drum. Both nozzles can be used while steam is on the boiler, and they may be lengthened by adding a piece of pipe or steam hose, thus affording access to parts remote from the cleaning doors.

Wrong and Right Ways to Shut a Boiler Down

A boiler properly shut down is easily cleaned; if improperly shut down, it means long, tedious and unnecessary labor to overcome mistakes that should not occur. The wrong way to shut a boiler down is to haul the fire, blow the boiler down and allow it to cool as rapidly as possible. This method requires plenty of labor after the boiler is opened to scrape and clean off the hard-baked scale and mud that would otherwise be carried off through the blowoff if the boiler was properly shut down.

The right way to shut a boiler down is first to see that there is the usual amount of water in the boiler before hauling the fire. Good results are obtained by not hauling the fire, but allowing the fire to cool in unison with the boiler, the water and surrounding brickwork. Second, close everything that may have a tendency to admit cold air through the tubes and around the drum; let everything cool together, and when the boiler is opened for cleaning a strong stream of water will wash off all the scale and mud that did not run out when the blowoff was opened. In nearly every case when a boiler is shut down in this way the scale remains soft and is easily removed.

FIG. 1

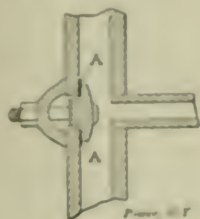


FIG. 2

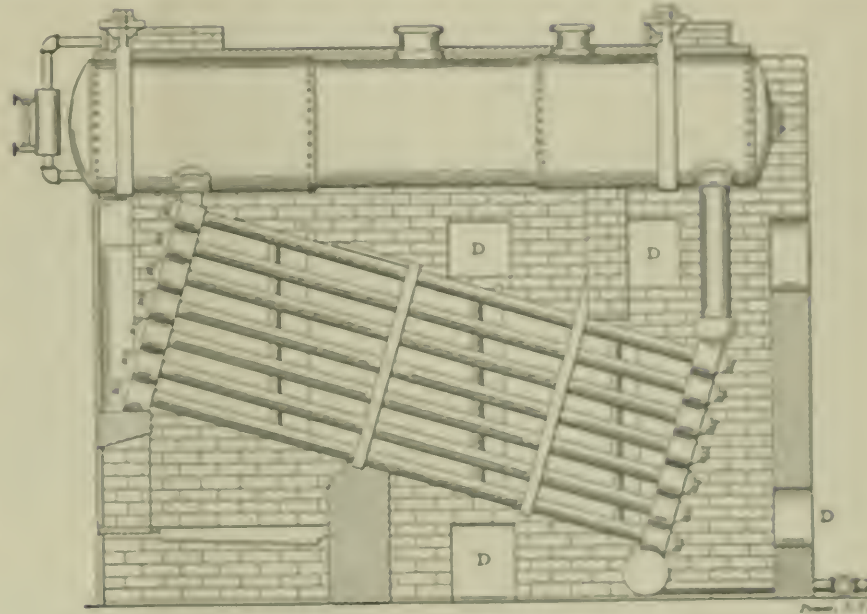


FIG. 7

FIG. [illegible]

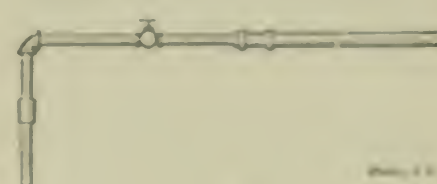


FIG. [illegible]

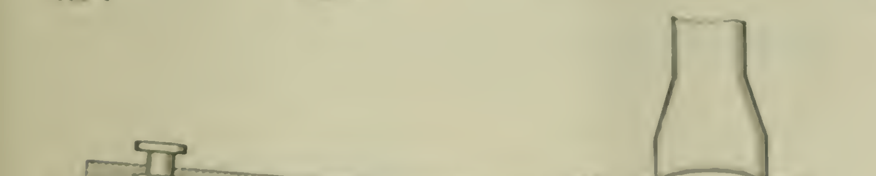


FIG. [illegible]

Another great mistake usually made in cleaning water-tube boilers is to open all the tubes. This is unnecessary. Where there is an open heater, and filtered water, or water not impregnated with scale-making properties, water that might be called good "steaming water," is used, it will be found that the opening of the "fire row" and one or two rows above the fire row will generally be sufficient to ensure a good job.

The cleaning of the caps with the Babcock & Wilcox type of boiler requires time, especially when all the caps are removed. Engineers acquainted with this type of boiler adopt various methods to clean the caps. Some scrape off the scale from the caps, others immerse the caps in kerosene oil and when the scale becomes soft, it is easily removed, leaving the ground joint intact. In some cases, however, it becomes necessary to use emery cloth in which case a fine grade of emery cloth should be used. By attaching it to a buffing wheel and revolving the wheel about 500 times per minute a quick job can be done on the caps. Sometimes it becomes necessary to apply emery cloth to the ground surfaces on the headers. A quick way to polish these surfaces is to make a wooden buffer or cleaner, as shown in Fig. 7, to fit the opening in the headers, and by attaching some fine emery cloth to the disk at *A* and inserting the plug *P* in the opening, the whole can be rotated by means of a carpenter's or similar brace; by placing the plug *P* in the tube opening, the plug acts as a guide and insures an equal amount of wear on all of the polished surfaces, which cannot be obtained if the emery cloth is used by hand. In this way all of the headers that are to be cleaned can each receive a polishing in a very short time.

Straight Water Tubes Easily Cleaned

The water tubes in this type of boiler are straight and are more easily cleaned than curved tubes. A turbine tube cleaner is attached to a hose. A stream of water flows through the hose, rotating the turbine at a high velocity. The rotative speed throws out cutters or scrapers (by centrifugal action) against the interior of the water tube, and by feeding the turbine and hose into each tube the scale is partially or wholly removed, depending on the thickness and density of the scale. Sometimes it will be found necessary to make more than one trip with the turbine through a tube, but in general one trip is sufficient, provided the scale is not too heavy and the cutters on the turbine are sharp.

In replacing the caps particular attention should be given to the cleanliness of the ground surfaces, and the mistake should not be made of plastering over these surfaces with a heavy coating of graphite and oil. Metal to metal insures the best joint. If graphite is used it should be used very sparingly. When the caps are in position it is an excellent idea to test them for tightness by pumping a water pressure equal to the steam pressure carried in daily operation. If any cap leaks and it cannot be made tight with an ordinary pull on the cap wrench, then the water should be lowered below the leaking cap, the cap taken off and the surface thoroughly cleaned before again putting the cap on. Sometimes it is necessary to change a cap and even do a little grinding before making a tight joint. After the caps are all in position the boiler should, if possible, be filled with warm water and allowed to remain so for at least twenty-four hours, when the blowoff can be opened and the water lowered to its regular hight, when steam can be raised as slowly as possible. After steam is raised it will be found a first-rate idea to go all over the caps with the wrench and try out the nuts for tightness. In most cases after steam is up and the boiler hot, half a turn and sometimes more can be given each nut. If this is not done, when the boiler cools there is sure to be a leaky header or cap. All that has been written about the Babcock & Wilcox boiler is equally applicable to the Heine boiler, with the exception of the caps. With the Heine boiler small handhole and tubehole plates and gaskets are used to close the tube connections, instead of ground joints. When inserting these plates care must be taken to see there are no lumps on either surface of the plate, header or water leg. The tubehole plates are round and cannot be placed in position like handhole plates, therefore the tubehole plates are first entered through a handhole opening and then zigzagged into place. A better plan than this is to use a string having a small weight attached to one end. By dropping the weighted end through a hole ready to receive a plate, the plate can be fastened to the string and by pulling on the string the plate can be hauled into place quickly.

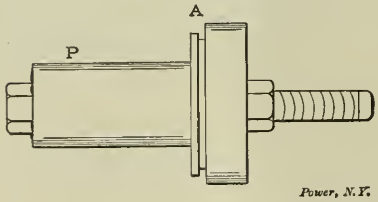


FIG. 7

When using this plan one should begin at or with the highest row first and then work downward until the handhole row is reached, when this row can be closed in the usual manner.

Inspecting the Water-tube Boiler

While inside the drum, the feed pipe, dry pipe and drum blowoff should receive attention. If there is a mud catcher attached to the feed pipe it should be cleaned out, and the blow-down cocks can receive new lining, if necessary. Water-column connections should be looked after and the drum inspected for corrosion along the water line. The portion of the tubes lying directly over the fire should receive particular attention, as these tubes become flat on their sides from the action of the heated gases and draft. They should receive the hammer test and all weakened tubes should be discarded. The neck or connection between the water leg and drum should be inspected for corrosion and leakage, and the point where the tubes enter the water leg should receive the hammer test. The deflecting arches and walls should be inspected, because waste of fuel can occur if the heat is not properly dispersed among the tubes.

Marking Valves of Refrigerating System

By Lewis C. Reynolds

It is quite usual to find the valves in a power plant marked in their running position so that the operator may know how to set them for certain conditions. The rheostats and voltage regulators will have a pencil mark on the marble panel, the valves have a chisel mark on nut and stem and probably the boiler-feed valves have a string tied on the wheel corresponding to some stationary point. Each man operating has his own mark or perhaps several relating to a different set of conditions. In a refrigerating plant with its numerous valves requiring at times the most exact adjustments some scheme of marking becomes absolutely necessary and can be accomplished by a system of dials with pointers which will intelligently indicate valve positions without disfiguring the valves.

Provide a disk of sheet brass say, 1/16 inch thick and 6 inches in diameter, for a 1-inch valve; divide the outside edge into a suitable number of divisions depending on the fineness of adjustment desired, and stamp each division with a figure punch, or if graduated close, at intervals, so that the figures will not become confusing. Attach the dial to a small brass collar which is secured to the valve stem by a small setscrew. The marking of the dial can best be done by fastening the disk to a wooden block attached to the faceplate of a lathe, and moving the carriage with a pointed tool across the disk so as to take a light cut. The spacing can be done by placing a suitable gear on the spindle and moving the faceplate after each cut until the next tooth comes in line. Set the dial on the valve stem so that the pointer will be at zero when the valve is closed. If the valve is opened more than one turn, it will be necessary to count them and read the fraction of a turn directly from the dial.

This device has proved of great advantage in operating a refrigerating plant. It has been placed on the expansion and weak liquor valves, also the steam valves to the retort pump and the condensing water valves. Any change made in their position is noted on the log sheet and also the reason for the change. A monthly memorandum sheet is ruled up with the first column for the day of month, the second column for the hour of day and the following columns for the different valves. Once each day a reading of the valve position is taken and the time noted. This is filed for future reference, and comparisons of valve positions can be made for different months and years. The men in the station become accustomed to referring to the valve positions by number, and the engineer when visiting the plant can tell at a glance if any changes have been made.

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

An Original Remote Control System

Recently an engineer was called upon to devise an economical method of controlling a direct-current 220 volt, 3 horsepower pump motor from his still room.

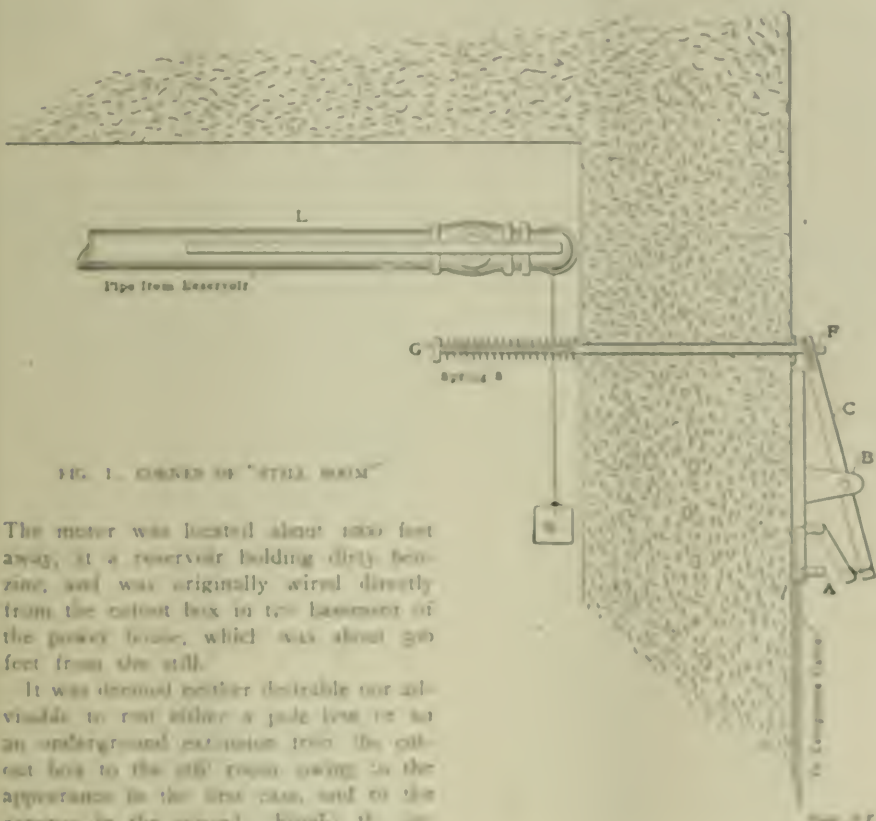


FIG. 1. CORNER OF "STILL ROOM"

The motor was located about 1200 feet away, at a reservoir holding dirty benzine, and was originally wired directly from the cutout box in the basement of the power house, which was about 500 feet from the still.

It was deemed neither desirable nor advisable to run either a pole line or an underground extension from the cutout box to the still room owing to the appearance in the first case, and to the expense in the second. Finally the engineer decided to make use of an extra pair of telephone wires in a cable which ran from the power house to the warehouse.

The extra wires were extended to the rear wall of the still room. At a point about 5 feet from the floor, and one foot from the corner of the room, a 1/2-inch hole was drilled through the wall. A double-pole single-throw switch was installed, having a pivot point at B, Fig. 1, a lever arm C pivoted at B and connected to the switch at A through a short link. A rod about 20 inches long and one-half inch in diameter was then run through the wall and connected to the lever arm C at the point F. A spring was put on the other end of the rod, and held in place by the flange G. The telephone wires were then connected to one side of the switch and a source of electric energy to the other. The switch, as required by the fire underwriters, was thus located outside of the still room.

By pressing on the end G of the rod, the switch A was closed. On removing the pressure, the spring S would immediately force the switch open again.

On the feed pipe leading to the still, an automatic self-closing valve was installed, also required by the underwriters. This valve was closed by means of a weight W, Fig. 1, hung from a lever L and was so located that when the valve was widely opened the lever would press on the flange G and close the switch. The lever would then be held against G until the still had as much benzine as required, and then be released, closing the valve automatically and opening the switch.

In the basement of the power house, close to the cutout box, the switchboard shown in Fig. 2 was installed. At the top of the board are two magnets connected in series to the telephone circuits, and energized whenever the switch A, Fig. 1, is closed. The cores of these magnets are connected to a steel frame F, which fits lightly around a 4-inch steel disk pivoted at P. This disk, instead of being controlled by a spring, is rotated by means of a long cord which is wound on a spool on the axle of the disk in the rear of the board, passed over several pulleys and attached to a heavy weight. The degree of rotation is limited by a projection on the disk, which makes contact with the catches H or O on the frame F, depending on whether the switch T is being opened or closed. Pivoted at the point x is a 6-inch lever P, which is connected at its lower end to a double-pole single-throw switch. The upper end is slotted half an inch to give play. When the magnets are energized, the cores are drawn up, lifting the frame F and allowing the disk to rotate with great speed

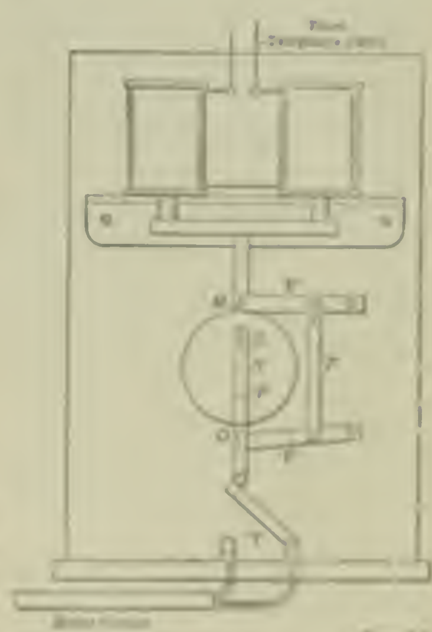


FIG. 2. STARTING DEVICE

until stopped by the catch O, the lever acting as a plunger closing the switch T and closing the motor circuit. When the magnets are deenergized by the opening of the switch A, Fig. 1, the cores drop, and frame F releases the disk, which turns until stopped by the catch H, opening the switch and thus opening the motor circuit.

cuit. Fig. 3 gives a rough diagram of the circuit.

The sump motor is thus quickly and conveniently operated from the still room in a manner that conforms entirely to the underwriters' specifications, and is reliable and inexpensive.

W. W. PARKER.

Chicago, Ill.

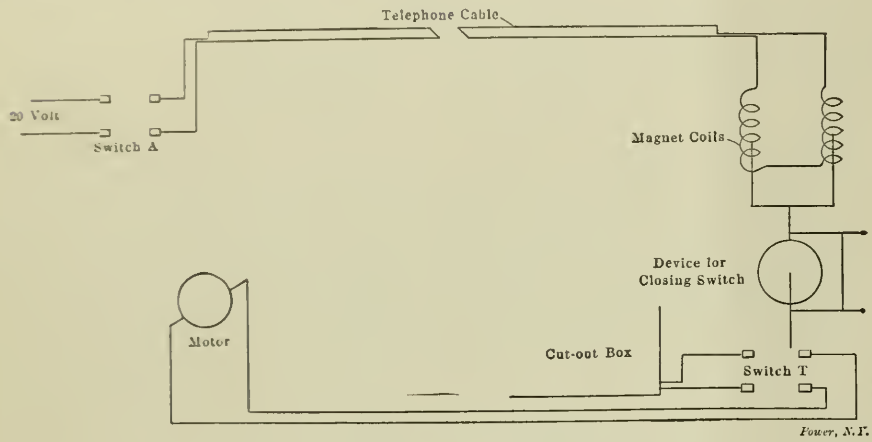


FIG. 3. DIAGRAM OF CONNECTIONS

Are Inside Screw Valves Unsafe?

On page 811 of the May 4 number, Thomas Sheehan has a letter on "State Inspection of Boilers," wherein he states that an inspector condemned one of the valves on a new boiler because it was not of the outside screw-and-yoke type.

Also on page 863 of the May 11 number is an editorial entitled: "Are Inside-screw Valves Unsafe?"

A person reading these articles, who is unacquainted with the Massachusetts laws on boiler construction and inspection, would very naturally condemn the boiler inspector for refusing to accept a new boiler simply because one of the connecting valves was not of the outside screw-and-yoke pattern. If, however, those who are interested in the matter will look at the "Boiler Rules," which are not made by the inspectors, they will find the following: "All stop valves 2 inches and over in diameter shall be of the outside screw-and-yoke type."

Therefore, the boiler was not "set up and connected as per law," as Mr. Sheehan claims, and neither was the inspector "guided by what he believed to be his duty in the matter" alone. There was, of course, no alternative whatever but to refuse to grant the certificate until the valves were installed in accordance with the "Boiler Rules."

The comparative safety of the two types of valve is another matter, but for convenience the outside-screw valve is far preferable to the other type. This may not make so much difference in the small plant, where one or two men alone handle the apparatus, but in the large plants, where momentum changes must be made rapidly, it certainly makes it much more convenient if the engineer can see at a glance whether certain valves are open or shut.

S. J. SMITH.

Lawrence, Mass.

Take a cross-section of a valve of the type alluded to and note the thread when the valve is closed. This is the point where all the strain comes when the valve seats and also when starting to open. There is no possible chance for lubrication, and if the thread begins to cut there is no knowledge of it, and no help if there were; there are but from one to three threads and they are right at the end of both stem and disk.

I consider them very dangerous, where the valve is important, and for many years have never put in one of this type over 2 inches in diameter.

W. E. CRANE.

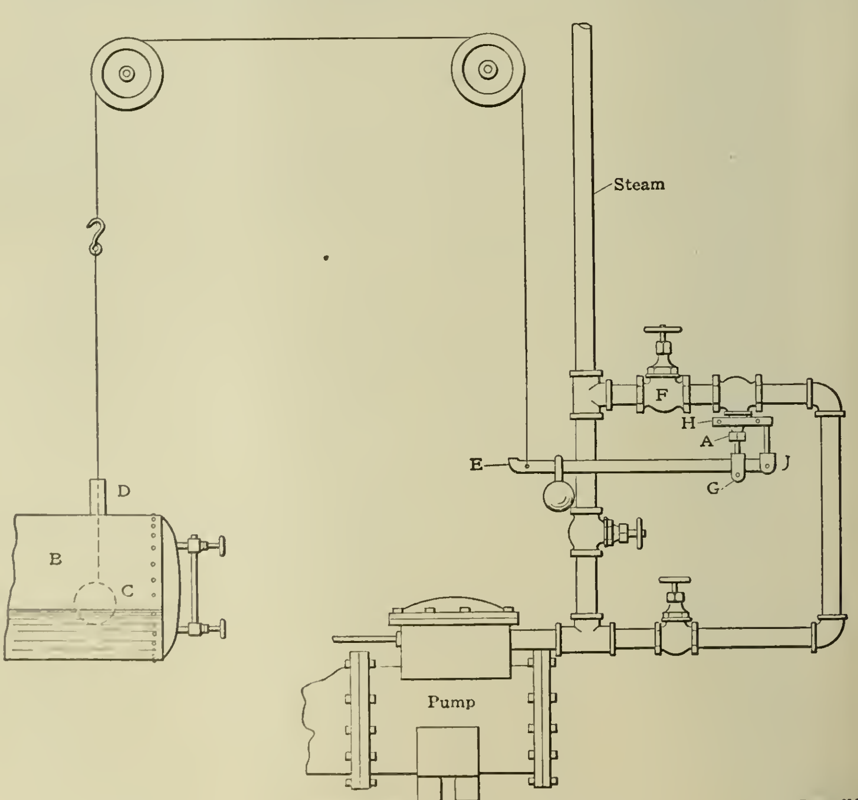
Broadalbin, N. Y.

Homemade Automatic Pump Regulator

After having connected up a reducing valve, extra valves, fittings, traps, etc., to overhaul an old 2-inch two-pipe heating system of 4000 square feet of cast-iron radiation, which has been operated many years without any of these appliances, I thought of completing the job at very little expense, by making a homemade pump regulator, as per the accompanying sketch.

It has worked for the last two years, needing only an occasional packing of the automatic-valve gland *A*.

The return tank *B* is directly connected with the heating system, and also through the traps; it also has connection with the pump suction. The float *C* is a seamless copper one, to which was fitted a ¼-inch brass rod. The tank *B* was drilled and tapped for ¼-inch standpipe, and a ¼-inch



HOMEMADE AUTOMATIC PUMP REGULATOR

nipple *D* long enough to serve as a guide for the rod was screwed in.

The float while separated from the rod, duly weighted with water, was introduced through the tank manhole and screwed to its rod. A hook was screwed on at O and an arrangement of cord and pulleys put up leading to the lever E.

The high-pressure line to the pump was bypassed and the regulating valve F inserted, together with other necessary valves. This regulating valve, which for reason of space was put in upside down, was made out of an ordinary globe valve, the stem threads being turned down and a pulley fork fitted to the end of the stem. The lever rests on the wheel pin G.

The hexagonal part of the valve bonnet was turned round, so as to fasten on an old pump-rocker arm H trimmed to suit the case. The forked eye J was taken from an old pump valve rod. The working of this contrivance hardly needs any explanation.

ALEXANDER DOLPHIN.

Jamaica, N. Y.

Return Tubular Boiler Setting

The accompanying sketches are of two return-tubular boilers with practically the same conditions existing, except that the plan of setting is different.

In Fig. 1 the boiler is set 3 feet above the grate surface and the bridgewall is built up square and is 28 inches high.

In Fig. 2 the boiler is set 2 feet above the surface of the grate and the bridgewall slopes back from the rear end of the grate until it reaches a vertical hight of 16 inches. The top of the bridgewall in each furnace is horizontal, thus bringing the center up to within 8 inches of the boiler shell.

FIG. 1

FIG. 2

The boiler furnace set as shown in Fig. 1 burns its coal more quickly and cleanly, requires less work and provides better combustion than can be secured in the furnace shown in Fig. 2.

Why does the furnace in Fig. 1 burn its coal with better results than can be obtained with the furnace shown in Fig. 2?

E. W. JACKSON.

Muddy, Ill.

A Blast Pressure Gage

The accompanying illustrations are of a pressure gage and telltale in use at the plant of the Tennessee Copper Company, Copperhill, Tenn. Six blowing engines discharge into one main receiver, at a pressure of 30 ounces per square inch. Each engine has a Crosby recording chart and draft gage to record the pressure, but as the chart is small and the gage set high, it is impossible for the oilers and engineers to keep the pressure even.

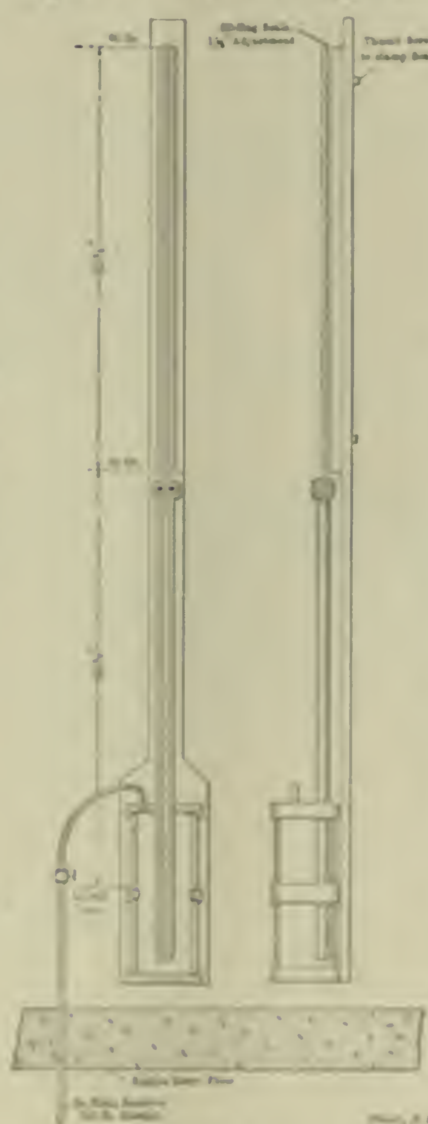


FIG. 1

A water gage was constructed as shown in Fig. 1. Two oil-pump glasses constitute the reservoir, clamped together on packings by some old oil-pump caps. A ½-inch pipe screws through the cap and extends to within 1 inch of the bottom. This pipe extends upward to a graduated scale, where a ¾-inch glass tube enters the pipe through the packing gland. The scale is made adjustable for 1½ inches to allow for evaporation of the liquid and difference in level.

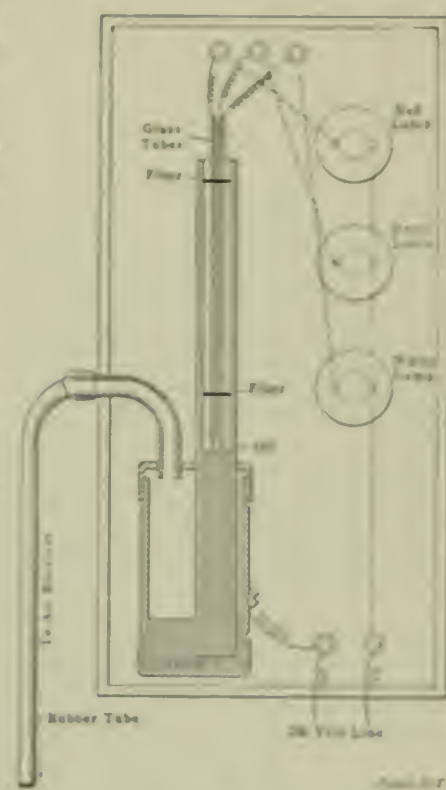


FIG. 2

From the top of the center ring on the reservoir, which is the point chosen to start from, to the beginning of the scale measures 59¾ inches, and is equal to 30 ounces pressure, based on the fact that one ounce pressure will support 1.73 inches of water. From this point the scale is graduated in ½-ounce graduations up to 40 ounces.

The liquid is colored red and the graduations are red and black on a white scale; the indicated pressure may be read 20 or 30 feet away. The gage is placed in the center of the engine room on the wall and is connected by a pipe line to the main receiver, some 300 feet away. Beside the water gage is fastened the electric telltale which is shown in Fig. 2.

This consists of a small reservoir and pipe similar to a water gage, but on a smaller scale, all constructed of iron. Three glass tubes, supported by two rings of fiber so they can neither touch each other nor the pipe containing them, have a platinum wire sealed in each tube at one end which projects through the tube ¼ inch; the other ends connect to a copper wire which extends to lamps as shown. The glass tubes have a difference of ⅛ inch in length on the bottom ends. The gage is filled with mercury so that with the water gage showing 49 ounces, the bottom light will burn; the other two lights are each 1 ounce apart in lighting up, and burning at 50 and 51 ounces. A bell could be used instead of lights if desirable.

A small amount of oil is used on the top of the mercury to break the small arc when the mercury recedes from the wire tips.

These gages have been very satisfactory in keeping the blast pressure even.

We use a similar water gage to adjust and test the recording gages on the blast pressure.

G. L. Fales.

Copperhill, Tenn.

Heating by Exhaust and Live Steam

Fig. 1 shows the piping arrangement where exhaust steam is used during the day when the engine is running, while at

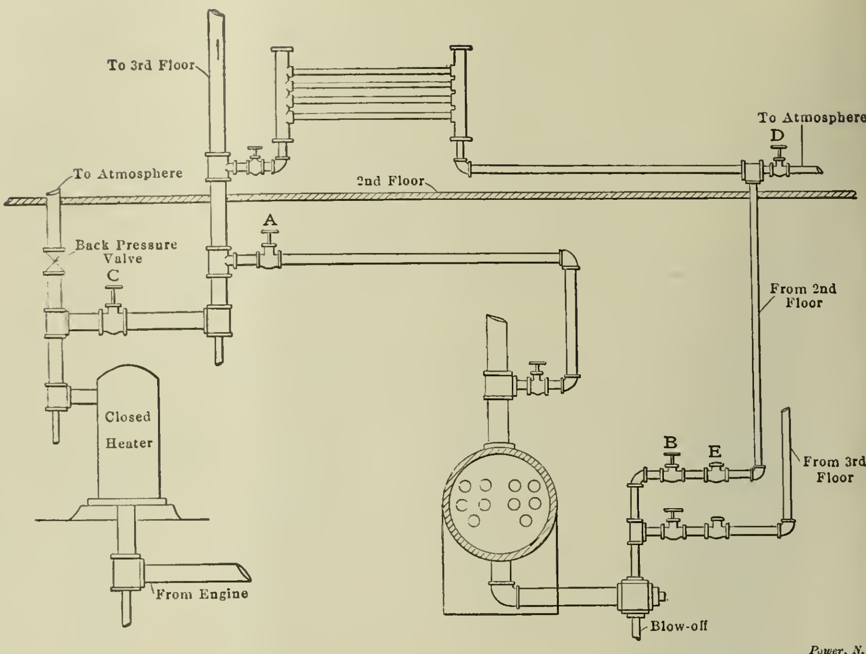


FIG. 1

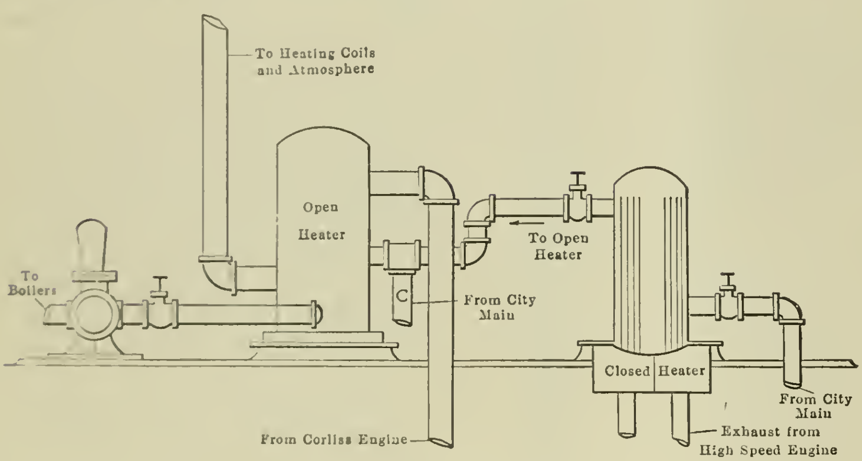


FIG. 2

night or when the engine is not running, live steam is used. This system is operated in the following way: In the morning, before the engine is started, the valve *A* in the steam line from the boiler and the valve *B* in the return pipes from the heating coils are closed, and shortly after the engine is running the valve *C* is opened and the back-pressure valve in the exhaust pipe is nearly closed, while the valve *D* leading to the atmosphere is opened just enough to let the water of condensation out of the heating coils. At night, after the engine is shut down, the valves *C* and *D* are closed, while the valves *A* and *B* are opened and left this way until the next morning, the night-watchman keeping the steam up.

It would have been an improvement if the pipe from the valve *D* were connected into a receiving tank, thereby saving the water of condensation from the exhaust steam during the day, or whenever the engine is running, and using this water over again for boiler feeding, as the water had to be paid for at meter rates.

The check valve *E*, which is in use when live steam is used and the water of condensation returned direct to the boilers, must be tight at all times, for if this check valve leaks, the system will not work satisfactorily.

There are many steam plants where no use is made of the heat in the exhaust steam, and it is hard to say whether the

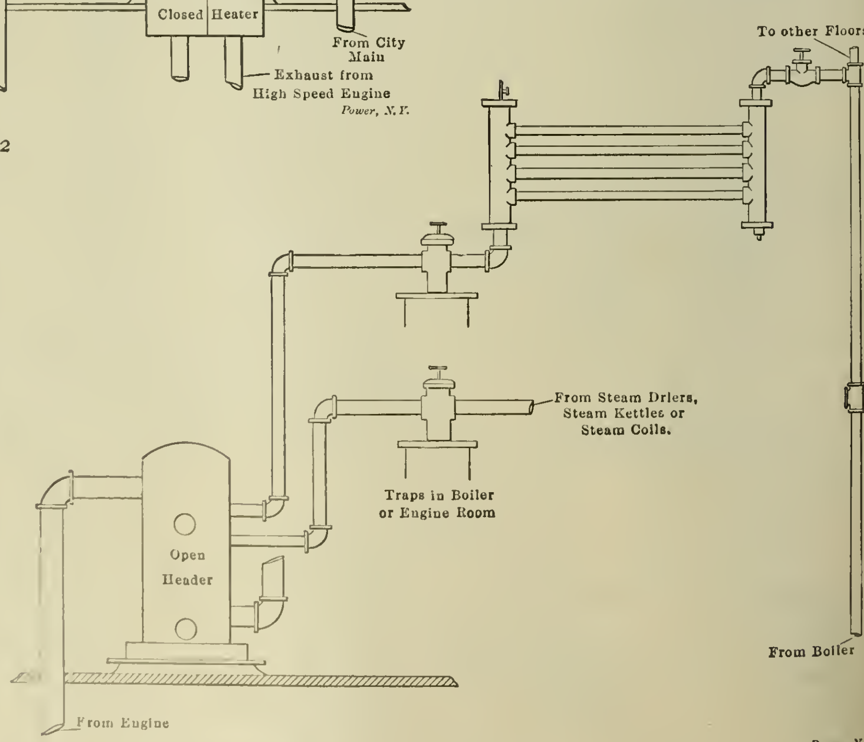


FIG. 3

owner or engineer is at fault for not making use of it for heating the building or heating the feed water for the boiler. Many steam-plant owners do not see any real gain from installing the necessary appliances for making use of the exhaust steam. The writer has in mind one plant where this is done. There is a large Corliss engine and the exhaust passes through an open heater. Some time ago a high-speed engine was installed for driving a dynamo for lighting the building, and the exhaust steam was run direct to the atmosphere. The reason it was not run through the open heater, as was that from the large engine, I think was because this heater was too small to take care of the exhaust from both engines.

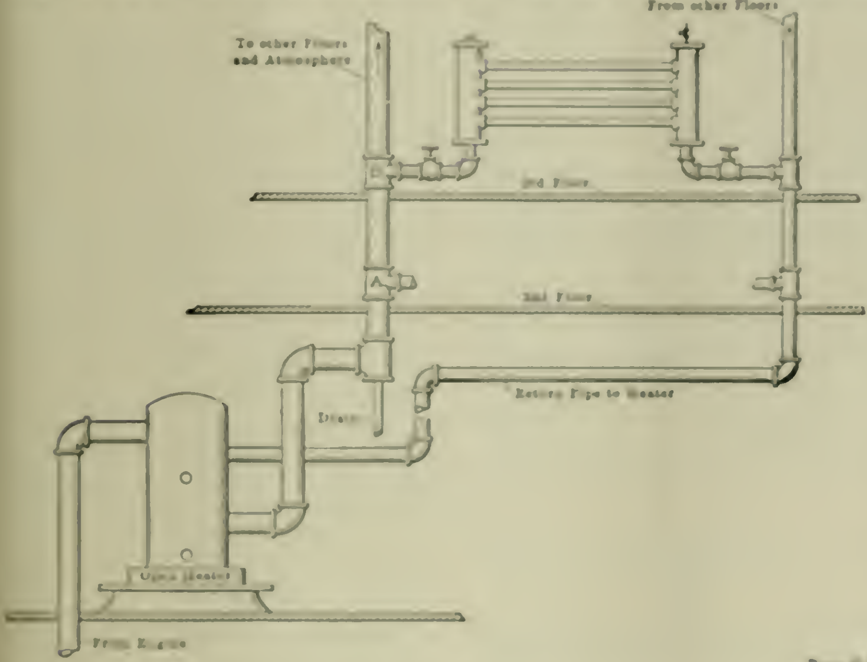
It would have paid the owner to install a larger heater, or a small closed heater could have been installed in the exhaust line of the high-speed engine and, as water was taken under pressure from the city main the water could be first passed through the closed heater and then into the open heater, as shown in Fig. 2, making the water much hotter before it went to the boilers, resulting in a saving in the coal bill. Should the high-speed engine be shut down for any cause, the valves A and B could be closed and the open heater fed with cold water through the pipe C from the city main, or the piping could be arranged so that if the open heater got out of order the water could be passed by this heater to the pump from the closed heater, thereby making it unnecessary to supply cold water to the boilers.

Fig. 3 shows a plan where live steam is used in heating coils, steam driers and steam kettles, and water of condensation is returned by means of steam traps to an open heater. The steam traps can be placed in any convenient place in the engine or boiler room, or on the wall on shelves, as shown.

Fig. 4 shows a plan where exhaust steam is used and water of condensation returned to an open heater in the engine room. In this plant the exhaust steam is carried to the fifth floor with a back-pressure valve in the exhaust pipe at the ceiling on the fifth floor. There are also tees in the exhaust pipe at each floor, as shown at A and B, and from these tees pipes are branched off to each coil of heating pipe on this floor.

H. Jahnke.

Milwaukee, Wis.



Power & E

FIG. 4

Compound Engines

Regarding G. W. Harding's contention in the April 20 number, that we can get twice the work out of an engine by compounding, whereas he says: "If the diagrams show, say, 100 horsepower in the high-pressure cylinder and 100 horsepower in the low-pressure cylinder, we have a 200-horsepower engine, do we not? Suppose we remove the low-pressure cylinder, do we still have a 200-horsepower engine?" To the first, yes, to the second, no; but by removing the low-pressure cylinder and other impediments, and running it as a simple engine about 120 horsepower would be developed, for the principal reason that there would be no receiver pressure to exhaust against.

Now, if we can gain from 20 to 40 per cent. in power by compounding, it would certainly be the sensible to do so, if steam consumption is taken into consideration.

Let us look in what light Mr. Harding regards a triple-expansion engine. According to his reasoning a triple-expansion engine would develop three times the power of a simple engine, and so on.

A. L. Anderson.

Douglas, Alaska.

G. W. Harding seems to be somewhat mixed in his article on the compound engine, in the April 20 number. He does not state clearly what he means by a compound engine having twice the power of a simple, but one would presume that he means that by compounding a 100-horsepower simple engine it would develop 200 horsepower, all other conditions remaining the same.

Suppose we have a 200-horsepower compound engine, with the work equally divided, or nearly so, between the two cylinders. He would say that we have only a 100-horsepower engine left if we remove the low-pressure cylinder with the steam pressure and revolutions remaining the same.

When we remove the low-pressure cylinder, we also relieve the back pressure on the high-pressure piston, thereby increasing the power developed in the high-pressure cylinder, say, 25 horsepower, with the same cutoff on the high-pressure cylinder, or a total of 125 horsepower, which the high-pressure cylinder of a 200-horsepower compound engine will develop if run as a simple engine.

Take a 100-horsepower simple engine of the same make, the steam pressure, revolutions and other conditions to remain the same. Change it to a compound by adding a low-pressure cylinder of the proper ratio. It will now develop with the same cutoff about 125 horsepower, not 200 as Mr. Harding would have us believe.

The last paragraph in Mr. Harding's article is all right, only he is mistaken as to the amount of power to be gained by compounding.

The initial cylinder condensation is less, the rotation is smoother, the strains are more evenly divided throughout the stroke, thereby permitting the use of lighter parts and lighter flywheels for the same degree of steadiness.

Charles E. Bigsworth.

Sprague, Wash.

I am afraid that Mr. Harding uses the terms rated horsepower, active horsepower, economy of a plant, economy of steam consumption, relative economy of two engines and what is considered good economy based on general practice, in a rather loose sense, and so [illegible] things are not what they seem.

A compound engine might be made to do twice the work of a simple engine and be much more economical, and at the same time the simple engine might be running in an uneconomical manner. Some times it is more economical to buy a [illegible] engine which may seem to be [illegible] uneconomical way than to buy a better engine which uses steam in a more economical way.

If the low-pressure cylinder is doing 100 horsepower and the high-pressure cylinder is doing 100 horsepower there is then a 200-horsepower engine, regardless of the builder's rating. If the low-pressure cylinder is taken away, we will still have a 200-horsepower engine, and it will develop 200 horsepower, but the fireman will sweat more, for it will use more steam as a 200-horsepower simple than as a 200-horsepower compound engine.

Mr. Harding says, in summing up: "I have learned that in order to increase the power of an engine one should raise the boiler pressure, speed the engine up, enlarge the cylinder or compound by adding a low-pressure cylinder."

I know a compound engine whose load is changed about 50 horsepower at a time. It is rated at 150 horsepower. When the full load is thrown on, it is changed from 150 horsepower (rated) to a 290-horsepower engine. The boiler pressure is not raised, the engine is not speeded up, the cylinders are not enlarged, and it is not compound, but on the contrary the speed is actually lowered trhee or four revolutions per minute. When the engine runs slower, the governor balls run in a lower phase and the cutoff is lengthened. The engine not only takes more steam, but more steam per horsepower and is therefore less economical.

Let us take a simple engine already overloaded, but developing 150 horsepower. It is actually a 150-horsepower engine. It is eating all the steam it can, but the power must be increased, therefore we will add a low-pressure cylinder which will use steam, but not the steam the high-pressure cylinder used or would use in developing 150 horsepower, but the steam it wasted by condensing it on its walls. For this reason the compound engine will develop, say, 200 horsepower, or the horsepower of the engine will be increased.

In order to make it run smoothly each cylinder is made to do an equal amount of work. The low-pressure cylinder is added not to increase the horsepower by using the same steam over again or to get more work out of the steam actually used by the high-pressure cylinder, but to increase the horsepower by using the steam which the original high-pressure cylinder condensed on its walls and wasted.

If Mr Harding will plot the two diagrams to the same spring scale and combine them into one, he will see that a compound engine does not consist of two separate engines using steam at two pressures but of one engine with two parts using steam at one pressure. The compounding does not make a second use of the steam but uses the steam that would be wasted. He must learn to look at a steam engine not as a machine which uses steam or changes the steam pressure into motion, but as a machine which changes the heat in the steam into work.

W. G. Talbott.

Angel Island, Cal.

Why Won't the Engine Carry the Load?

The accompanying indicator diagrams were taken from an Armington & Sims cross-compound engine, size 10½ and 16½ x 12 inches, speed 278 revolutions per minute, indicator spring, 60, steam pressure, 122 pounds, vacuum power, 30 pounds. This engine is connected to a two-phase induction alternator by a belt and was delivering 83.6 kilowatts to the switchboard when the diagrams were taken. During the time the indicator was being changed from the high-pressure cylinder to the low-pressure cylinder the load did

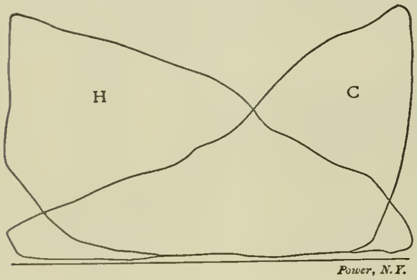


FIG. 1

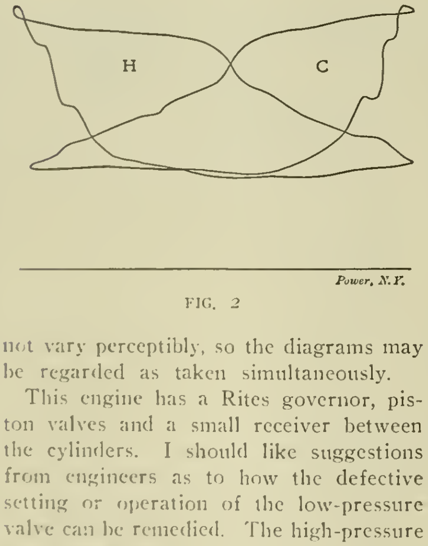


FIG. 2

not vary perceptibly, so the diagrams may be regarded as taken simultaneously.

This engine has a Rites governor, piston valves and a small receiver between the cylinders. I should like suggestions from engineers as to how the defective setting or operation of the low-pressure valve can be remedied. The high-pressure valve takes steam at the outside edges and exhausts at the center, while the low-pressure valve takes steam at the center and exhausts at the outside edges.

Another fault of this engine is its inability to carry a load one time that it will carry another time. For instance, in the evening the lighting load builds up gradually to 92 kilowatts which is this engine's limit. We put in another engine to help over the peak load, and when the load builds up to, say, 100 kilowatts, if we take out the other engine when the load goes down to 92 kilowatts, the Armington & Sims will not carry it, the steam pressure being the same. Why is this?

At what position should the governor be blocked while setting the valve?

J. W. Blake.

Mt. Kisco, N. Y.

Boiler Inspection and License Laws Desirable

The editorial in the April 27 number, "Boiler Inspection and License Laws Desirable," leads me to the belief that the situation in Maine is not fully understood, nor why the license law failed to pass at the last session of the State legislature. The bill that was proposed was so wretchedly drawn that no self-respecting engineer could possibly approve of it. It should have been called: "A Law to Corner the Market in Stationary Engineers and Firemen." The writer is a stationary engineer of more than fifty years' active experience and believes in a thorough inspection of all steam boilers, and any practical law that will prevent or reduce in number the loss of life by boiler explosions; and he so stated to the committee on legal affairs at the last session of the legislature.

The lawyer who appeared for Portland No. 1, N. A. S. E., stated that he did not draw up the bill and had passed a very unpleasant afternoon while advocating it. With other engineers from some of the largest and best-managed corporations in the State, the writer attended the hearing to protest against the proposed bill and at the same time to recommend the passing of a rigid inspection law for steam boilers. The lap seam and the factor of safety were explained to the committee, and legislation upon these was strongly recommended.

I do not believe there were any measures taken by any person or corporation to check the discussion in the newspapers of the State. The most intelligent and the best-equipped engineers of the State were opposed to this bill as presented, and so stated at the hearing. No one except the lawyer spoke in its favor. There was no minority report.

At the last session of the Massachusetts legislature there was a bill praying for relief from the hardships imposed on the manufacturers by the present license law. A recent visit to several of the large power plants and manufacturing concerns in that State and interviews with their chief engineers convinced me that they had abundant reason for complaint. If the Massachusetts law has proved to be a hardship, the bill offered in Maine would have proved a much greater one.

I do not think that the recent explosion at Farmingdale should be quoted against Maine any more than the disaster at Brockton should be cited against the Massachusetts license law.

C. D. Thurber.

Biddeford, Me.

Use Cylindrical Flywheels for Safety

There are several important points in Mr. Hodges' article in the May 4 number, page 798, that do not look at all like good reasoning.

The energy delivered by a flywheel is, as stated, proportional to the moment of inertia, but in reducing the mass, M contains the variables R = radius and b = the breadth, and hence should be simplified. Equating the moments of inertia for two wheels we shall get an expression as follows:

$$M_1 R_1^2 = M_2 R_2^2;\ I_1 = M_1 K_1^2;\ I_2 = M_2 K_2^2$$

where

M = Mass,

K = Radius of gyration, which can be taken equal to R for this discussion.

Reducing M to its components we have:

$$M = k\ b\ t\ R,$$

where

k = Density,

b = Width,

t = Thickness,

R = Radius.

Substituting in the first equation we have:

$$k\ b_1\ t_1\ R_1^3 = k\ b_2\ t_2\ R_2^3;$$

t and k can be taken as constant; $t_1 = t_2$, $k = k$. Then

$$b_1 R_1^3 = b_2 R_2^3,$$

or

$$\frac{b_1}{b_2} = \frac{R_2^3}{R_1^3},$$

from which it follows that the widths of two wheels of the same moment of inertia are to each other inversely as the cubes of the radii. As the weight varies as the width × the radius, the foregoing formula may be written as follows:

$$\frac{b_1 R_1}{b_2 R_2} = \frac{R_2^2}{R_1^2}.$$

In other words, the weights vary as inversely as the squares of the radii. Hence if a flywheel weighed, say, 2000 pounds, one of half the diameter would weigh 8000 pounds and one one-third the diameter 18,000 pounds. As ball bearings can be used only for light work, the inadvisability of putting in ball bearings to take care of this increased load can be easily seen.

The purpose of the article was also to show how the stress varies with a change in diameter. The same fallacy occurs here, also, as M is again a variable containing b and R, and should be reduced as low as possible. The force tending to burst a flywheel is, however,

$$F = \frac{M V^2}{4 R},$$

where

F = Force,

M = Mass of all rotating particles,

V = Velocity,

R = Radius.

Reducing V to $2 \pi R N$,

$$F = \frac{M (N\ 2 \pi R)^2}{4 R}.$$

N = Number of revolutions.

This force F is the total force at any one section, and dividing by $b \times t$, we get unit stress:

$$S = \frac{M (N\ 2 \pi R)^2}{4 R b t}.$$

Reducing M:

$$S = \frac{k\ b\ t\ R\ (N\ 2 \pi R)^2}{4\ b\ t\ R}$$

$$S = k\ \pi^2\ R^2\ N^2$$

Calling $k\ \pi^2 = C$,

$$S = C\ R^2\ N^2,$$

which is the formula given by Kent.

As to why this formula is incorrect, the reasoning is not at all clear. There are some four or five arguments, some directly opposed to others, which mean little and prove less. It is at once evident from the formula that the stress does not depend on either breadth or thickness, within the limits of the assumption, for the more material in the rim, the greater the cross-section to withstand the force. The mass, however, increases as the radius increases and the R^2 will stay in the discussion. In other words the stress varies as the square of the radius, which is even better for the purpose of the article.

To sum up conclusions then: To replace the present flywheel by one, say, one-third as large, we should have to increase the width twenty-seven times and the weight nine times, which would also decrease the liability of explosion by a factor of nine. The last may be secured, however, by increasing the spokes.

J. H. Snow.

Madison, Wis.

Boiler Efficiency

In the issue of May 4, page 811, W. Kent takes exception to my remarks appearing in the March 16 number, concerning the use of the term "efficiency" in connection with boilers, and states that I have used the term "boiler efficiency" in a different sense than it has been used for the past forty years by all authorities on steam boilers, and in a sense that is not in harmony with the meaning of the word "efficiency" as applied to other things in boilers.

There is no difference of opinion between us regarding the definition of "efficiency," which he gives as "output divided by input," but this is not the point. He states that the efficiency of a boiler is not a constant quantity, but necessarily variable due to rate of driving and other things. This is surprising. The difference, for example, between the early boilers in the form of kettles heated on the outside, with but a relatively small portion of the heat finding its way into steam, and those made later with tubes within them and passages arranged around the outside so that a much greater portion of the heat was absorbed, was one of mechanism and necessarily a constant; therefore the efficiency must be a constant and not a variable. Thus it is clear that the latter type is more efficient due to the fact that there were tubes through it and passages around it, and it is the recognition of this fact which I urge. Therefore the only difference between the two boilers being that of design and construction, serving them with a good or poor fire can in no way change their characteristics. Of course, if a good fire is made under a poor boiler and a poor fire under a good boiler, the result, which is the efficiency of operation, might be the same in each case.

Mr. Kent confuses the efficiency of operation with the efficiency of the boiler, and it is surprising to me that arguments of this kind should be presented, because a little thoughtful consideration will make it perfectly clear that the efficiency of a boiler itself should be recognized, and the efficiency of operation, which has masqueraded in some cases as the efficiency of the boiler, is inadequate to give definite information relative to the boiler itself.

A. Bement.

Chicago, Ill.

Cause of an Engine Wreck

On page 892 of the May 18 number Leroy H. Wheat asks, "If the load is all thrown off of a Corliss engine would there not be a checking of the speed before the governor would drop from its highest place to the point where the intake valve would again open to admit steam?" And he suggests the setting of the collar on the governor stem so that the cutoff shall never be less than the valve opening, or 1/16 inch. This might not be too much, and yet with a good vacuum and no load I should be afraid to risk it, and I speak from long experience in rolling-mill work.

This was not the point I was looking at when writing the article alluded to. The question was, "What would be the result of lengthening the long rod and shortening the short rod on the governor of a Corliss engine?" This question had nothing to do with the limit to which this might be carried.

To show what can be done in this direction, a man had a large Corliss engine fitted with one condenser and the latest cutoff being too early for his work, he changed the rods as indicated until the shortest cutoff was at one-fifth stroke. This was all right as long as the entire empty mill was attached, but one day the main belt broke and there was an empty engine whose shortest cutoff was at one-fifth.

Lengthening the long rod and shortening the short rod may bring the shortest distance of cutting off at any place, and the result appears in the papers: "The load was suddenly thrown off and the engine ran away."

W. E. CRANE.

Broadalbin, N. Y.

State Supervision of Boilers

In answer to Mr. Sheehan's inquiry I will say that the State requires all stop valves 2 inches and over in diameter to be of the outside screw-and-yoke type, on new construction; that is, on boilers installed since May 1, 1908. This rule, however, does not affect valves on boilers installed prior to this date. That is why the inspector required the valve on the new boiler to be changed and allowed the others to remain.

Evidently Mr. Sheehan has not made use of the opportunity to get a copy of the State "Boiler Rules," which are published in pamphlet form and contain much valuable information for engineers. These rules can be had free of charge by applying to any member of the boiler-inspection department.

RALPH F. BLANCHARD.

Fitchburg, Mass.

Economy of Different Sized Engines

In relation to statements contained in James L. Guile's letter on page 891 of the May 18 number, I think Mr. Guile is making a mistake in presuming that the 8x8 engine will be more economical in the use of steam than the 8x10. It seems to me that he is basing his calculations on a 10x8 instead of an 8x10; that is, he considers the 10-inch dimension as the diameter of the cylinder instead of the stroke, which it really is, it being usual to name the diameter first and the stroke second, and in that case the 8x8 engine would not be the better under the other assumed conditions.

Suppose the initial steam pressure, absolute, to be 150 pounds, the back pressure 17 pounds, the revolutions per minute 250, and the indicated horsepower 50 for both engines.

Let x equal the mean effective pressure for the 8x8 engine; then by transposing the terms of the horsepower formula and substituting the given values, we have

$$x = \frac{33{,}000 \times 50}{\frac{8}{12} \times 50 \times 500} = 99$$

pounds. For the 8x10 engine the mean effective pressure will be

$$x = \frac{33{,}000 \times 50}{\frac{10}{12} \times 50 \times 500} = 79.2$$

pounds. I have used the round number 50 for the area of the 8-inch pistons in both cases in order to simplify matters, and further will consider that there is not any clearance. We want to find out at what points of cutoff, respectively, 99 and 79.2 pounds mean effective pressure can be obtained, bearing in mind the assumed data. The formula for finding the mean effective pressure is:

$$p = P \times \frac{1 + hyp\ log\ R}{R} - back\ pressure,$$

where

p = Required mean effective pressure,
P = Absolute initial pressure,
R = Ratio of expansion.

Back pressure is also expressed in terms absolute.

From the formula we can solve for the value of R, from which we can find where cutoff takes place, and then determine the difference in the quantity of steam used in the engines. First, to simplify, let

$$a = \frac{p + back\ pressure}{P};$$

then

$$a \times R - hyp\ log\ R = 1.$$

Assume a value for R and see how near to 1 we can get. For the 8x8 engine,

$$a = \frac{99 + 17}{150} = 0.773 +,$$

and,

$$0.773 \times R - hyp\ log\ R = 1.$$

Try $R = 2.5$; the hyperbolic logarithm of $2.5 = 0.9163$; so that the statement becomes

$$0.773 \times 2.5 - 0.9163 = 1.01.$$

This is sufficiently close to 1 for the purpose, to permit the use of 2.5 as the ratio of expansion in the 8x8 engine.

For the 8x10 engine assume the value of R to be 3.5. Then, as before,

$$a = \frac{79.2 + 17}{150} = 0.641;$$

and

$$0.641 \times R - hyp\ log\ R = hyp\ log\ of\ 3.5 = 1.2528.$$

Therefore,

$$0.641 \times 3.5 - 1.2528 = 0.99.$$

This also is sufficiently close to 1 to permit the use of 3.5 in the 8x10 engine.

From the foregoing, the point of cutoff in the 8x8 engine will be at or about 3.2 inches from the beginning of the stroke, to produce a mean effective pressure of 99 pounds, with the assumed conditions. For the 8x10 engine the cutoff will occur at or about 2.86 inches from the beginning of the stroke to produce a mean effective pressure of 79.2 pounds.

The difference is

$$3.2 - 2.86 = 0.34$$

inch, and

$$0.34 \times 50 = 17$$

cubic inches in favor of the 8x10 engine, or

$$17 \times 500 = 8500$$

cubic inches per minute, or 4.8 cubic feet of steam per minute, difference in favor of the 8x10 engine.

Of course the foregoing figures are not absolutely correct arithmetically, but they show the trend. I think there is hardly any doubt that the 8x10 will be the more economical engine and that William E. Snow, in the March 30 number, page 602, is correct in his findings.

CHARLES J. MASON.

Scranton, Penn.

"Notice to Visitors"

The ten notices to visitors in the April 27 number, suggest the following:

(1) Visitors are always welcome.

(2) Please clean your shoes.

(3) The engineer's time is limited, but he will be glad to answer sensible questions.

(4) The engineer-in-charge delights in keeping this engine room clean; please do not spit on the floor.

(5) Danger! Do not go near the engines, you are liable to get injured.

(6) The engineer does not know it all; sensible suggestions are always considered.

(7) If you do not know the engineer, make his acquaintance, you might find him interesting.

(8) Do not touch any of the apparatus in this room; it is liable to cause the engineer much trouble, and may prove fatal to you.

(9) The engineer's duties are many; if he has no time to entertain you, don't think he's "stuck up."

(10) Call again.

L. EARLE BROWN.

Ensley, Ala.

Kerosene Oil in Boilers

In Charles H. Taylor's article, page 807, May 4 number, concerning the use of kerosene oil in boilers, he states that if a boiler is excessively scaled there is danger in using kerosene oil, as it will undoubtedly find the weak places in the shell and tubes and is liable, in removing the scale, to start a leak.

I believe that if a boiler is made tight with excessive scale it is about time that something were done to remove the scale and show up the leaks so that they can be repaired. I cannot see where the danger lies, as the condition of the boiler certainly will not improve if the scale is allowed to remain.

Mr. Taylor gives the vaporizing point of kerosene oil at from 118 to 122 degrees, while Mr. Durand, in the same issue, on page 806, gives it at 338 degrees, and at the same time criticizes Mr. Mellon for stating that it vaporizes at 150 degrees. Now who is right? Kent gives the temperature of distillation at 338 degrees and the flashing point from 100 to 122 degrees.

LOUIS B. CARL.

Marshfield, Wis.

Some Useful Lessons of Limewater

What Causes the Limelike Deposit on Boiler Tubes; How to Get Rid of It; Softening Permanent-Hardness Water; Interesting Tests

BY CHARLES S. PALMER

As we begin this chapter on the uses of sulphuric acid, our attention is also called to the abuse of the acid and its salts; and this brings us square up against some of the problems and troubles of the fireman in the first lesson. We recall that there are two kinds of hard water, and that one kind, the temporary hardness, is caused by calcium bicarbonate or extra carbonate, in the water, which can be removed by simple heating when the plain carbonate of lime or calcium comes down, while the other kind of hardness, permanent hardness, is caused by calcium sulphate, which is not removed from the water by simple heating, but stays in the water.

The reason why this hard limelike layer gathers on the boiler tubes is that most of the water which goes into the boiler is evaporated off into steam, and the sulphate of lime or calcium, which makes the water permanently hard, naturally goes out of solution, settling on the tubes as a hard and dense layer, which in many cases has to be literally chiseled off. We noted that this special kind of trouble can be removed in part by treating the water with some soluble carbonate, like soda carbonate, which throws down the lime as insoluble calcium carbonate, leaving the sulphuric-acid part still in the water, as soda sulphate, for example.

Chemicals to Soften Permanent-hardness Water

Another way to get rid of this permanent hardness, in part, is to treat the water with something like sodium oxalate, or sodium [illegible], each of which will precipitate the lime or calcium part of the hardness, leaving the sulphate part still in solution in the water, as salt of sodium. These salts of sodium are soluble, and hence do not precipitate as crusts or layers on the boiler tubes.

The statement is frequently made that these soluble salts of sodium left in the boiler water do not hurt the boiler nor hinder the making of steam; and while this may be true in part, yet they can hardly be of any help in steaming, although the overcoming of the greater trouble of the hard sulphate of lime scale may more than offset the lesser trouble of still leaving the boiler water heavily charged with soluble salts of sodium. However, if the cost of the chemicals used to soften the permanent-hardness waters is not too great, no doubt there is great advantage in using them, for it merely means, in some cases, that the boiler must be blown off often enough to get rid of the salts accumulating in the water. You can see what this means by treating some of your hydrant water with a little dilute soda carbonate (washing soda, or the like), that is, if the water happens to be of the permanent-hardness kind.

After the lime part has settled out (or you can filter the calcium carbonate off, leaving the water perfectly clear), you can evaporate the solution down to dryness. Be sure not to use too strong a solution of soda carbonate, only just enough to leave the water barely alkaline; that is, so that it barely turns litmus paper blue. You will be interested to learn how little residue there is from the evaporation of the softened water; the residue is, of course, sodium sulphate, if you used sodium carbonate to soften the water.

But just stop and figure out what it means to handle the tons of water which goes through the boiler every week. Suppose that you treated only a pint of water in your experiment; that is about a pound roughly. Now suppose that you are firing the boiler for a fifty-horsepower steam engine. It is good practice to get a horsepower-hour with twenty pounds of dry steam. That makes one thousand pounds of dry steam every hour for your fifty-horsepower engine, or ten thousand pounds (five tons of water) every working day of ten hours. Now multiply the residue from your little pint of softened water by ten thousand and you will begin to get an idea of what it means to handle large quantities of hard water. Also, multiply the soda carbonate used to soften the pint of hard water by ten thousand, and you will get some notion of what it means to pay for the softening of water for a fifty-horsepower engine for one day.

But the steam is not always dry, and there is much waste, and perhaps you are using rather more than twenty pounds of dry steam per horsepower-hour; and hence the question of the advisability of using this or that water softener, or indeed, of using any water softener at all, comes up for consideration.

Other Questions to be Considered

But there are several other questions which will come up for study in connection with this subject of hard water. One is: What will one do if he has both permanent hardness and temporary hardness to handle at the same time? Another is: What will one do if he has not alone the salts of lime or calcium to handle, but also the salts of magnesium with those of calcium? These conditions are by no means uncommon, and something may have to be done when often it seems almost impossible to do anything. But the right way to look at troubles is that there is always some method of doing the trick, if one will stay with the game and never give up until he has found out what is best under the circumstances. We will first take up the question of the presence of both calcium carbonate and sulphate in the same water.

We will suppose that you have made such a water as that just described. This can be made by making some of the solution of extra, or double or bicarbonate of lime or calcium; as by blowing into limewater until the plain carbonate first thrown down by the breath is redissolved, at least in part. Let this stand; or, better, filter it to have it clear. It will be well to test a little of this water, which is temporary-hardness water, by heating to see if you really have what will throw down the plain carbonate. Then make some permanent-hardness water by shaking up some plaster of paris, calcium sulphate, with water. Then stand and decant off the clear liquid; or you can filter it to be sure.

Now mix the two, the solution of calcium bicarbonate or temporary-hardness water, and the solution of calcium sulphate or permanent-hardness water. If there is any precipitate on mixing, let the mixture stand until it is clear; or you can filter it. Perhaps you do not have to make any such mixture. Perhaps you are unlucky enough to have an abundant supply of this mixture right at hand in the city hydrant water. Never mind; take hold of the trouble and let us see what can be done with it all. Of course, the first thing to be done with this mixture of temporary-hardness and permanent-hardness water is now to get rid of the temporary-hardness part. This can be done either by heating in the heater and settling out, or by Clark's process as described in one of the earlier lessons.

Having got rid of the carbonate part of the lime, go right on to the sulphate part, using soda carbonate, as shown in the following reaction:

$$\left.\begin{matrix} CaSO_4 \\ \text{Calcium Sulphate} \\ \text{Soluble} \end{matrix}\right\} - \left\{\begin{matrix} Na_2CO_3 \\ \text{Soda Carbonate} \\ \text{Soluble} \end{matrix}\right\} = \left\{\begin{matrix} CaCO_3 \\ \text{Calcium Carbonate} \\ \text{Insoluble} \end{matrix}\right\} - \left\{\begin{matrix} Na_2SO_4 \\ \text{Sodium Sulphate} \\ \text{Soluble} \end{matrix}\right.$$

This soda carbonate will not only precipitate the calcium from its sulphate, but it will also precipitate any other soluble salts of calcium which may happen to be present in the water; such as the chloride. The same solution of soda carbonate will also thrown down the magnesium salts which may happen to be in the water along with the calcium. Some of these magnesium salts may go down with the scale on the boiler tubes, and some of them may do a worse thing still, eat out the iron tubes themselves. You will see in a moment how it is that some of the salts of magnesium can eat out the iron of the tubes; but note that you have actually removed the chief evil of having any of the lime settle on the boiler tubes from the mixture of both temporary- and permanent-hardness water in one, and that is something to be thankful for.

Sulphuric Acid is Very Strong

Now for the magnesium, and that brings us back to sulphuric acid. Sulphuric acid is a very strong acid, but it is not by any means the strongest acid. Thus, if you mix some soda with both sulphuric and muriatic (hydrochloric) acids, and evaporate the whole down to dryness, you will find that the sulphuric acid has driven off the hydrochloric acid, and thus the sulphuric acid seems to be the stronger; but this is not so, for the hydrochloric acid goes off simply because it is more volatile than the heavy and nonvolatile sulphuric acid, which takes a heat of nearly that of molten solder to drive it off. You will see what is meant if you stop to think that when two boxers meet in the ring, the stronger is not the one who can easily jump the ropes and quit the ring, but the man who stays in the field and does the most work for the same weight in the same time. So though the hydrochloric acid is really the stronger, if kept in the ring, yet his volatility gets away with his courage when he meets the heavier and more sluggish sulphuric acid; and so the sulphuric acid seems the stronger.

I shall later show something of the ways which are used in testing the comparative strengths of acids; but meanwhile we will look at the case of magnesium. If you take a bit of common salt and dissolve it in water, you can evaporate it down to dryness and still have the salt, sodium chloride, just as it was at the start. If you dissolve some limestone in hydrochloric acid, just enough acid barely to dissolve it, you can evaporate this down to dryness, and you will still have most of the calcium chloride with which you started, but not all; for, although all of the calcium part of the calcium chloride is there in the saucer, yet a small part of the calcium is in the form of lime, calcium oxide, as you can prove by letting it stand in the air for some time, when it will slowly gain in weight, as the five or ten per cent. of the lime in the seeming calcium chloride takes on some carbonic-acid gas from the air.

Magnesium Chloride

If you get some common magnesia and barely dissolve it in hydrochloric acid, you will have magesium chloride; and if you evaporate this solution down to dryness, you will not have pure magnesium chloride in the saucer, but largely magnesium oxide, or magnesia, just what you started with. This experiment is worth some trial and study, for it has much to do with the special question of waters which are hard with salts of magnesium. On the other hand, if you evaporate a solution of magnesium sulphate, epsom salts, down to dryness, you will still have magnesium sulphate in the saucer; but if you evaporate a solution of magnesium chloride down to dryness you have some plain oxide of magnesia, MgO, in the saucer.

You can prove that something of this sort is happening as you evaporate the solution of magnesium chloride down to dryness, both by holding a bit of blue litmus paper in the steam from the evaporating solution, when the paper will turn red, showing that the volatile hydrochloric acid is coming off. You can also readily smell the acid fumes from the evaporating solution. This is one of the facts to get clearly in mind about the chemistry of water hard with magnesium salts. We do not have many of these kinds of water in the eastern part of the country, but in the far West such waters do occur; and it is often a serious matter as to whether they can be treated economically in any way. Of course, there is always some way which is best under the circumstances. The point is that solutions of magnesium chloride (and magnesium bromide comes in the same list), when evaporated, act as though they were dilute solutions of hydrochloric acid, not very strong of course, but plenty strong enough to make trouble in time. Now the two great medicines for the treatment of such waters, as just shown, are lime and cheap soda carbonate; and both of these should be added, not at once, but in turn, and before the water is admitted to the boiler.

Tests for Sulphuric and Hydrochloric Acids

I shall have more to say about this question later; but meanwhile it will be convenient to have some simple tests with which to be on the lookout for both sulphuric acid and hydrochloric acid. The best test for hydrochloric acid is silver nitrate. This you can make by dissolving a silver dime in nitric acid. Of course, there are several other metals in the dime, put in to harden the silver, which would be otherwise much too soft to stand the wear and tear of daily handling. You can get around this by putting a piece of common sheet copper into the solution of silver nitrate, when you will see the silver come down on the copper in a beautiful crystalline form. This will take some hours to be thoroughly done; when all the silver is down on the copper, take out the copper, wash off the silver, say back into the tumbler, rinse off the silver several times with clean water to get rid of the copper solution, and then redissolve the pure silver in a fresh supply of nitric acid. *One thing you will want to note is that the dissolving of metals in nitric acid should be done in the open air; or before the furnace door, where there is a good draft to carry away the poisonous brown "nitric fumes" from the action of the metal on the nitric acid. Do not breath these fumes.* You can see that the metals are all chemically equivalent to hydrogen in some form; and as the metal acts on the acid, it reduces the acid if it can be easily reduced, as can nitric acid; and hence in this case we have the production of the fumes, which will be explained further as we come to nitric acid and the compounds of nitrogen.

This solution, from one dime, will last you a long time with careful use. It takes only a drop or two to test water; and though you can add enough to get the thick curd-like silver chloride, yet a single drop of the colorless solution of silver nitrate will give a distinct cloudiness in most common hydrant water. This white silver chloride will settle to the bottom of your test tube, and it will turn purplish gray in a few minutes, depending on the amount of light that strikes it; for you are close to photography when you use this test of silver nitrate with the chlorides.

This white silver nitrate is readily soluble in ammonia, and it is readily brought back by reacidifying with nitric acid. Silver nitrate is also a test for soluble bromides, salts of hydrobromic acid, and for iodides, salts of hydriodic acid; but in the case of the bromides, silver bromide is yellowish, and is soluble with difficulty in ammonia; while in the case of the iodides, silver iodide is distinctly yellow, and it is not soluble in ammonia.

I shall consider the tests for sulphuric acid and soluble sulphates next time.

Obituary

James Bennett Forsyth, president and general manager of the Boston Belting Company, died at his home in Boston June 11.

Discussion on "Small Steam Turbines"

Following is an abstract of a discussion presented by Charles B. Burleigh at the local Boston meeting of the A. S. M. E., on Friday, June 11, on George A. Orrok's paper on "Small Steam Turbines," presented at the Washington meeting of the society in May. Mr. Burleigh said:

While this paper is extremely interesting as presenting comparative data on the different small turbines at present available, the details as given (with the exception of the efficiency curves) are more general than specific.

A careful examination and comparison of the water-rate curves presented in this paper is extremely interesting, particularly in view of the fact that the author states that these curves "have in most cases been obtained from the manufacturers."

It is unfortunate that the curves vary so widely in capacities and speeds that a complete comparison of all is not possible, and it is also to be regretted that the paper does not state the normal rating given to the machines to which the different curves apply or which of the speeds is their commercial standard; but nevertheless, I have attempted to compare such as are closely similar with a view to determining as closely as possible the relative efficiencies of the different types.

For instance, the Terry curve (Fig. 25) gives a water rate of 57 pounds per brake horsepower at 2330 revolutions per minute, at 150 pounds gage pressure when developing 25 horsepower.

The Sturtevant curve (Fig. 26) shows a water rate of 61 pounds at 2300 revolutions at 121 pounds pressure when developing the same output; therefore according to these figures the Sturtevant turbine is 7 per cent. less efficient than the Terry, but I am inclined to feel that this is rather unjust to the Terry machine, for I should infer from the Sturtevant curve that 25 horsepower represented maximum load or its most efficient point, while the same inference would lead one to infer that the 25 horsepower point on the Terry curve represented less than half load, or practically its most inefficient point, and as the Sturtevant curve shows this machine to be some 16 per cent. less efficient at half load than at full load, and the Terry curve shows this machine to be some 22 per cent. more efficient at full load than at half load, it is safe to infer that the Terry machine on general principles is much more efficient than the Sturtevant.

The same Terry curve shows that when developing 60 horsepower the water rate is 44 pounds. The Bliss curve (Fig. 27) at the same output, 1900 revolutions, is 55 pounds. The Kerr curve (Fig. 31) at 2800 revolutions and 175 pounds pressure and 60 horsepower output shows a water rate of 52 pounds. The Curtis curve (Fig. 28) at 2400 revolutions, 150 pounds pressure and 60 horsepower shows a water rate of 40 pounds; therefore, according to these figures the efficiencies rank: Curtis, 40; Terry, 44; Kerr, 52; Bliss, 55; and this allowing Kerr 15 pounds higher pressure and 400 revolutions higher speed.

On the same basis, allowing the Curtis turbine its standard designed speed of 3600 revolutions, the water rate on its curve is shown to be 31 pounds. The Terry turbine is more than 18 per cent. more efficient than the Kerr and 25 per cent. more efficient than the Bliss. The Curtis at the same speed is 10 per cent. more efficient than the Terry and more than 25 per cent. more efficient than the average of the three and, at standard designed speed, 42 per cent. more efficient than the Terry and 62 per cent. more efficient than the average of the three at 60 horsepower output.

Comparing the Bliss curve (Fig. 27) at 120 horsepower, 2600 revolutions, the Kerr curve (Fig. 31) at 175 pounds, 150 horsepower, 2000 revolutions, and the Curtis curve (Fig. 29) at 150 pounds, 2000 revolutions and 150 horsepower, we note the water rates as follows: Bliss, 40 pounds; Kerr, 41 pounds; Curtis, 29 pounds.

These figures tend to show that the Bliss and Kerr are not widely different, but that the Curtis is some 40 per cent. more efficient at 150 horsepower output. These curves, therefore, would tend to show that the efficiencies of the Terry, Kerr and Bliss turbines were not widely different, and that the small Curtis turbine is in a class by itself, some 40 per cent. more efficient than any of the other types.

It is to be regretted that the author was unable to present efficiency curves of the other turbines described.

The paper credits the De Laval and Curtis types each with 70,000 horsepower of turbines in "successful commercial operation," and also states that the first De Laval turbines were "introduced into this country about 1898." The small Curtis turbine was not introduced until some 10 years later.

As this capacity includes the small Curtis units used for all purposes, it is reasonable to assume that it also covers all applications of the De Laval machine, and this latter machine has been extensively used for driving pumps, blowers or other high-speed rotary machinery, while at least 90 per cent. of the small Curtis units in service are operating generators for lighting or driving industrial establishments, for which reason they have all been sold in competition with the highest-grade and most efficient reciprocating units.

While the Curtis turbine is eminently well adapted for driving centrifugal pumps, air compressors and exhausters and other high-speed rotary machinery, it has not as yet invaded this field to any great extent, due largely to the fact that its manufacturers are more familiar with and have better facilities for making their initial bow to the commercial electrical field than to the mechanical, and it must be admitted that 70,000 horsepower in less than five years is a very profound bow.

Further than this (with apologies to the public who find it necessary to operate pumps and blowers), it is the exception rather than the rule, where refinements are considered as warranting any increase in investment or efficiency is seriously considered in the purchase of this class of machinery.

It is interesting to note from the paper that the buckets used in the De Laval, Terry, Dake, Bliss, Sturtevant and Kerr turbines are of steel, some cast and others milled. Originally the Curtis buckets were milled in the wheel periphery, but experience has demonstrated the fact that steel buckets are far from ideal where any perceptible moisture is present in the steam, for wet steam will wear steel turbine buckets.

The liability of operation under wet-steam conditions is much more common in connection with the use of small steam units than with large ones, as superheaters are seldom, if ever, installed in small plants, pipes are seldom covered and long steam mains are usual. For this reason the use of steel buckets in the Curtis turbine was abandoned some years ago, and all turbines from the smallest to the largest are fitted with composition buckets, upon which many years of use with wet steam has no appreciable effect.

The paper states that the Sturtevant, Bliss and Curtis machines are provided with an emergency governor. It would be rather interesting to learn if the Terry, Dake and Kerr turbines are not similarly equipped. I should be rather surprised to learn that they were not, and if not should feel it to be a serious handicap against their successful introduction.

The author emphasizes the reliability of this type of prime mover, which to my mind is its principal reason for existence, which is greatly increased by its simplicity. These characteristics of the impulse steam turbine are practically admitted by its worst enemy, as in these particulars it is almost identical with the hydraulic turbine which, previous to the commercial development of the steam turbine, stood alone as the simplest power-producing prime mover.

I want to call attention to the statement to the effect that "in none of these machines is clearance an important factor."

This is characteristic of the steady-running impulse turbine regardless of size, and is due to the fact that in this type of machine all steam admitted through and expanded by the nozzle or nozzles, on entering the machine or any stage of it, is of a pressure corresponding to that of the stage into which it is admitted; therefore, the atmosphere surrounding the buckets is of a given density at all points, and consequently there is no tendency for the admitted steam which has been given direction by the expanding nozzle to change its course and escape into an atmosphere of its own density.

This calls to mind another feature of the small-turbine situation, which is brought prominently to notice by this paper, and that is the entire absence of any development of the so-called reaction type of turbine in the small sizes. There are good and sufficient reasons for this, but as this type of turbine is not mentioned in the paper they cannot properly be made a part of this discussion.

In closing, I wish to comment in a friendly way on the author's implication that the small turbine is less efficient than the high-speed steam engine, where he says, "The field of the small steam turbine is somewhat narrow when compared with the high-speed steam engine. The small turbine has its place, however, and with the development of a more economical machine at lower speed ranges, will have a much wider field."

I will readily admit that its present speed characteristics limit its field in comparison with the high-speed engine to the extent of the mechanical application of its output; but will not admit that the present efficiency of the Curtis type in any way limits its field in comparison with the high-speed engine, nor do I think the author intended to be so understood; but to obviate any possibility of error I will call your attention to a paper presented by Messrs. Dean and Wood before this society last June, at the Detroit meeting, and the discussion which followed by Messrs. Young and Treat, detailing the results obtained from water-rate tests of some fourteen high-grade, high-speed engines of different design and manufacture, which had been in service three months or longer.

As these water rates were given on the indicated horsepower and on the kilowatt basis, I have allowed 5 per cent. for friction in each case, to facilitate a comparison on a brake-horsepower basis, in accordance with the curves forming a part of the paper.

Mr. Dean's figures are as follows:

Engine	No. 1	No. 2	No. 3	No. 4
Capacity	[illegible]	[illegible]	110 h.p.	160 h.p.
Water rate	30.45	37.7	33.6	39.5

Mr. Wood's figures are as follows:

Engine	A	B	C
Capacity	[illegible] h.p.	[illegible] h.p.	160 h.p.
Water rate	31	35.2	35.8

Mr. Young's figures are as follows:

Engine	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
Capacity	70 h.p.	30 h.p.	28 h.p.	130 h.p.	123 h.p.	45 h.p.
Water rate	48.3	39.9	37.8	36.3	33.2	31.9

Mr. Treat's figures were as follows:

Engine	No. 1
Capacity	30 h.p.
Water rate	43

Compare the foregoing water rates per horsepower with the curves of standard Curtis turbines, as shown by the curves in Figs. 28 and 29 of this paper.

To assist in this comparison I have tabulated the results, placing the turbine water rate under the water rate of the corresponding capacity of engine and we have:

Horsepower	28	30	30	45	70	100	123	130	130	140	150	150	160	250
Engine water rate	37.8	39.9	43	31.9	48.3	35.8	33.2	36.3	35.2	33.6	30.45	37.7	39.5	31
Curtis water rate	41	41	41	32	31	30	30	30	30	29	29	29	29	29

It will be noted from the foregoing that on the smallest sizes it has been necessary to compare the half-load water rates of the turbine with the full-load water rate of the engine, for the reason that the smallest Curtis curve in the paper is 65-horsepower, but even under these conditions the average of the four smaller engines at full load is only 0.85 of a pound better than the half-load water rate of the turbine.

From this point up we have an exact comparison and at no point does the engine water rate begin to compare with that of the turbine. The nearest approach is at 150 horsepower, and here the turbine is 5 per cent. better and the widest margin at 160 horsepower, where the turbine is 36 per cent. better, while the average from 70 to 250 horsepower shows the turbine to be 22 per cent. more efficient than the engine.

But it may be said that these curves were obtained from the manufacturers and apply to new machines, while the engines were tested in service and had been in use for some time. This enables me to bring to notice the fact that the engine deteriorates with wear while the turbine does not, and it is the day-in-and-day-out water rate in which we are interested and not the builder's guarantee on the new machine.

The Curtis turbine does not fall off in efficiency due to long service, nor is its efficiency affected by adjustments, and in this connection I will refer to a statement made by Prof. R. C. Carpenter in discussing this paper at the time it was presented before the association at Washington, in which he said that he had tested a 75-kilowatt Curtis turbine which had been in service some 7000 hours and the results were not materially different from the results obtained on a new machine of the same capacity and design.

It is extremely rare that an opportunity is offered for procuring reliable data on different types of apparatus operated under identically similar conditions. I may, therefore, be pardoned for quoting from a letter recently received from a gentleman who had this opportunity and availed himself of it to profit thereby. He says in part:

"We have a 50-horsepower automatic engine, operated at 200 revolutions per minute, driving a 35-kilowatt compound-wound generator, which we use in connection with our 35-kilowatt turbine. We have made tests running the turbine and engine on alternate nights, off the same boiler and under the same conditions of load, steam pressure and exhaust, and find that for the same run and load the engine set requires 1500 pounds of coal, against 900 pounds for the Curtis turbine, or a saving in coal in favor of the turbine of about 40 per cent."

From the foregoing I am inclined to feel I may be excused for not admitting that the present efficiency of the small Curtis turbine in any way limits its field in comparison with the high-speed engine or other types of turbine.

Convention of the American Water Works Association

Occupying the entire week between June 7 and 12, the sessions of this, the twenty-ninth annual convention of the American Water Works Association, embraced every phase of the problem of supplying water to cities. Scientists, mechanical engineers and men skilled in every department of such work were present, and read papers of educational and technical value, making this one of the most successful meetings of the association. The convention, which was held at Milwaukee, Wis., was opened in the Plankington house Monday afternoon. Mayor D. S. Rose had been scheduled for the address of welcome, but he was called out of town, so Assistant City Attorney Clinton G. Price extended the keys of the city to the visitors. President French then read his annual address, after which the session adjourned until the following day.

Business was transacted promptly, and strictly according to schedule, this being made necessary by the large number of papers that had been prepared. The character and scope of them may be judged by the following list of titles and authors:

"Valuation of Water Power and Diversion Damages," by Robert C. Horten.

"Hypochloride of Lime on Mechanical and Slow Sand Filters," by A. E. Walden.

"Test and Notes on Gas Producer Pumping Plant," by J. R. Fitzpatrick.

"Fire Losses," by H. W. Wilson.

"Growth in Water Mains," by Erastus G. Smith.

"Sterilization of Water at Boonton Reservoir," by George W. Fuller.

"Sterilization of Jersey City Water," by Dr. J. L. Leal.

"Notes on 'Sterilization and Cost of Treatment,'" by George A. Johnson.

"An Attempt to Annul a Perpetual Charter," by James R. Fitzpatrick.

"Liability of Water Companies for Fire Losses," by Chester R. McFarland.

"The Wisconsin Utility Bill," by C. B. Salmon.

"Notes on Going Value and Methods by which It may be Completed," by John W. Alvord.

"Development of Water Supply at Superior, Wis., by William C. Lounsbury.

vision were: "Coal for Hand-fired Steam Plants," by D. T. Randall; "The Use and Abuse of Fuels," by H. M. Wilson; "Smoke and Smoke Prevention," by Profs. L. P. Breckenridge and K. G. Smith; "Buying Fuel by Test," by E. W. Bemis and C. F. Schultz; "The Purchase of Coal upon Heat Value Contract," by Edward H. Taylor; "Chemical Data as Related to the Power Plant," by Prof. S. W. Parr.

These papers discussed questions relating to the fuel which enters into the cost of operation of water-works systems as one of the first and most important expense items, one which may, with proper management, be reduced considerably in the majority of plants.

of boiler for different pressures, conditions, etc., was outlined. "Superheating for Duty," by Ernest H. Foster, and "Test of Pumping Engines with and without Superheating Steam," by John Primrose, the two latter being treated together by Mr. Primrose.

Much detailed information on the practical operation of plants and the cost of pumping water was contained in George G. Kennedy's contribution, "Boiler Equipment, Practice and Results at the Pumping Station of Harrisburg, Penn." "Boiler Room Symposium," by J. M. Whitham, in the absence of the author, was read by Secretary Diven, and in a paper entitled "Practical Coal Handling for Pumping Stations," by S. Bent Russell, this neces-

DELEGATES AND VISITORS AT AMERICAN WATER WORKS ASSOCIATION CONVENTION, MILWAUKEE, WIS., JUNE 7-12, 1909

"The Maidstone Epidemic," by William P. Mason.

"A Typhoid Epidemic Due to Milk," by Erastus G. Smith.

"The Sanitary Condition of the Southern End of Lake Michigan," by J. Herbert Brewster.

"The Acquisition by New York City, of the Larger Two Water Systems of Staten Island," by Leslie L. Tribus.

"Municipal Ownership of Public Utilities," by E. MacLean.

"Concrete in Water Works Construction," by William Curtis Mayley.

Thursday was devoted to papers on boiler-room economics and allied subjects. These papers were of special interest to engineers, as the questions were those directly affecting the operation of the plant from a dollars-and-cents standpoint. Among the papers presented in this di-

Another group of papers took up boiler feed water under the headings: "Boiler Water Treatment and Its Saving," by Marshall Miller; "Water Supply and Treatment for Power Plant Purposes," by William Miller Booth; "The Boiler Water," by Edward Barrow. Much of interest and value was developed from the reading and discussion of these papers.

"Milwaukee Pumping Engines" was the subject of a paper by Cornelius T. Myers, outlining the history of the city water-works pumping equipment and containing a large amount of valuable test data on the remarkably efficient results being obtained there.

Other papers of interest were: "Modern Boiler Practice," by John W. Hill, in which the construction of boilers for use in water-works pumping stations was taken up and the determining of different types

sary part of the power-house equipment was analyzed.

Officers for the ensuing year are: Dr. W. P. Mason, Troy, N. Y., president; Alexander Milne, St. Catharines, Ont., first vice-president; John W. Alvord, Chicago, Ill., second vice-president; Dow R. Gwinn, Terre Haute, Ind., third vice-president; R. J. Thomas, Lowell, Mass., fourth vice-president; J. A. Affleck, Harrisburg, Penn., fifth vice-president; J. M. Diven, Charleston, S. C., secretary-treasurer.

Of the Water Works Manufacturers' Association, the officers for 1909 are: Dennis F. O'Brien, Newark, N. J., president; Fred A. Smith, New York, N. Y., vice-president; Robert K. Mulligan, New York, N. Y., secretary-treasurer.

New Orleans was chosen as the next place of meeting.

POWER AND THE ENGINEER

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Contents

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What is the Maximum Bearing Pressure in Compound Engines?

The following question is exercising the drafting-room corps of a prominent engine factory: "Assuming a certain initial pressure of, say, one hundred and fifty pounds as applied to a simple engine, the diameter of cylinder and the dimensions of bearings, pins, etc., being designed for this pressure, what area of cylinder would be permissible in a tandem or cross-compound engine using the same bearing and pin dimensions?"

That is to say, if the engine were simple, the pins, bearings, etc., would have to be designed to sustain a pressure upon the piston of one hundred and fifty pounds per square inch, but if it were a compound, this initial pressure would be neutralized in part by the receiver pressure; but again there is the receiver pressure acting upon the whole area of the low-pressure cylinder. It is a pretty subject for discussion, and we shall be glad to have our correspondents take it up.

As to Books

A book that would tell the reader how to locate a thump in an engine, determine the efficiency of a tungsten lamp, rewind an obsolete type of arc light dynamo, analyze boiler feed water, learn all about alternating currents and locate trouble in a balky gas engine would "fill a long-felt want." We receive almost daily requests for a small manual of some such modest range, written in plain English, without any mathematics; and we wish somebody would publish one or send us the manuscript and let us publish it. Of course, there are many handbooks covering a wide range, such as Kent, Suplee, Tulley, etc., but these don't quite reach. If the price isn't too high or the treatment too scientific, the range is too low or the information is not given in sufficient detail. What is needed is a book that will tell a man anything he wants to know about any engineering subject, in a plain, practical way.

Of course, dear readers, you recognize that this is more or less of a joke, but we assure you in dead earnest that we really are asked to recommend books just as impossible as the imaginary one described in the preceding paragraph. Now, we don't mind in the least receiving and answering letters like that; the only thing about it that worries us is that we can't do what we are asked to do. Books on engineering are necessarily of two kinds: one treating a single branch or subject very fully and the other covering a wide range of subjects in very condensed style. A book written in elementary style, without any formulas, cannot deal thoroughly with a dozen branches of engineering; it would take several volumes about the size of the Century Dictionary to do that. Consequently, a general handbook covering a wide range must be limited to stating fundamental facts, without attempting complete explanations of principles or practical working instructions, and formulas must be used to save space.

Every engineer, no matter how small a job he is filling now, should have a little library of books dealing with all the subjects that relate in any way to his work. The library should include one or two good handbooks, for quick reference, but there should be at least half a dozen other books, each devoted to one branch or subject and covering that branch or subject very thoroughly. If you are shaky on simple mathematics, a good arithmetic and a very elementary algebra should occupy prominent places on the bookshelf. If you get stuck, write to us and we'll help you over the stump if we can, but don't turn up your nose at formulas or get discouraged as soon as you meet one; the road to success is a whole lot rockier without them than if you can use them. And don't forget that you can't learn much about a great many subjects from any single book.

Proper Distribution of Draft

If a boiler plant consisting of six boilers, of the same capacity, and with each boiler equipped with an individual stack, all the stacks being of the same diameter and of suitable area, but varying in hight from one hundred and fifty feet for the highest down to twenty-five feet, any engineer would at once condemn the layout and think it absurd that a design of this kind should exist. However, we believe we are safe in saying that there are hundreds of plants being operated under similar conditions, without the engineer in charge giving the matter the slightest thought.

It is rare that a plant consisting of a number of boilers has an individual stack for each boiler, but conditions approximating those just stated are frequently obtained in plants where several boilers are supplied by a single stack. Movement of flue gas is obtained by very small differences in pressure, and it is greatly affected by the slightest variations in size, shape or direction of the flue passages and the method of discharging currents from individual boilers into the main connection, or any condition tending to form eddies or pockets in the flue. On account of this sensitiveness, it is practically impossible to design a breeching or connections that will give each boiler exactly the same amount of draft. Individual dampers are generally supplied with each boiler, so that those which have the freest draft may be choked down, while the others are opened up and in this way the draft at the grate may be made the same on all the boilers.

A simple means of determining when the draft is equalized, is to note if the same amount of coal can be burned per square foot of grate under each boiler, and when this condition is obtained the position of the individual dampers can be marked, so that they may be kept set at these points while the boilers are in operation; the drafts in the furnaces can also be measured by the use of an ordinary draft gage, and the proper damper adjustments made.

Often a supposed lack of boiler capacity is merely the improper distribution of the load between existing boilers, and if you need more steam, be sure that none of your boilers are "soldiering" on account of poor draft distribution.

Engine Room Ignorance

If you were told the truth about yourself, the probabilities are that it would not be gratifying. No one sees himself as others see him, hence the jolt when brought face to face with the real facts of the individual case. There is no use beating about the bush, but rather come out into the open and make observations of your own condition as well as that of others.

The question of technical versus practical knowledge has been discussed again and again, but assuming that the engineer is fortunate enough to have acquired knowledge in both schools, one is compelled to admit that there are many things about the engine room of which he is even then ignorant. When either the technical or practical experience is lacking, this ignorance must be greatly increased in either one or the other branch of engineering science.

This ignorance in the engine room is the result of several conditions, none of which is unsurmountable.

The most common excuses for not knowing things are: "I don't have time to read." "I never had an opportunity to obtain an education." "When I have worked twelve hours in a hot, dirty, ill-ventilated engine room, I don't feel that I owe my employer any more of my time—time spent for his benefit that he will never pay me for," and so on.

Such excuses are entirely in error. You *do* have time to read, you *have* had an opportunity to obtain an education, for you have it now, and your employer will pay you for the time you spend in digging into the whys and wherefores of things; but even suppose he refuses to do so, there are others who will one.

Most engineers know that the information regarding engineering matters, as understood by the average engineer, is a long way from being complete. If this were not so, the educational work in the various organizations not only would not be continued, but would never have been instituted. In a large number of instances the leaders of such organizations are more watchful of the engineer's condition than he is himself, because of the thousands of stationary engineers in the United States but a small percentage of them are visibly interested in either the betterment of themselves or their fellow workmen.

There are no two ways about it, the engineer is either forging ahead or falling behind. The following aptly illustrates this fact: In a certain steam plant the engineer in charge somehow or other labored under the delusion that he knew enough to hold his position with his company without any more knowledge than he then possessed. Result—something happened of a nature which showed that he was not of sufficient caliber to handle the job, and he was assigned to a place in the fire room, whither he went, not with the best possible grace, perhaps, but he went nevertheless. This was a case of going backward, but who was to blame? Just one instance of lost opportunity with none to blame but "self."

In the same plant was another man, employed as electrician, who knew he did not know a good many things about engineering but wanted to know. Result—he read and studied engineering subjects, and when the regular engineer "fell down" he was placed in charge of the plant, with his former chief in the fire room. Just an instance of being ready for the opportunity, with credit to no one but himself.

Which man do you believe pursued the right course, which man was the one to pattern after, which man forced his employer to recognize his ability, and how would you have liked to have been in the engineer's place?

Easy to answer, easy to understand, easy to see the benefit of knowledge, and an easy matter to decide as to your own attitude.

Peat in the United States

The following has recently been issued by the United States Geological Survey:

A number of cities and towns in the United States may obtain their light, heat and power direct from peat bogs in the near future. The statement is made by Federal experts that millions of dollars worth of fuel lies undeveloped in the swamps and bogs of the country, awaiting only the genius and business ability of the American before it drives the wheels of progress. Its value, as a basis of its use roughly guessed at by experts of the Geological Survey, who have been studying the peat deposits for some time, is more than thirty-eight billion dollars—more money than is represented in all the property, stock, implements and buildings owned by the farmers of the United States.

With the coal supply being used at a tremendous rate peat is expected to become a most important auxiliary fuel and one that will prolong the life of the coal itself. An important fact which leads the experts to believe that peat will soon come into quite general use in certain parts of the country is that it is as a rule found in quantities in regions far removed from the coal fields, so far that the cost of transporting the coal amounts to several times the cost of the fuel itself at the mines.

The States containing the greatest amount of peat are the eastern Dakotas, Minnesota, Wisconsin, Michigan, northern Iowa, Illinois, Indiana, Ohio, New York, the New England States, New Jersey, portions of Virginia, North and South Carolina, Georgia and Florida.

A thorough investigation of the peat resources is now being undertaken by the Geological Survey, not only as to the amount of peat and its location, but also its use. Prof. Charles A. Davis of the technologic branch, has general charge of the investigations.

Professor Davis, who has just issued jointly with Edson S. Bastin a bulletin on peat, is optimistic on the future of peat, yet he believes the development of the industry should be accompanied by great caution.

"The operation of a gas engine at the experiment plant on peat in one or two tests has shown that this fuel is but little inferior to many grades of soft coal now on the market and superior to some in the quantity of power gas produced," says Professor Davis. "I believe the day is coming soon when cities located near the peat bogs and away from the coal fields will obtain their power and light from peat. I understand that Florida is to have a power plant soon that will use peat as fuel and will transmit the electricity to Jacksonville.

"In the development of this industry, however, it must be remembered that peat contains from 85 to 90 per cent. water as it comes from the bogs. All but 15 or 20 per cent. can be dried out by exposure of the peat to the air. In burning peat in gas producers to make power gas, this peat will burn successfully with 50 per cent. moisture, which is impossible in a furnace.

"The burning of peat for power, heat, or light is but one of its many uses. The byproducts of great value include coke, illuminating oils, lubricating oils, paraffin wax, phenol, asphalt, wood alcohol, acetic acid, ammonium sulphate and combustible gases of good fuel value. If used for fuel gas there is enough nitrogen stored in the peat resources of the country to supply six hundred and forty-four million tons with a value of thirty-six billion dollars in addition to the gas.

Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

The Marion Flue Blower

The blower illustrated herewith is a permanent fixture in the rear wall of the boiler setting and blows the soot in the direction of the draft, out through the chimney, cleaning the boiler while in commission, without reducing the steam pressure.

The feature of the device is the rotating nozzle which has three, sometimes four, openings, according to the size of the boiler; these openings all pointing to a different section of the tube sheet. On the base of the nozzle casting is a flat valve seat on which a disk with one opening is held by the steam pressure. The disk may be rotated by a valve stem attached to the indicator on the handwheel, as shown in Fig. 1, and thus each nozzle opening may be blown in turn. As the nozzle is rotated while each opening is being blown, all of the boiler tubes are cleaned.

Fig. 1 shows the heavy cast-iron cap which protects the nozzle from the fire, Fig. 2 shows the parts, and Fig. 3 shows the blower installed. It is located opposite the center of the tube space, but not in the center of the boiler, and each one is constructed especially to fit the existing conditions of combustion space, firewall, etc., in the different boiler settings, a nozzle being furnished which will insure the steam reaching all tubes. This blower is manufactured by the Marion Machine, Foundry and Supply Company, Marion, Ind.

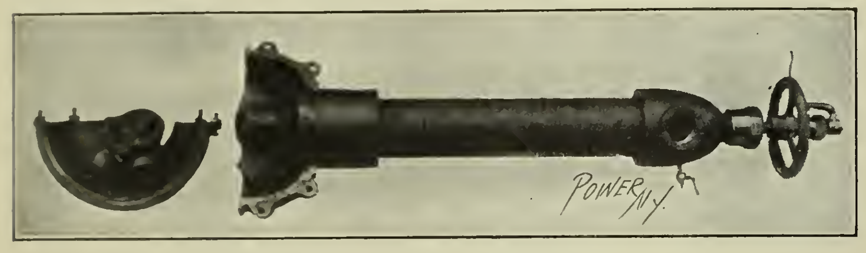


FIG. 1. CONSTRUCTION OF CAP

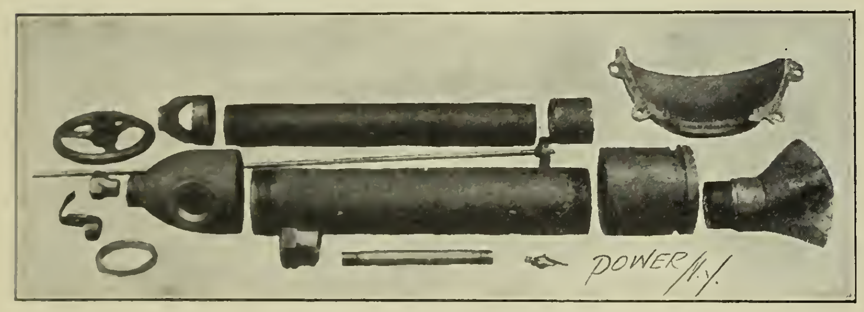


FIG. 2. SHOWING THE PARTS

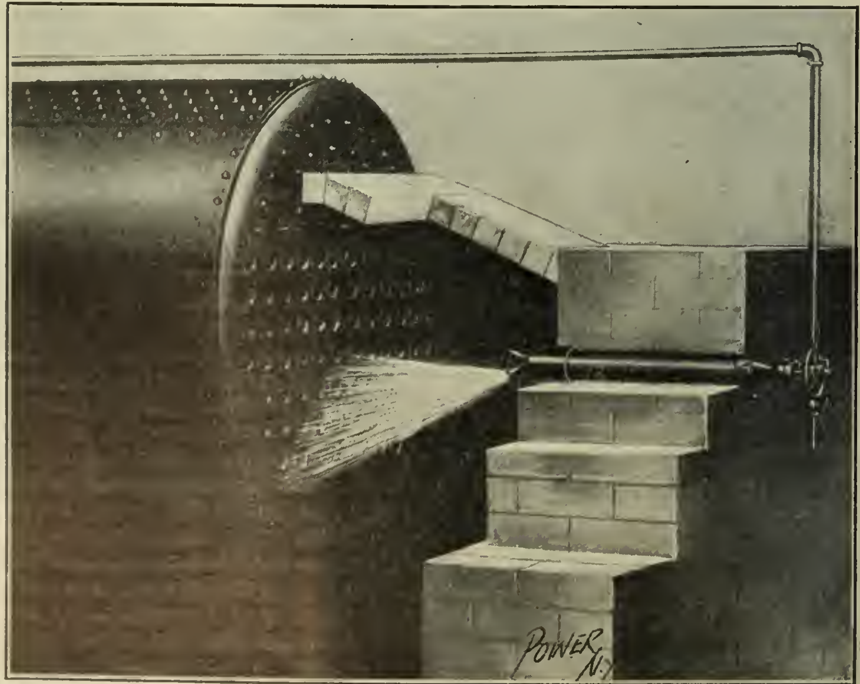


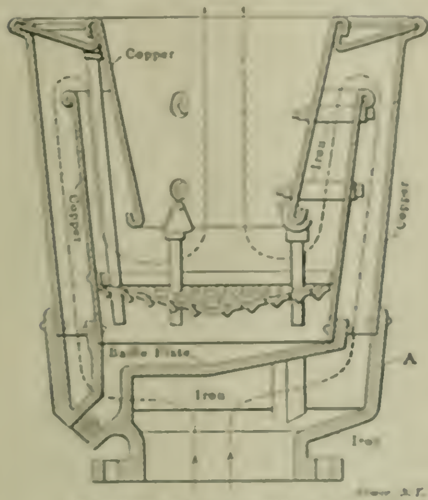
FIG. 3. "MARION" BLOWER IN OPERATION

The "Neverust" Exhaust Head

The "Neverust" exhaust head, which is manufactured by Franklin Williams, 39 Cortlandt street, New York City, is novel as regards its manner of construction and the materials used. It is made entirely of copper and cast iron, which permits of making it of large size, due to the fact that owing to its lightness, it can be made of heavy gage copper and still combine strength and efficiency.

The base is composed of a cast-iron casting to which the copper shell is riveted. It will be seen from the illustration that directly over the opening at the bottom of the head is a cast-iron baffle plate, cast solid with the base of the head. To this baffle plate is riveted an inner shell, which in turn supports the outlet shell of the exhaust head, which having a turned edge at the top laps over the turned edge of the piece forming the top of the exhaust head proper. This in turn fits into the turned edge of the outer shell, thus forming the top of the exhaust head.

A drain runs from the top of the exhaust head to the upper side of the baffle plate, which is connected to the atmosphere by means of the drain as shown, thus thoroughly draining the head from all accumulation of condensed steam. The construction of the head is most rigid and thorough. The passage of the steam as it goes to the head takes the course indicated by the dotted lines. Owing to the fact that the base of the head is extended upward at *A*, the steam current



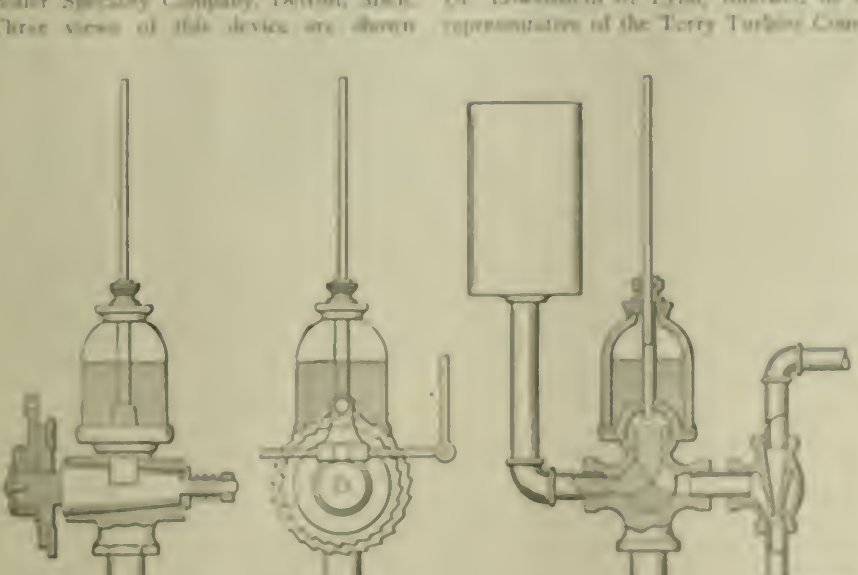
"[illegible]" EXHAUST HEAD

will not cut it away at this point, and as the steam expands at the top of the head, there is no tendency to cut at that point.

The "Success" Boiler Compound Feeder

The "Success" boiler compound feeder is manufactured by the Cunningham Boiler Specialty Company, Detroit, Mich. Three views of this device are shown herewith. As the name implies, this feeder is for the purpose of feeding boiler compound to a boiler. It feeds the exact amount required and does it with every stroke of the feed pump. The "Success" feeder is actuated by the boiler-feed pump and consequently when less water is being pumped to the boilers less compound is used, and the proportions of the neutralizing agent and feed water remain the same.

It is fitted with a glass measuring receptacle which permits the attendant to see and regulate the amount of boiler compound admitted and delivered to the boiler. No valves are employed, save one, which is a three-way plug. A duplex ratchet is used to actuate the plug which is designed to insure a slow and positive movement.



DETAILS OF "SUCCESS" BOILER-COMPOUND FEEDER

Boston A. S. M. E. Meeting Successful

On Friday, June 11, there was a very successful meeting of the Boston branch of the A. S. M. E., at the Lowell building of the Massachusetts Institute of Technology, Professor Hollis presiding and E. L. Moulthrop acting as secretary.

The meeting opened at eight o'clock with a few preliminary remarks by Professor Hollis with regard to the object of the meeting, and he invited all interested in mechanics to attend the meeting. He introduced Calvin W. Rice, who assured those present that this was not a branch meeting but a bona-fide meeting of the association, and he hoped they would so consider it.

The subject of the evening was then taken up, the discussion of Mr. Orrok's paper, which discussion was opened by Dr. Lowenstein of Lynn, followed by a representative of the Terry Turbine Company, and he by a representative of the Sturtevant people, and the local representative of the De Laval people. He was followed by a representative of the Kerr people and the paper was also discussed by Capt. Manning of the Amoskeag Mills, C. F. Crissy and Richard H. Rice of Lynn.

Professor Miller, of the Massachusetts Institute of Technology, had tabulated the efficiencies from the different curves on the board and offered a few remarks in connection with these. Charles B. Burleigh also discussed the paper, and an abstract of his remarks appears on another page of this number.

There were about 150 present.

Carborundum in Wireless Telegraphy

By J. G. Smith

Carborundum as an abrasive is undoubtedly a pretty well-known article among the readers of POWER, but it is doubtful if many are aware that it is now used by the big American wireless telegraph company, the United, as a detector in receiving instruments. In fact it has almost entirely supplanted other substances, such as silicon, molybdenite, etc., in this particular work, because of its greater reliability for all-around service, it being affected to a hardly noticeable degree by the heavy discharges of the sending apparatus, as is common with other substances, and thus not requiring new adjustment after each period of sending.

Carborundum comes from the electric furnaces at Niagara Falls in cakes about an inch or two in thickness, and in color ranges from a silver-gray to plain black, sometimes with all the colors of the spectrum interspersed, including the inimitable green of Niagara. This color scheme does not mix in one bundle, but runs in sections, and the dark blue, solid portion of a cake is the part the wireless man is after. Carborundum seems to be the hardest when the color is dark blue, and when a piece of this kind is used the oscillations give a sharp, clear tone in the receiving telephones, which quality seems to be lacking in the other colors; for when it is of any other color it seems to be softer and the sounds are inclined to be muddy.

The writer has made a careful study of this question and can properly say no carborundum of any color than can approach in any way the dark blue for sensitiveness and general results. Carborundum has a positive and negative side and careful adjustment must be made with this in view in wireless work. It also has a high resistance to direct current, but is susceptible to alternating-current oscillations, one of the reasons why it is found so useful in wireless telegraphy.

Disastrous Boiler Explosion at Denver

At 6 o'clock on the evening of June 15, a boiler explosion, serious in the loss of life it produced, occurred in the west side plant of the Denver Gas and Electric Company, which is controlled and operated by Henry L. Doherty, of New York City. The plant in question is the largest of the three stations in Denver operated by this company, and has a capacity of about 9000 boiler horsepower. It is really the main distributing station, as the other two are smaller and are tied in with the main station.

Some three years ago an addition was made to the station, and in this new part were installed two 400-horsepower Wickes vertical boilers, also a 2000-kilowatt Curtis turbine and two 1500-kilowatt direct-connected alternators. These units were supplied as much as possible with steam from the Wickes boilers, and the balance of the steam beyond their capacity was drawn from the remainder of the boiler installa[illegible], consisting of Heine water-tube [illegible]ers, the piping being so arranged that it was an easy matter to switch from the new installation to the older boilers, or draw from both as desired.

The explosion occurred in one of the Wickes boilers, which was carrying 150 pounds steam pressure. The tubes all broke away from the lower drum and the upper part of the boiler went straight up into the air for a distance of 300 feet, then dropped down through the roof of the old part of the station at a point 175 feet distant, landing directly on top of two generators, one a 500-kilowatt, 500-volt, direct-current belted machine and the other a 600-kilowatt, 2300-volt, alternating-current belted generator. Part of the gallery and railing in front of the switchboard were torn away, but the switchboard was not injured. None of the prime movers in the station was harmed in the slightest degree, and what is more strange the piping of the Heine boilers was all left intact, so that the station was put in operation in a very short time after the accident. Only the piping in the new part of the station was twisted out of place, and the second Wickes boiler was toppled over but did not explode, although it was carrying full steam pressure.

Three firemen who were working around the Wickes boilers were reported killed, among them being Chief Engineer Harry L[illegible]ner, and a child one-half a mile distant met a similar fate from flying débris. Six others in the plant were seriously injured and others in the immediate vicinity received injuries of a more or less serious character. The damage to property is estimated at $75,000, and from this standpoint the owners of the plant were most fortunate, as the general destruction of the plant might easily have been expected.

It has been rumored that low water was the cause of the explosion, the fireman pumping in a fresh supply instead of pulling the fires and observing the usual precautionary measures. Within a week previous to the explosion, William Lawless, deputy boiler inspector for the city, had made an interior inspection and W. H. Odett, chief inspector for the London Guarantee and Accident Company, had made an exterior inspection about the same time and had inspected the interior in February. Neither could account for the explosion.

It is reported that this is the first explosion of a Wickes boiler, and it will be of interest to learn from the manufacturer or perhaps from the London Guarantee and Accident Company, in which the boilers were insured, the exact cause of the explosion. Photographs of the accident and a fuller description will be published in an early issue.

Cleveland Industrial Exposition

The Cleveland (Ohio) Industrial Exposition, which was held from June 7 to 19, inclusive, was an unqualified success and unique in that it was participated in by Cleveland industries only. The project of thus exploiting Cleveland-made products was conceived in December, 1908, and it received such hearty support by the local manufacturing interests that it was soon seen that the available public halls would not accommodate the prospective exhibitors. Therefore, an exposition building having a larger ground-floor exhibit area than any other exposition structure in the country was erected. The total area was 72,030 square feet. It was nearly opposite the Central armory, the use of which for exhibition purposes was also secured, giving a total area of 114,565 square feet, including the bridge connecting the exposition building and the armory.

The walls of the new building, which was on the site of the proposed city hall, were of wood covered with staff, and it had a fire- and waterproof canvas roof supported by three huge masts mounted on structural-iron supports anchored to 30-ton blocks of iron-weighted concrete.

F. F. Prentiss, of the Chamber of Commerce, chairman of the executive committee, suggested the exposition.

Business Items

There are now in operation thirteen sets of Neemes shaking grates in the Fulton Mills of the American Woolen Company, Fulton, N. Y. The Woolen company has just ordered from Neemes Bros., of Troy, N. Y., ten more sets six feet six inches square. This will make 23 sets of these grates in use in these mills.

The Farmers' Coöperative Brick and Tile Company, of Mason City, Iowa, has ordered a 14x30-inch heavy-duty Twin City Corliss engine from the Minneapolis Steel and Machinery Company, together with transmission machinery and piping for the plant. This is the second Twin City Corliss engine that they have installed within a year.

Further improvement in trade conditions is reported by the Wisconsin Engine Company, of Corliss, Wis., which has recently shipped two more of its "higher-speed" Corliss engines, one for the Chicago, Milwaukee & St. Paul Railroad Company and the other to the Carbon brick yards, at Carbon, Penn. The above company reports a large number of inquiries, not only for its standard and "higher" speed Corliss engines, but for its complete-expansion gas engines, most of the inquiries being from well-known concerns to which operating economies are of great importance.

A new folder issued by the International Acheson Graphite Company is known as 273-B. It is descriptive of the company's graphited greases, products which are designed for gear, cup and ball-bearing use. In the manufacture of its graphited grease, the company states that it uses the purest and best graphite, which is a perfect lubricant in itself. The graphite and grease are carefully blended, and it is claimed that the resultant product will do far more work than any other grease product on the market, great value being given the combination by the superior lubricating qualities of the graphite.

The Chapman Valve Manufacturing Company recently issued $300,000 worth of preferred stock. This was done because the board of directors, in conjunction with the stockholders, believe that a better product, if such a thing be possible, must be put on the market to keep up with competition. They advise us that the Chapman valve has been the standard for high class for years. It would, therefore, appear that this company has no intention of allowing its product to remain at a standstill on past reputation, but intends to make an even greater fame for Chapman valves. Under these conditions it is not at all strange that this preferred stock has been over-subscribed three or four times, as we are given to understand from reliable sources.